

UNIT V - ELECTRICITY

Lesson 11: Lightning Protection

Competency/Objective: Describe procedures for planning and installing lightning protection.

Study Questions

1. What is lightning, and why does it strike structures?
2. What lightning protection is necessary for the operation?
3. What constitutes a good system of protection?
4. How is the lightning protection system installed?
5. How is equipment protected from lightning?
6. How is lightning grounded off a structure?

References

1. *Agriculture Structures (Student Reference)*. University of Missouri-Columbia: Instructional Materials Laboratory, 1999, Unit V.
2. Transparency Masters
 - a) TM 11.1: When Lightning Strikes
 - b) TM 11.2: Components of a Lightning Protection System
 - c) TM 11.3: Grounding Practices
3. Activity Sheet
 - a) AS 11.1: Assessing Lightning Protection

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Lesson 11: Lightning Protection

B. *Review*

Lesson 10 described the formulas used to measure the consumption of electricity and the cost of electricity. Lesson 11 discusses efficient lightning protection systems. Lightning protection is important because lightning strikes can overload electrical systems, damage structures, and injure or kill people and animals.

C. *Motivation*

Use a 6-volt battery to demonstrate how electricity jumps from a negative to a positive pole to demonstrate how electrons jump between the clouds and earth to create lightning. Attach a short wire to the positive electrode of the battery and another to the negative electrode. Move the wires together until a spark appears. Use a capacitor attached to the positive wire to increase the voltage for a longer arc.

D. *Assignment*

E. *Supervised Study*

F. *Discussion*

1. Ask students to explain what lightning is and why it occurs. Discuss their answers, explaining why lightning strikes structures. TM 11.1 can be used to help illustrate the conditions that produce lightning. Emphasize that more than 125 people are killed by lightning each year.

What is lightning, and why does it strike structures?

- a) Lightning
 - 1) It is the visible discharge of static electricity within a cloud, between clouds, or between the earth and a cloud.
 - 2) It is basically a large electric spark caused when current jumps a gap in the air.
- b) Strikes
 - 1) Strikes occur when hot and cold air masses meet, causing atoms to lose electrons.
 - 2) Negatively charged electrons gather at the cloud base.
 - 3) Positive ions converge at high locations on the earth's surface.
 - 4) The ions and electrons are attracted to each other, creating a stepped leader, an unseen conduit through which negative charges move from the cloud to the earth.

- 5) From the earth, ion streamers called leaders travel upward.
 - 6) If the two puncture the air gap insulator and converge, a channel is created for electrical energy to move between the earth and the cloud as the charges rapidly equalize themselves.
2. Lightning protection is necessary not only to prevent injuries and fatalities but also to provide protection against fires and damage from electrical surges. Discuss the factors to consider when determining what lightning protection is needed by an agricultural operation.

What lightning protection is necessary for the operation?

- a) Before installing lightning protection, the need for such protection should be assessed.
 - 1) Frequency of lightning
 - 2) Type of structure and its construction
 - 3) Location of the structure
 - 4) Topography of the surrounding area
 - 5) Contents of the structure
 - b) Tall structures such as silos should be grounded not only to protect them but because they can provide a cone of protection with a diameter that is two times the height of the object.
 - c) Electric fences should be grounded.
3. Ask students what components make up a lightning protection system. Show them TM 11.2 and describe the purpose of the different components pictured.

What constitutes a good system of protection?

- a) Air terminals or lightning rods
 - 1) The points where lightning strikes
 - 2) Installed on high points on structures, such as roof ridges or ventilators
 - b) Main conductors - cables that connect the air terminals to the grounding electrodes, or ground terminations
 - c) Ground terminations - copper or copper-clad rods driven into the earth, preferably to a minimum of ten feet in depth
 - d) Lightning arresters - protect wiring from lightning-induced damage
 - e) Surge suppressors - used to further protect electrical equipment, such as computers
4. Proper installation of a lightning protection system is crucial to its efficiency. Describe the guidelines for installing lightning protection. Emphasize that having a professional install the system will provide the best protection by ensuring that it has been done properly.

How is the lightning protection system installed?

- a) Number of grounding electrodes
 - 1) All buildings with a perimeter of 250 feet or less must have two grounding electrodes, preferably diagonally at opposite corners of the structure.
 - 2) If the perimeter is between 250 and 350 feet, three electrodes are required.
 - 3) At perimeters of 350 to 450 feet, four electrodes are necessary.
 - 4) Another grounding electrode is added for every 100 feet of perimeter.
 - b) Grounding conductors
 - 1) They should follow a straight horizontal or vertical path to the grounding electrode.
 - 2) The cables need to be free of sharp turns and “U” or “V” pockets.
 - 3) Turns in conductors should not exceed 90 degrees.
 - 4) Bends should not have a radius of less than eight inches.
 - c) Air terminals - should be properly sized, spaced, and installed
 - d) Conductors
 - 1) The down conductors should carry the discharge directly to the ground.
 - 2) Entrance conduits, gutters, drain pipes, pipe vents, metal water pipes, radio and T.V. antennas, metal roofing, fences, and other metal objects should be bonded to the down conductors and ground rods.
 - 3) The main bonding conductors must be at least AWG 6 copper wire or its equivalent.
 - 4) Down conductors should be enclosed in a conduit or metal tubing extending from a point at least five feet above ground level to one foot below the ground’s surface.
 - e) Ground rods
 - 1) Ground rods of adequate size must be located properly throughout the system.
 - 2) Lightning system ground rods must be driven to a minimum depth of 10 feet where soil conditions permit.
 - 3) Other acceptable options are to dig a trench 3 to 4 feet deep by 10 feet long and bury a grounding rod or to bury a grounding plate at least 18 inches deep.
 - 4) Another method involves connecting down conductors to a metal water system, as long as the pipes are a minimum of three feet deep and ten feet long and are in direct contact with the earth.
 - 5) If ground rods used for the electrical or telephone system are within 6 feet of a grounding electrode, they must be bonded together to prevent side flashes.
5. Providing protection to equipment is another important function of lightning protection systems. Discuss the methods used to prevent damage to equipment.

How is equipment protected from lightning?

- a) Power supply system
 - 1) Stepping down
 - (a) Power from the source passed through several transformers and other devices
 - (b) Reduce and convert the electricity into forms the consumer can use
 - 2) Offers lightning protection at each level
- b) Surge suppressor
 - 1) Used to protect electronic equipment, particularly computers, from surges
 - 2) Provide a receptacle or a bank of receptacles with a breaker that automatically trips when the electricity spikes
 - 3) Prevent damage from lightning if computer equipment is plugged into telephone lines
 - (a) Telephone companies - lightning suppression devices in the lines
 - (b) Special surge suppressors - connections for telephone lines
- c) Lightning or surge arrester
 - 1) Used to remove high voltage charges from the system by breaking the circuit and then diverting the electricity to the ground
 - 2) Installed where service wires enter the building at the service entrance panel or prior to the connection of specialized electrical loads or other equipment away from protected buildings
- d) Controller
 - 1) Normally used for starting and stopping motors
 - (a) For small motors of _ hp or less - overcurrent device at the service entrance panel
 - (b) For larger motors - separate switch with a current capacity at least twice the full load rating of the motor
 - 2) Should have overload devices installed that stop the current to the motor during electrical surges and power overloads
 - 3) Should also have a manual reset so the motor does not restart automatically when normal power is restored

6. The grounding of the lightning protection system will determine the extent of protection available. Discuss how lightning is grounded off a structure. TM 11.3 shows grounding practices for a building. Have students complete AS 11.1.

How is lightning grounded off a structure?

- a) Electrical grounding - connecting one end of a properly sized copper conductor to the air terminals and the other end to a metal conductor that is in direct and permanent contact with the earth
- b) Grounding
 - 1) ½-inch copper rod
 - 2) _-inch copper-clad rod
 - 3) ¾-inch galvanized iron pipe
 - 4) Metallic water system
 - 5) Metal plate if a ground rod cannot be used due to rock beneath the soil

- c) Size of the grounding wire determined by the size of the wire supplying power to the service entrance panel
- d) Wire clamped to the grounding electrode using lugs or clamps

G. *Other Activities*

Invite a certified electrician or a professional who installs lightning protection systems to give a presentation to the class about his or her work.

H. *Conclusion*

Lightning can be dangerous to humans and animals and destructive to structures and equipment. An efficient lightning protection system is necessary to help prevent damage and loss of life. For the best possible protection, a qualified and certified professional should install systems for the home and farm.

I. *Answers to Activity Sheet*

J. *Answers to Evaluation*

1. d
2. d
3. c
4. Answers may include any two of the following: frequency of lightning, type of structure and its construction, location of the structure, topography of the surrounding area, and contents of the structure.
5. They are the points where the lightning strikes.
6. A channel is created for electrical energy to move between the earth and the cloud.
7. To dig a trench 3 to 4 feet deep by 10 feet long and bury a grounding rod or to bury a grounding plate
8. The size of the wire supplying power to the service entrance panel
9. Used to protect electronic equipment, particularly computers

EVALUATION

Circle the letter that corresponds to the best answer.

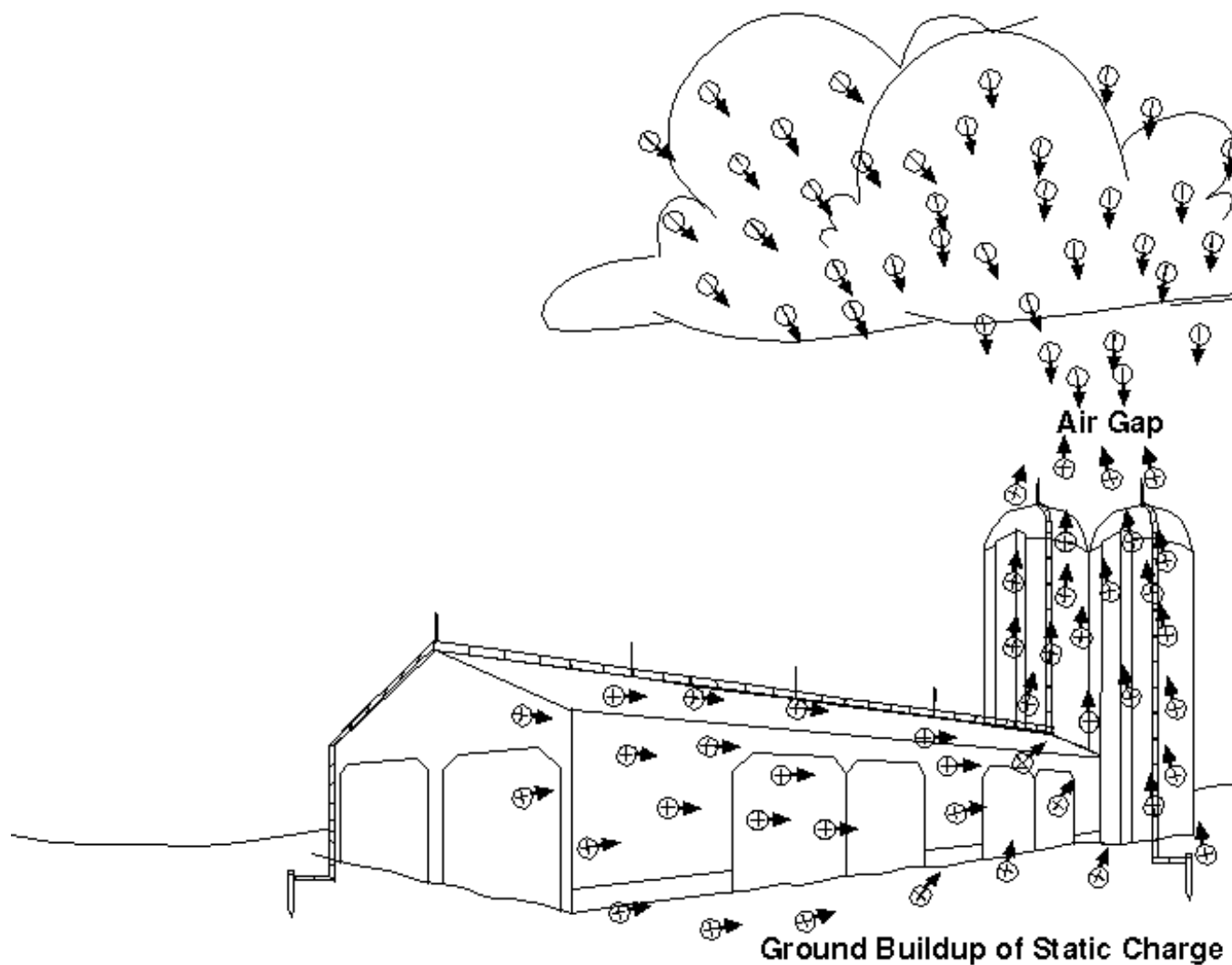
1. How many ground rods are required for a structure with a perimeter of 410 feet?
 - a. 1
 - b. 2
 - c. 3
 - d. 4
2. Before lightning strikes, _____ travel(s) upward from the earth.
 - a. Electrons
 - b. Ions and electrons
 - c. A stepped leader
 - d. An ion streamer
3. What size copper wire should be used for the main bonding conductors?
 - a. AWG 2
 - b. AWG 4
 - c. AWG 6
 - d. AWG 8

Complete the following short answer questions.

4. What are two factors to consider when assessing the need for lightning protection?
 - a.
 - b.
5. What is the function of air terminals?
6. What happens when the air gap insulator is punctured?

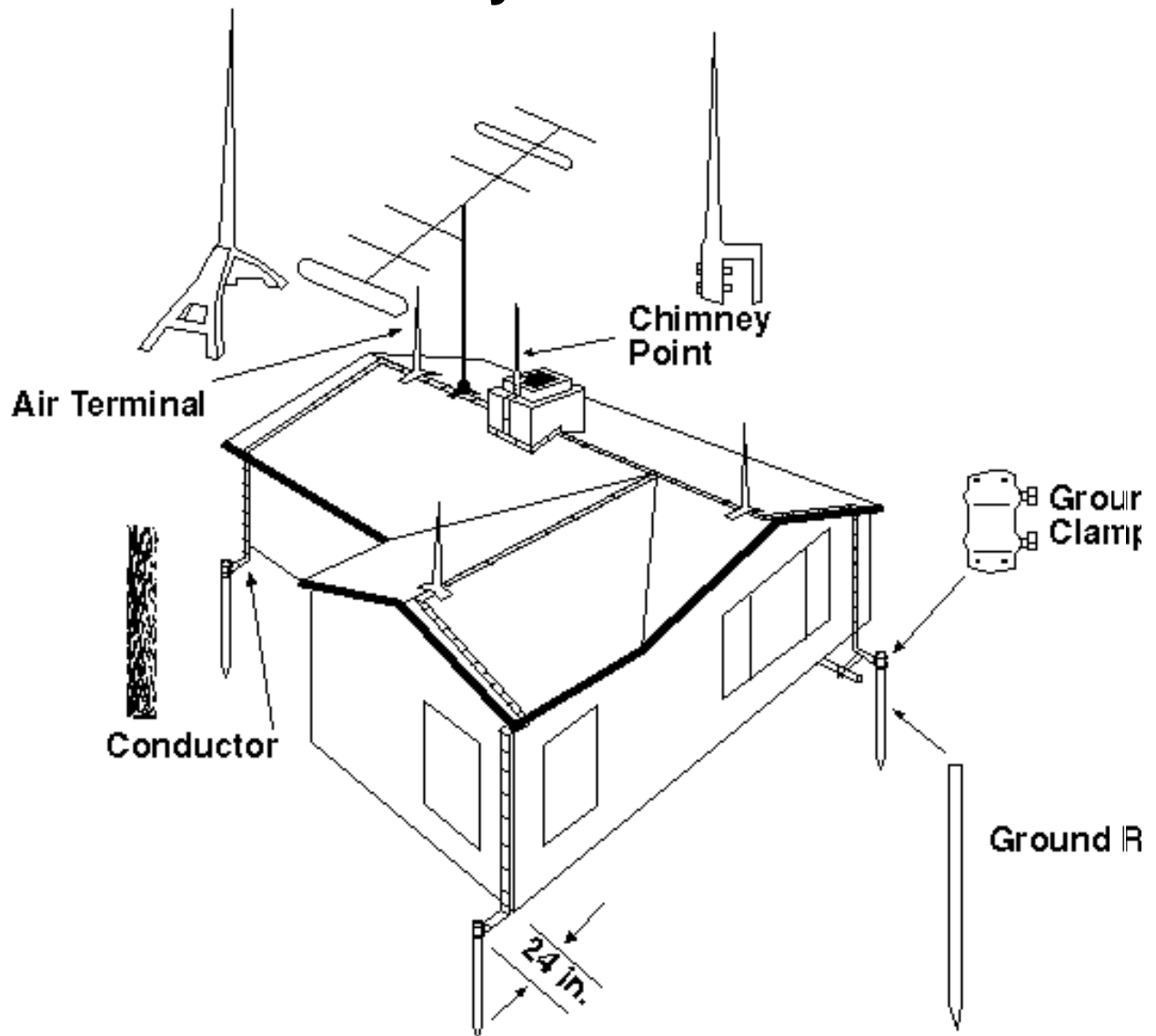
7. What are two alternative methods of establishing a grounding electrode if one cannot be driven to the proper depth?
 - a.
 - b.
8. What determines the size of the grounding wire?
9. What is the function of surge suppressors?

When Lightning Strikes

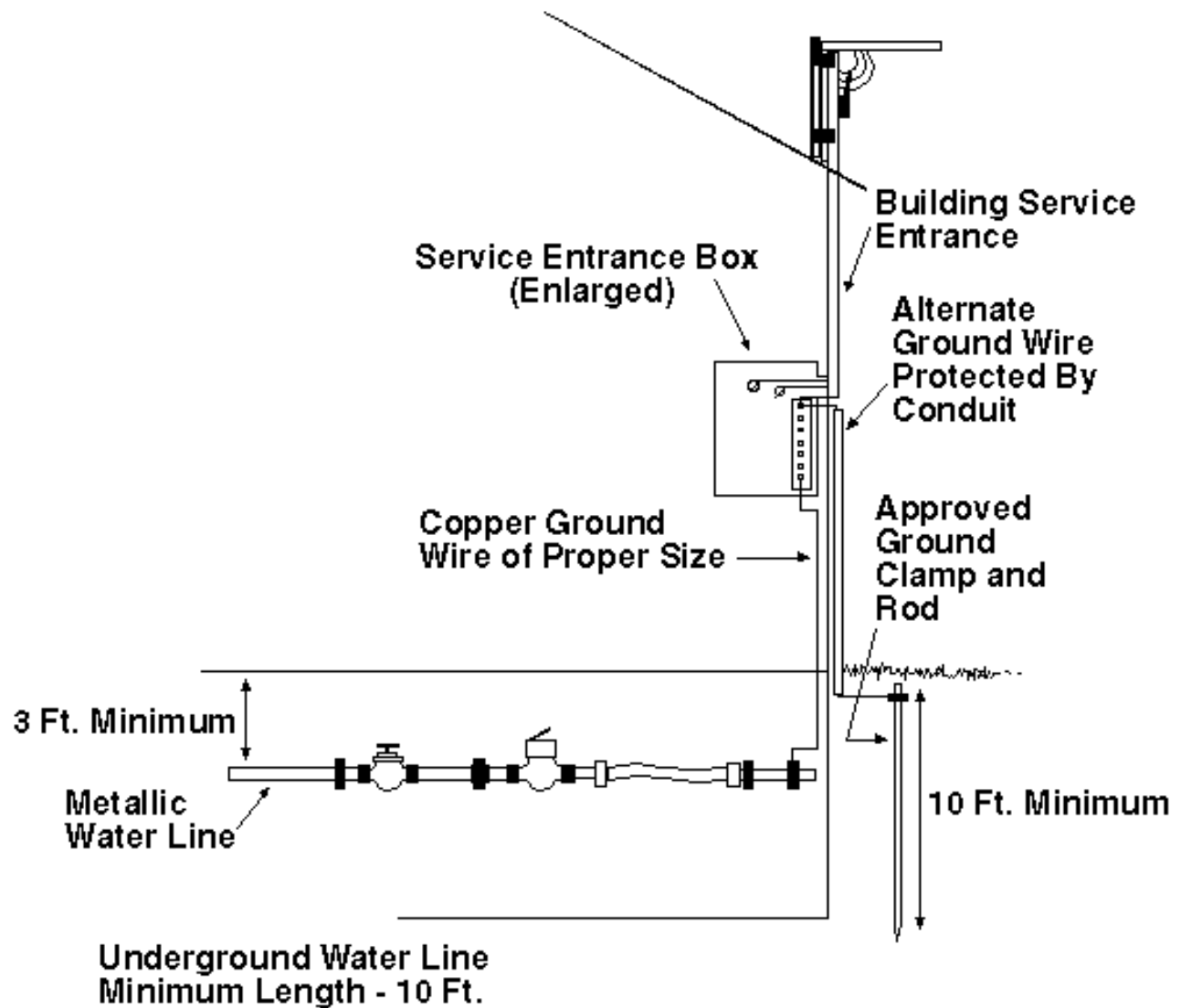


When the force is great enough to puncture the air gap, the charge follows the path of least resistance to the ground.

Components of a Lightning Protection System



Grounding Practices



Assessing Lightning Protection

Objective: Identify the components of the lightning protection system in a structure.

Investigate the lightning protection system installed in your home or an agricultural structure. Identify the components of the system and fill out the chart. If no lightning protection is present, indicate what components would be needed and where they would be installed.

Components	Number	Location
Air terminals		
Down conductors		
Ground terminations		
Lightning arresters		
Surge suppressors (telephone/electrical)		

