General Guidelines

The Pole Framing and Guying training unit is composed of a video and associated Student Manual. The DVD contains one Course. The course is divided into Lessons, where each Lesson consists of a number of Topics. The number of Lessons and Topics will vary with each course.

Recommended Sequence of Instruction

1. After the instructor’s introductory remarks, read the segment objectives found in the block at the beginning of the first segment.
2. Briefly discuss the segment objectives with the instructor and other class members.
3. View the first segment of the video.
4. Read the text segment that corresponds to the first segment of the video.
5. Answer the questions at the end of the text segment. Check your answers with the correct answers provided by the instructor.
6. Participate in a class discussion of the material just covered. Ask any questions you might have concerning the material in the video and the text, and note any additional information given by the instructor.
7. Before proceeding, be sure you understand the concepts presented in this segment.
8. Work through all segments in this manner.
9. A Course Test covering all the material will be administered by the instructor upon completion of the unit.
10. Additional instruction and testing may be provided, at the instructor’s discretion.

This recommended sequence may be modified slightly by the instructor due to scheduling or other special considerations.

OSHA Regulations Snap-Shot

OSHA Regulations, primarily in 1926.955, 1910.269 and 1910.268 will be used in conjunction with this training unit. Where applicable, regulations will be highlighted and placed in a box like this.

Regulations are used that are in force at the time of the workbook printing. Instructors and students are expected to review the current OSHA Regulations to familiarize the student with the safety requirements expected by USDOL OSHA, specifically as they relate to the topic being discussed. This information is an important part of this training unit.

This T&D PowerSkills Training workbook is designed to be used in conjunction with the associated training video.
### Field Performance Requirements (FPR)

**NAME:** ______________________________   #___________

**SECTION:** OVERHEAD DISTRIBUTION - DE-ENERGIZED

**UNIT(S):** Pole Framing and Guying

<table>
<thead>
<tr>
<th>REQUIREMENTS</th>
<th>SUPERVISOR SIGN-OFF</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SEGMENT 1 – PRINCIPLES OF POLE CONSTRUCTION</strong></td>
<td></td>
</tr>
<tr>
<td>1.1 Can describe typical wooden pole construction configurations..................................................................................</td>
<td>□ □ □ □</td>
</tr>
<tr>
<td>1.2 Can describe forces exerted on a wooden pole based on the placement and angle of the conductor wire ................................................................................................................</td>
<td>□ □ □ □</td>
</tr>
<tr>
<td><strong>SEGMENT 2 – CONSTRUCTION TYPES</strong></td>
<td></td>
</tr>
<tr>
<td>2.1 Can describe the three basic pole construction types and how they can be modified to meet different needs ................................................................................................................</td>
<td>□ □ □ □</td>
</tr>
<tr>
<td><strong>SEGMENT 3 – FRAMING A POLE, PART 1</strong></td>
<td></td>
</tr>
<tr>
<td>3.1 Can describe the types of cuts that can be made in a pole as well as the types of bolts and other hardware that is approved for use in pole framing ................................................................................................................</td>
<td>□ □ □ □</td>
</tr>
<tr>
<td><strong>SEGMENT 4 – FRAMING A POLE, PART 2</strong></td>
<td></td>
</tr>
<tr>
<td>4.1 Can read a ‘spec sheet’ or engineering drawings and demonstrate how to plan out and execute a pole framing job ................................................................................................................</td>
<td>□ □ □ □</td>
</tr>
<tr>
<td><strong>SEGMENT 5 – GUYS</strong></td>
<td></td>
</tr>
<tr>
<td>5.1 Can describe typical wooden pole guy wiring configurations ................................................................................................................</td>
<td>□ □ □ □</td>
</tr>
<tr>
<td>5.2 Can describe typical anchoring solutions and when each may be used ................................................................................................................</td>
<td>□ □ □ □</td>
</tr>
</tbody>
</table>

**SUPERVISOR SIGN-OFF**

| Complete | □ |
| Incomplete | □ |

**VG** = Very Good  
**ACC** = Acceptable  
**NI** = Needs Improvement  
**NA** = Not Able to Complete on this Crew
CONTINUED:

SEGMENT 6 – GUYING AND GROUNDING

6.1 Can demonstrate approved procedures for installing anchors .......................................... ☐ ☐ ☐ ☐

6.2 Can demonstrate approved procedures for installing the guy wire................................. ☐ ☐ ☐ ☐

__________________________  ________________________  ______________________
Apprentice’s Signature       Supervisor's Signature       Date

NOTES:

________________________________________________________________________
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________________________________________________________________________
________________________________________________________________________

OSHA Regulations Snap-Shot

1910.269(a)(2)(vii)

The employer shall certify that each employee has received the training required by paragraph (a)(2) of this section. This certification shall be made when the employee demonstrates proficiency in the work practices involved and shall be maintained for the duration of the employee’s employment.

Note: Employment records that indicate that an employee has received the required training are an acceptable means of meeting this requirement.
Table of Contents

Segment 1: Principles of Pole Construction 8
1.1 Types of Pole Construction 8
1.2 Functions of a Pole 11
1.3 Effects of Conductor Forces on Pole Construction 12

Segment 2: Construction Types 18
2.1 Crossarm Construction 18
2.2 Armless Construction 26
2.3 Vertical Construction 29

Segment 3: Framing a Pole, Part 1
3.1 Roofs and Gains Error! Bookmark not defined.
3.2 Bolts Error! Bookmark not defined.
3.3 Insulators Error! Bookmark not defined.

Segment 4: Framing a Pole, Part 2 Error! Bookmark not defined.
4.1 Pole Framing Preparation Error! Bookmark not defined.
4.2 Installing a Crossarm on a Newly Erected Pole Error! Bookmark not defined.
4.3 Framing a Double Crossarm Error! Bookmark not defined.

Segment 5: Guys Error! Bookmark not defined.
5.1 Guys That Run from a Pole to the Ground Error! Bookmark not defined.
5.2 Guys That Run from One Pole to Another Error! Bookmark not defined.
5.3 Guys That Run from a Crossarm to Another Pole Error! Bookmark not defined.
5.4 Attachment of Guy Wires Error! Bookmark not defined.
5.5 Push Guys Error! Bookmark not defined.

Segment 6: Guying and Grounding Error! Bookmark not defined.
6.1 Installing an Expansion Anchor Error! Bookmark not defined.
6.2 Installing a Screw Anchor Error! Bookmark not defined.
6.3 Preparing the Guy Wire for Attachment Error! Bookmark not defined.
6.4 Attaching the Guy Wire Error! Bookmark not defined.
# Table of Figures

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-1</td>
<td>Crossarm Construction</td>
<td>9</td>
</tr>
<tr>
<td>1-2</td>
<td>Armless Construction</td>
<td>10</td>
</tr>
<tr>
<td>1-3</td>
<td>Vertical Construction</td>
<td>11</td>
</tr>
<tr>
<td>1-4</td>
<td>Wires All on One Side of the Structure</td>
<td>12</td>
</tr>
<tr>
<td>1-5</td>
<td>Direction of Force Due to Strain on Conductor Wire</td>
<td>13</td>
</tr>
<tr>
<td>1-6</td>
<td>Conductors on Straight Line Poles</td>
<td>14</td>
</tr>
<tr>
<td>1-7</td>
<td>Conductors Leading from Pole at an Angle</td>
<td>15</td>
</tr>
<tr>
<td>1-8</td>
<td>Guy Wire Resisting Lateral Strain from Conductors</td>
<td>16</td>
</tr>
<tr>
<td>2-1</td>
<td>Wooden Crossarm</td>
<td>18</td>
</tr>
<tr>
<td>2-2</td>
<td>Steel Braces</td>
<td>19</td>
</tr>
<tr>
<td>2-3</td>
<td>Wooden Braces</td>
<td>20</td>
</tr>
<tr>
<td>2-4</td>
<td>Double Wooden Crossarm</td>
<td>21</td>
</tr>
<tr>
<td>2-5</td>
<td>Conductors Tied to Sides of Insulators</td>
<td>22</td>
</tr>
<tr>
<td>2-6</td>
<td>Post Insulators</td>
<td>23</td>
</tr>
<tr>
<td>2-7</td>
<td>Suspension Insulators</td>
<td>24</td>
</tr>
<tr>
<td>2-8</td>
<td>Side Arm, or Alley Arm</td>
<td>25</td>
</tr>
<tr>
<td>2-9</td>
<td>Armless Construction: Center Phase Next to Another Phase on the Lateral Rod</td>
<td>26</td>
</tr>
<tr>
<td>2-10</td>
<td>Armless Construction: Center Phase Extended Up from Top of Pole</td>
<td>27</td>
</tr>
<tr>
<td>2-11</td>
<td>Armless Construction: Insulators Bolted Directly to Pole</td>
<td>28</td>
</tr>
<tr>
<td>2-12</td>
<td>Horizontal Post Insulators</td>
<td>29</td>
</tr>
<tr>
<td>2-13</td>
<td>Two Phases of a Running Corner</td>
<td>30</td>
</tr>
<tr>
<td>2-14</td>
<td>Insulators Holding Jumper Away from Pole</td>
<td>31</td>
</tr>
<tr>
<td>3-1</td>
<td>Pole Roofs</td>
<td>Error! Bookmark not defined.</td>
</tr>
<tr>
<td>3-2</td>
<td>Pre-Cut 'Gain'</td>
<td>Error! Bookmark not defined.</td>
</tr>
<tr>
<td>3-3</td>
<td>Patent 'Gain' with Teeth on the Curved Side</td>
<td>Error! Bookmark not defined.</td>
</tr>
<tr>
<td>3-4</td>
<td>Machine Bolt</td>
<td>Error! Bookmark not defined.</td>
</tr>
<tr>
<td>3-5</td>
<td>Double-Arm (DA) Bolt</td>
<td>Error! Bookmark not defined.</td>
</tr>
<tr>
<td>3-6</td>
<td>Carriage Bolt</td>
<td>Error! Bookmark not defined.</td>
</tr>
<tr>
<td>3-7</td>
<td>Lab Screw</td>
<td>Error! Bookmark not defined.</td>
</tr>
<tr>
<td>3-8</td>
<td>Insulator Pin</td>
<td>Error! Bookmark not defined.</td>
</tr>
<tr>
<td>3-9</td>
<td>Pal Nut</td>
<td>Error! Bookmark not defined.</td>
</tr>
<tr>
<td>3-10</td>
<td>Insulator Pin on Armless Construction</td>
<td>Error! Bookmark not defined.</td>
</tr>
<tr>
<td>3-11</td>
<td>Post Insulator</td>
<td>Error! Bookmark not defined.</td>
</tr>
<tr>
<td>3-12</td>
<td>Porcelain Spool Insulator</td>
<td>Error! Bookmark not defined.</td>
</tr>
<tr>
<td>3-13</td>
<td>Suspension Insulators</td>
<td>Error! Bookmark not defined.</td>
</tr>
<tr>
<td>4-1</td>
<td>&quot;Spec Sheet&quot;</td>
<td>Error! Bookmark not defined.</td>
</tr>
<tr>
<td>4-2</td>
<td>Through Bolt Length Calculation</td>
<td>Error! Bookmark not defined.</td>
</tr>
<tr>
<td>4-3</td>
<td>Beveled Top Edge on a Crossarm</td>
<td>Error! Bookmark not defined.</td>
</tr>
<tr>
<td>4-4</td>
<td>Insulator in Correct Position</td>
<td>Error! Bookmark not defined.</td>
</tr>
<tr>
<td>4-5</td>
<td>Patent Gain with Hole</td>
<td>Error! Bookmark not defined.</td>
</tr>
<tr>
<td>4-6</td>
<td>Handline Tied Around Insulator Pins</td>
<td>Error! Bookmark not defined.</td>
</tr>
<tr>
<td>4-7</td>
<td>Measuring the Diameter of a Pole</td>
<td>Error! Bookmark not defined.</td>
</tr>
<tr>
<td>5-1</td>
<td>Down Guy</td>
<td>Error! Bookmark not defined.</td>
</tr>
</tbody>
</table>
Figure 5-2: 1-to-1 Ratio ................................................................. Error! Bookmark not defined.
Figure 5-3: Sidewalk Guy ............................................................. Error! Bookmark not defined.
Figure 5-4: Down Guy in Line with Dead-Ended Straight-Run Conductor .... Error! Bookmark not defined.
Figure 5-5: Railroad Crossing Storm Guys ...................................... Error! Bookmark not defined.
Figure 5-6: Transfer Pole Guyed with a Stub Guy ............................. Error! Bookmark not defined.
Figure 5-7: Advance Guy ............................................................. Error! Bookmark not defined.
Figure 5-8: Arm Guy ................................................................... Error! Bookmark not defined.
Figure 5-9: Guy Wire Secured to Pole .......................................... Error! Bookmark not defined.
Figure 5-10: Multiple Insulators in a Guy ................................. Error! Bookmark not defined.
Figure 5-11: Expansion Anchor .................................................... Error! Bookmark not defined.
Figure 5-12: Guy Wrap ............................................................... Error! Bookmark not defined.
Figure 5-13: Automatic Dead End ............................................... Error! Bookmark not defined.
Figure 5-14: Push Guy ............................................................... Error! Bookmark not defined.
Figure 6-1: Expansion Anchor Base ............................................. Error! Bookmark not defined.
Figure 6-2: Screw Anchor ............................................................ Error! Bookmark not defined.
Figure 6-3: Installing Screw Anchor with Truck Auger ................ Error! Bookmark not defined.
Figure 6-4: Banded Coil ............................................................ Error! Bookmark not defined.
Figure 6-5: Hoist Pulling Down Guy ............................................. Error! Bookmark not defined.
Figure 6-6: Down Guy with Guy Guard ........................................ Error! Bookmark not defined.
Segment 1: Principles of Pole Construction

The main function of a utility pole is to support conductors. Because conductors are heavy, they can pull on a pole with a great deal of force. The equipment on a pole that supports the conductors must be constructed to withstand this force. This training program describes methods of framing a pole, that is, installing crossarms and other conductor supports. Also described are methods of supporting a pole using several different types of guying techniques.

OBJECTIVES:
- Describe three basic types of pole construction.
- Describe general functions that are performed by poles and their components.
- Describe forces that conductors exert on poles.

1.1 Types of Pole Construction

Utility poles are constructed in various ways to support conductors and insulators. Three common types of pole construction are crossarm construction, armless construction, and vertical construction.

OSHA Regulations Snap-Shot

1910.269
Electric power generation, transmission, and distribution
(a) General.
(1) Application.
(i) This section covers the operation and maintenance of electric power generation, control, transformation, transmission, and distribution lines and equipment. These provisions apply to:
[A] Power generation, transmission, and distribution installations, including related equipment for the purpose of communication or metering, which are accessible only to qualified employees.

1926.950 subpart “V” (as of January 2007)
General requirements
(a) Application. The occupational safety and health standards contained in this Subpart V shall apply to the construction of electric transmission and distribution lines and equipment.
An example of crossarm construction is shown in Figure 1-1. In this example, crossarms support the insulators and conductors.

![Crossarm Construction](image)

*Figure 1-1: Crossarm Construction*

**OSHA Regulations Snap-Shot**

1910.269p (a) (2)

Training.

(i) Employees shall be trained in and familiar with the safety-related work practices, safety procedures, and other safety requirements in this section that pertain to their respective job assignments. Employees shall also be trained in and familiar with any other safety practices, including applicable emergency procedures (such as pole top and manhole rescue), that are not specifically addressed by this section but that are related to their work and are necessary for their safety.

(ii) Qualified employees shall also be trained and competent in:

(A) The skills and techniques necessary to distinguish exposed live parts from other parts of electric equipment,

(B) The skills and techniques necessary to determine the nominal voltage of exposed live parts,

(C) The minimum approach distances specified in this section corresponding to the voltages to which the qualified employee will be exposed, and

(D) The proper use of special precautionary techniques, personal protective equipment, insulating and shielding materials, and insulated tools for working on or near exposed energized parts of electric equipment. Note: For the purposes of this section, a person must have this training in order to be considered a qualified person.
Figure 1-2 shows an example of armless construction. Instead of crossarms, armless construction uses a variety of devices to support conductors. For example, fiberglass rods might be used, or insulators might be attached directly to the pole.

Figure 1-2: Armless Construction
Figure 1-3 shows an example of vertical construction. In this type of construction, insulators are attached directly to the pole in a vertical line, one above the other.

![Figure 1-3: Vertical Construction](image)

### 1.2 Functions of a Pole

A pole is built, or framed, in a certain way to perform specific functions. These functions are as follows:

- Supporting the weight of conductors and resisting their pulling force
- Maintaining the proper spacing between conductors to provide the right amount of electrical clearance
- Maintaining enough working clearance to enable a lineman to work safely
- Allowing enough room for other equipment, such as transformers, telephone lines, and cable TV lines
- Maintaining adequate clearance between conductors and trees, buildings, and/or street lights
1.3 Effects of Conductor Forces on Pole Construction

When a pole is framed, the components to which the conductors are attached must be carefully selected and put together so that they can withstand the strong forces that the conductors can exert. Conductors exert two different kinds of forces: (1) the weight of the conductor wire and (2) the strain, or pull, on the conductor that keeps them elevated and provides clearance below.

The force that is created by the weight of the conductor wire is directed straight down on the pole. The direction of this force may be balanced or unbalanced as in Figure 1-4.

Figure 1-4: Wires All on One Side of the Structure
The force that is created by the strain on the conductor wire acts in the direction of the wire. This direction is indicated by the arrows in Figure 1-5.

Figure 1-5: Direction of Force Due to Strain on Conductor Wire

The forces that conductors exert on poles vary, depending on several factors. These factors include the angle that the conductors make with the pole, the length of the conductors, and the weight of the conductors.
The least amount of force is placed on the pole and its components when the conductors are in a straight line, as shown in Figure 1-6. When the conductors are in a straight line, the only force is the weight of the conductor, because the strains from the wires stretching off in either direction cancel each other out. In this example, the insulators, their pins, and the structure are strong enough to withstand the weight of the conductors resting on them. 

Figure 1-6: Conductors on Straight Line Poles
Other conductor arrangements can put much more strain on a pole. For example, conductors that are not in line with the rest of the line will be attached at an angle, causing a strain on the pole in addition to the weight of the conductors. If there is only a slight deviation from a straight line, as shown in Figure 1-7, the side strain, or lateral strain, caused by the conductors is relatively small. In such cases, the pole and its components are strong enough to resist the strain. However, as the conductor angle is increased, the lateral strain also increases. Even a moderate bend in the conductors can create enough lateral strain to eventually pull a pole over.

Figure 1-7: Conductors Leading from Pole at an Angle
When lateral strain requires additional support, guy wires are generally used. The guy wire shown in Figure 1-8 is used to resist the lateral strain from angled conductors, and thus prevent the pole from falling over.

**Figure 1-8: Guy Wire Resisting Lateral Strain from Conductors**

Angled conductors are not the only source of unequal strains on a pole. Conductor spans of different lengths can also cause an unbalanced pull on one side of a pole. Guy wires are commonly used to offset the strain of the long span, with an in-line guy supporting the added weight of the long span.
Section Quiz

1-1. What is the main function of a utility pole?

_______________________________________________________________

1-2. ______________________ pole construction may use devices such as fiberglass rods instead
crossarms to support conductors.

1-3. True or False. Poles must be built, or framed, to maintain the proper electrical clearance
between conductors.

1-4. List two types of conductor forces.
   a) _________________________________
   b) _________________________________

1-5. True or False. Angles made between a conductor and a pole place a lateral strain on the pole.
Segment 2: Construction Types

OBJECTIVE:
- Describe how the three basic pole construction types can be modified to meet different needs.

2.1 Crossarm Construction

Figure 2-1 shows an example of a wooden crossarm. Most wooden crossarms are approximately 4 inches thick and 8 to 10 feet long. Holes are usually predrilled through crossarms to hold insulator pins. The insulator pin, or mounting bolt, fits through the hole and is secured with a nut on the other end.

Figure 2-1: Wooden Crossarm
A ‘through’ bolt generally attaches a crossarm to a pole, and braces are used to keep the arm straight. Crossarm braces may be a pair of flat metal pieces of steel (Figure 2-2) or a single V-shaped piece of angle steel.

Figure 2-2: Steel Braces
Wooden braces (Figure 2-3) are sometimes used instead of metal for medium to higher voltages to minimize current leakage, or tracking.

Figure 2-3: Wooden Braces
If the weight of conductors is too much for a single crossarm, a double wooden crossarm may be used. A double crossarm (Figure 2-4) requires some modifications of the basic crossarm construction. The modifications may include an additional set of insulators and extra bolts. The additional insulators help to reduce the strain on each conductor by distributing its weight over two points instead of one. They also keep the conductors away from the second crossarm. The extra bolts are needed to attach the crossarms to each other. They hold the crossarms securely at a distance from each other that is equal to the thickness of the pole.

*Figure 2-4: Double Wooden Crossarm*
Modifications may also be needed to handle additional strain forces from conductors. For example, one way to handle a small lateral strain is to tie the conductor on the side of the insulator. Tying the conductor in this way puts the lateral strain on the insulator instead of on the tie wire. This technique should only be used if the downward strain is not strong enough to pull the conductor down. Special insulator pins that tilt against the strain (Figure 2-5) may also be used to resist lateral strain.

![Figure 2-5: Conductors Tied to Sides of Insulators](image-url)
Another technique for resisting the strain of conductors is to use post insulators. Post insulators (Figure 2-6) are thicker and stronger at the base than pin insulators, and they are often used to support heavy conductors. The base of the post insulator sits directly on a crossarm, so it is braced against a pull to the side.

![Figure 2-6: Post Insulators](image-url)
Modifications to the basic crossarm construction are also needed at dead-ends, where conductor strain is greatest. Sometimes, the additional strain can be handled by doubling, tripling, or quadrupling the crossarms, or by using thicker crossarms. Another option is stacking double crossarms one above the other instead of side by side. Since conductors at dead-ends put the maximum strain on insulators, suspension insulators (Figure 2-7) are used instead of pin or post insulators.

Figure 2-7: Suspension Insulators
Crossarm construction may also have to be modified to provide the clearance required to keep the conductors away from nearby objects. For example, if a pole near a building or tree does not have enough room for a conventional crossarm, a side arm, or alley arm (Figure 2-8), may be used to provide the clearance. Alley arms can also be used to hold conductors off to the side of a pole to keep the conductors closer to a straight run if, for example, one pole is out of line with the rest of the poles in the line.

*Figure 2-8: Side Arm, or Alley Arm*
2.2 Armless Construction

Armless construction is generally chosen because it requires very little maintenance. The fiberglass rods or other insulator supports cannot rot or split the way wood can. The center phase on the armless construction shown in Figure 2-9 is placed next to another phase on a lateral rod.

Figure 2-9: Armless Construction: Center Phase Next to Another Phase on the Lateral Rod
In Figure 2-10, the center phase is extended directly up from the top of the pole.

![Figure 2-10: Armless Construction: Center Phase Extended Up from Top of Pole](image)

Another type of armless construction support is a heavy fiberglass bracket that is sometimes called a chicken wing because of its wing-like shape. The bracket base is through-bolted to the pole at the top and at the bottom.
Armless construction does not have to have a supporting structure for the insulators. Insulators are sometimes bolted directly to the pole (Figure 2-11).

As with crossarm construction, the components used in armless construction can be modified to handle additional strain or weight from the conductors. For example, they can be doubled, or they can be made stronger and heavier.
2.3 *Vertical Construction*

The insulators used in vertical construction are often the horizontal post type (Figure 2-12). The base of this type of insulator is usually through-bolted to the pole at the top and the bottom. Horizontal post insulators used with higher voltages often have a clamp end. The clamp is tightened around a conductor to hold it firmly in place.

*Figure 2-12: Horizontal Post Insulators*
Post insulators are typically used with vertical construction as long as the conductor angle is not extreme. Sharper angles usually require a suspension insulator to handle the additional lateral pull. The configuration shown in Figure 2-13 is known as a running corner. The main difference between this kind of suspension insulator and those used on dead-ends is that the running corner conductor attachment holds the conductors in a gentle curve to spread the weight out over a larger area, and thus keep the wires from flattening out. Dead-end suspension insulators are attached to the conductor attachments.

*Figure 2-13: Two Phases of a Running Corner*
In some situations, a dead-ended vertical pole may have to be framed differently. For example to prevent unsupported jumpers from swinging against the pole under certain conditions, additional insulators can be added to hold each jumper away from the pole (Figure 2-14).

Figure 2-14: Insulators Holding Jumper Away from Pole
Section Quiz

2-1. **True or False.** If the weight of conductors is too much for a single crossarm, a double crossarm may be used.

2-2. One way to handle a small lateral strain is to tie the conductor to the side of the __________________.

(insulator, crossarm)

2-3. **Circle the correct answer.**

___________________ insulators are used at dead-ends to withstand greater strains.

a) Pin  
b) Post  
c) Suspension  
d) None of the above

2-4. **True or False.** Armless construction components cannot be modified to handle additional strain.

2-5. A running corner can be used in vertical construction to handle additional __________________ pull.

(vertial, lateral)