This course covers the hazards and protective measures related to OSHA's "Focus Four" hazards: falls, caught-in or -between, struck-by, and electrocution.
OSHAcademy Course 812 Study Guide

OSHA Focus Four Hazards

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Contact OSHAcademy to arrange for use as a training document.

This study guide is designed to be reviewed off-line as a tool for preparation to successfully complete OSHAcademy Course 812.

Read each module, answer the quiz questions, and submit the quiz questions online through the course webpage. You can print the post-quiz response screen which will contain the correct answers to the questions.

The final exam will consist of questions developed from the course content and module quizzes.

We hope you enjoy the course and if you have any questions, feel free to email or call:

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# Contents

Course Introduction .................................................................................................................. 1

Module 1: Fall Hazards and Protective Measures ......................................................................... 2
  Definition .................................................................................................................................. 2
  Examples .................................................................................................................................... 2
  Edges and Openings .................................................................................................................. 3
  Steel Erection .......................................................................................................................... 3
  Improper Scaffold Construction ................................................................................................. 5
  Unsafe Portable Ladders .............................................................................................................. 7
  Protective Measures .................................................................................................................. 9
    Use Fall Protection Equipment ............................................................................................... 9
    Safe Ladder Use .................................................................................................................... 10
    Choose the Right Ladder for the Job ..................................................................................... 11
  Secure the Ladder ...................................................................................................................... 12
    Carrying Tools While Climbing the Ladder .......................................................................... 12
  Three-Point-Contact ................................................................................................................ 13
  Three-Point-Control .................................................................................................................. 13
  Ladder Angle ............................................................................................................................ 14

Module 2: Fall Hazards Protective Measures ............................................................................. 16
  Basic Scaffold Safety ................................................................................................................ 16
  Fall Protection for Workers ...................................................................................................... 18
  Employer Requirements ............................................................................................................ 19
    Provide Fall Protection ........................................................................................................ 19
  Fall Protection Training ............................................................................................................ 21
Proper Scaffold Construction ........................................................................................................ 22
Ladder Use and Condition ........................................................................................................... 22
Worksite Maintenance .................................................................................................................. 23
Module 3: Caught-In or -Between Hazards .................................................................................. 24
Common Types of Caught-In or-Between Hazards in Construction ........................................... 24
Examples of Caught-in or Caught-Between Hazards ................................................................. 25
Machinery with Unguarded Moving Parts .................................................................................... 27
Buried-in or -by ............................................................................................................................. 30
Pinned Between ............................................................................................................................. 31
Module 4: Caught-In -Or Between Hazards Protective Measures .................................................. 34
Clothing and Jewelry ..................................................................................................................... 34
Machine Guarding ......................................................................................................................... 34
Other Methods to Secure Machinery .............................................................................................. 35
Crushed-by Heavy Equipment ....................................................................................................... 36
Crushed-by Collapsing Walls ......................................................................................................... 36
Pinned Between Equipment, Materials, or other Objects .............................................................. 37
Excavation Sites ............................................................................................................................ 38
Buried-by Structures ...................................................................................................................... 39
Designate a Competent Person ...................................................................................................... 39
Training ......................................................................................................................................... 40
Module 5: Struck-By Hazards ........................................................................................................ 42
Definition ....................................................................................................................................... 42
Examples ........................................................................................................................................ 43
Struck by Flying Objects ................................................................................................................ 44
Course 812

Struck by Falling Objects ................................................................. 47
Struck by Swinging Objects .............................................................. 50
Struck by Rolling Object ................................................................. 52
Module 6: Struck-By Hazard Protective Measures .................................. 56
  Heavy Equipment ........................................................................... 56
  Cranes, Excavators, and More ......................................................... 57
  Motor Vehicles – Trucks, Cars, and More ......................................... 58
  General Safe Work Practices ......................................................... 60
  Personal Protective Equipment (PPE) .............................................. 63
  Training ......................................................................................... 64
Module 7: Electrocution Hazards ........................................................... 66
  Contact with Power Lines ............................................................. 68
  Contact with Energized Sources ..................................................... 69
  Examples ....................................................................................... 71
  Improper Use of Extension and Flexible Cords ................................ 73
Module 8: Electrocution Hazards Protective Measures .............................. 75
  Maintain Safe Distance from Overhead Power Lines ....................... 75
  Cranes and Other High-Reaching Equipment .................................. 76
  Mobile Heavy Equipment .............................................................. 76
  Ladders ......................................................................................... 76
  Material Storage ............................................................................. 76
  Excavations .................................................................................. 76
  Employer Responsibilities ............................................................. 77
  Use Ground-Fault Circuit Interrupters (GFCI) ............................... 78
<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>A Classic Example of the GFCI at Work</td>
<td>78</td>
</tr>
<tr>
<td>Types of GFCIs</td>
<td>78</td>
</tr>
<tr>
<td>What Must Your Employer do to Protect You?</td>
<td>80</td>
</tr>
<tr>
<td>Assured Equipment Grounding Conductor Program (AEGCP)</td>
<td>80</td>
</tr>
<tr>
<td>Inspect Portable Tools and Extension Cords</td>
<td>81</td>
</tr>
<tr>
<td>Wire Size and Ampacity</td>
<td>81</td>
</tr>
<tr>
<td>Use Power Tools and Equipment as Designed</td>
<td>83</td>
</tr>
<tr>
<td>Common Examples of Misused Equipment</td>
<td>83</td>
</tr>
<tr>
<td>Follow Lockout/Tagout Procedures</td>
<td>84</td>
</tr>
<tr>
<td>Protecting Workers</td>
<td>85</td>
</tr>
<tr>
<td>Isolate Electrical Parts</td>
<td>85</td>
</tr>
<tr>
<td>Ensure Proper Guarding</td>
<td>86</td>
</tr>
<tr>
<td>Train Employees</td>
<td>86</td>
</tr>
<tr>
<td>Additional Resources</td>
<td>87</td>
</tr>
</tbody>
</table>
Course Introduction

Construction safety is one of OSHA's top concerns. Construction is among the most dangerous industries in the country and construction inspections comprise 60% of OSHA's total inspections.

The Bureau of Labor Statistics indicates that each year there are more fatalities in the construction industry than in any other single industry sector: nearly one out of every five work-related deaths in the U.S.

Private industry construction workers have a fatal occupational injury rate nearly three times that of all workers in the United States.

The course describes basic hazards associated with falls; being caught in or between objects; being struck by objects; and electrocution. It also discusses the protective measures workers can take to prevent fatalities, injuries, and illnesses from exposure to these hazards.
Module 1: Fall Hazards and Protective Measures

Definition

Fall hazards are present at most worksites, and many workers are exposed to these hazards on a daily basis. A fall hazard is anything at your worksite that could cause you to lose your balance or lose bodily support and result in a fall. Any walking or working surface can be a potential fall hazard.

Any time you are working at a height of four feet or more, you are at risk. OSHA generally requires fall protection be provided at four feet in general industry, five feet in maritime and six feet in construction. However, regardless of the fall distance, fall protection must be provided when working over dangerous equipment and machinery. The importance of fall protection cannot be stressed enough.

Falls from heights are the leading cause of fatalities in construction, while falls on the same level (slips and trips) are one of the leading causes of injuries.

Some of the working conditions that contribute to fall hazards include: unprotected edges of elevated work surfaces, including roofs, scaffolds, and ladders, unprotected roof edges, roof/floor openings, and structural steel & leading edges.

Examples

Fall hazard incidents are injuries produced by impact between the injured person and the source of injury when the motion producing contact was generated by gravity.

Fall hazards in construction cause accidents such as the following:

1. A makeshift scaffold collapsed under the weight of four workers and their equipment, seriously injuring all four.

2. A worker carrying a sheet of plywood on a flat roof stepped into a skylight opening and fell to the level below.

3. A roofer, while attempting to remove a roof opening cover, fell approximately 21 feet to the concrete floor below and was killed.
Quiz Instructions

After each section, there is a quiz question. Make sure to read the material in each section to discover the correct answer to these questions. Circle the correct answer. When you are finished go online to take the final exam. This exam is open book, so you can use this study guide.

1. OSHA generally requires fall protection be provided at _____ in construction.
   a. 4 feet
   b. 5 feet
   c. 6 feet
   d. 7 feet

Edges and Openings

One of the most frequently cited serious OSHA violations involving roofing and fall protection is unprotected sides and edges. Almost all sites have unprotected sides and edges, wall openings, or floor holes at some point during construction. If these sides and openings are not protected at your site, injuries from falls or falling objects may result, ranging from sprains and concussions to death.

Fatalities from falls is, by far, the most common "Fatal Four" cause of death on construction sites.

- Improperly covered or protected floor holes and openings are a common fall hazard. It's easy to step into a hole or opening when carrying something that blocks one's forward view.

- Roofing falls are the leading cause of roofing injuries and fatalities. Roofing, siding and sheet metal work have the highest rate of occupational injuries and illnesses for a non-manufacturing industry.

Steel Erection

Workers involved in steel erection are exposed to fall hazards. According to The Construction Chart Book (CPWR, December, 2007), more ironworkers are killed from falls than workers in any other construction occupation. The rate of work-related deaths among ironworkers is 10 times higher than the construction average. The most frequently cited serious OSHA violations
involving steel erection are fall protection, fall hazard training and fall protection for connectors.

In steel erection, workers on walking/working surfaces with unprotected sides or edges above 15 feet must be protected (There are some exceptions for connectors and workers working in controlled decking zones for heights between 15 and 30 feet.

**Practice Identifying Hazards**

Try to identify the hazards present in the picture below. Then continue to the next page to see if you correctly identified the hazards.
2. Which of the following is, by far, the most common "Fatal Four" cause of fatalities on construction sites?

   a. Fall accidents  
   b. Struck-by accidents  
   c. Caught-in accidents  
   d. Electrocutions

**Improper Scaffold Construction**

Working with heavy equipment and building materials on the limited space of a scaffold is difficult. Without fall protection or safe access, it becomes hazardous. Falls from improperly constructed scaffolds can result in injuries ranging from sprains to death. Guardrails or personal fall arrest systems for fall prevention/protection are required for workers on platforms **10 feet** or higher.

The majority of the workers injured in scaffold accidents attribute the accident to factors like the planking or support giving way, or to lack of guardrails or other fall protection. OSHA’s most frequently cited serious scaffold violations include lack of fall protection; scaffold access; use of aerial lifts without body belts and lanyards, platform construction and no worker training.
Practice Identifying Hazards

Try to identify the hazards present in the picture below. Then continue to the next page to see if you correctly identified the hazards.
3. Guardrails or personal fall arrest systems for fall prevention/protection are required for workers on platforms _____.
   a. above 4 feet
   b. at least 8 feet high
   c. 10 feet or higher
   d. over 20 feet high

Unsafe Portable Ladders

If a portable ladder is not safely positioned each time you use it, you could fall from the ladder. While you are on a ladder, it may move and slip from its supports. You can also lose your balance while getting on or off an unsteady ladder. Falls from ladders can cause injuries, ranging from sprains to death.

BLS data show that falls from ladders account for more than 100 fatalities each year. Factors that contribute to falls from ladders are ladder slip (top or bottom), overreaching, ladder placement, slipping on rungs/steps, defective equipment, and improper ladder selection for a given task. Frequently cited OSHA ladder violations include:

- not having a portable ladder extend 3 feet above the landing,
• no worker training, and

• improper use of the top of stepladders.

Practice Identifying Hazards

Try to identify the hazards present in the picture below. Then continue to the next page to see if you correctly identified the hazards.
4. All of the following factors contribute to over 100 fatalities a year due to falls from ladders, EXCEPT _____.

   a. defective ladders
   b. ladder slips
   c. ladder material
   d. improper selection

Protective Measures

Use Fall Protection Equipment

The three generally acceptable methods of protection for workers on a construction site who are exposed to vertical drops of 6 feet or more are guardrails, safety net systems, and personal fall arrest systems.

- Guardrails are considered prevention systems, as they stop you from having a fall in the first place.
• Safety net systems are designed to catch you and break your fall. They must be placed as close as practicable beneath your working surface, but never more than 30 feet below.

• A personal fall arrest system consists of an anchorage, connectors, and a full-body harness that work together to break your fall.

When working next to a fall prevention barrier from an elevated position, such as a step ladder next to a guardrail, the guardrail no longer serves as a fall protection device. Additional protection is needed.

In general, it is better to use fall prevention systems, such as guardrails, than fall protection systems, such as safety nets/fall arrest devices. That’s because prevention systems prevent falls from occurring in the first place.

Scaffold work requires guardrails or a personal fall arrest system on any platform 10 feet or higher. Also, do not climb cross-bracing as a means of access; your employer must provide safe access. Ensure your fall protection equipment is right for the work you are doing, in good condition, and used properly. Remember, your employer needs to provide you with protection to prevent falls at your worksite. Please take a moment to refer to Appendix A to review information regarding, "Guardrail and Safety Net Systems", and "Personal Fall Arrest Systems".

The anchorage for a worker’s personal fall arrest equipment must be independent of any anchorage used to support or suspend platforms. It must be able to support at least 5,000 lbs. per worker attached to it.

5. Which of the following would be the preferred method to protect workers from falls?
   a. Safety belts
   b. Guardrails
   c. Safety nets
   d. Fall arrest devices

Safe Ladder Use

There are many ways you can prevent a fall from a ladder—below are a few suggestions to get you started.
Choose the Right Ladder for the Job

First, you need to make sure a ladder is the best equipment for what you need to do. Would scaffolding or a mechanical lift be better?

Many times, the ladder is the only physical support you have while you are working. If it fails, you can fall. That's why it is so important to find the right ladder when you do need to use one. The three main types of ladders—step ladders, straight ladders, and extension ladders—are used in different situations for different tasks.

Is the ladder long enough? It should be long enough to set it at a stable angle and still extend over the top edge to give you something to hold on to when you get on the ladder to descend. Setting the ladder at the right angle helps you keep your balance on the ladder. It also helps keep the ladder from falling backward.

- Make sure the ladder extends 3 feet (3 rungs; 0.9 meters) above the surface you will be working on.
- Make sure the ladder is placed at a stable angle. For every four feet (1.2m) high the ladder is, the base should be 1 foot (.3 m) out from the wall.

For example, if you will be working on a 10 foot-high roof (3 m), you need a ladder that is at least 14 feet (4.25 m) long. The base should be 2 ½ feet (.75 m) from the wall.

Is the ladder in good working condition? It shouldn't be missing pieces or be cracked or otherwise damaged. Check the duty rating on extension ladders – is it high enough for the weight you will be putting on it? Longer ladders don't always have higher duty ratings, so be sure to check. In construction, the most common ratings are:

- Heavy Duty (I) supports up to 250 pounds (113 kg)
- Extra heavy duty (IA) supports up to 300 pounds (136 kg)
- Special duty (IAA) supports up to 375 pounds (170 kg)
6. How far should the ladder extend above the surface you will be working on?

- a. At least one foot
- b. Two feet or more
- c. Three feet
- d. One to four feet

Secure the Ladder

It is necessary to tie the top and bottom of a ladder to fixed points when:

- the ladder doesn’t extend 3’ above the landing,
- it is contacting slippery surfaces; or
- where it could be displaced by work activities or traffic.

Tie both sides of the top of the ladder to a fixed point on the roof or another high surface near where you are working. The bottom should be tied to a fixed point on the ground. Securing the ladder in this way prevents the ladder from sliding side-to-side or falling backward and prevents the base from sliding.

Tying the ladder off at the beginning of the day and untying it at the end of the day will only take you about five minutes. It can make all the difference for your safety. If you need to move the ladder around, allow extra time for this important step or consider using something else, such as a scaffold.

Carrying Tools While Climbing the Ladder

Take precautions when you are going up or down a ladder. Instead of carrying tools, boards, or other materials in your hands, use a tool belt, install a rope and pulley system, or tie a rope around your materials and pull them up once you have reached the work surface. Ask for help if you need to use more than one hand to pull them up.

Carrying tools or anything else in your hands as you climb the ladder can throw you off balance. When you climb a ladder, always use at least one hand to grasp the ladder when going up or down.
7. In which of the following situations must a fixed ladder be secured at the top and bottom?

a. The ladder extends more than three feet above the landing
b. The ladder is an extension type
c. The ladder is made of wood
d. The ladder is contacting slippery surfaces

Three-Point-Contact

This method is not the preferred method for climbing ladders. The three-point-contact method requires a worker to depend solely on three points of contact with the ladder. The stomach or palm are examples of unstable points of contact; these points of contact are unreliable and lead to a false sense of stability.

Though some argue leaning against a surface is acceptable as a point of contact, there is a significant problem with this assumption. For example, if a worker has both feet on a ladder while resting one palm on the roof (three-point contact) they will not be able to prevent a fall if both feet were to slip.

Three-Point-Control

On the other hand, the three-point-control method requires a worker to use three of his or her four limbs for reliable, stable support. This climbing strategy could prevent many of the ladder falls and deaths occurring throughout the United States and world. The three-point-control method requires the worker to place his hand on the ladder in a way to support the full weight of the body if needed in an emergency. The breakaway force from a vertical rail is too great for a worker, male or female, to fully support their weight if only gripping with one hand. During a fall, the hand would slide down the bar until it contacts a rung on the ladder. The hand would most likely disconnect from the ladder when it collides with the rung. A vertical grip can only support approximately 50 percent of person’s bodyweight.

Because the three-point contact method does not require reliable, stable support, it is not the preferred method to use when on a ladder.

If a worker is using the three-point-control method and has both feet on the ladder and is gripping a horizontal rung, they are much less likely to fall if both of their feet were to slip. When a worker uses a horizontal grip, it allows for about a 75 percent to 94 percent increase in
breakaway force. This compares to using a vertical grip, which allows the worker to hold their bodyweight and prevent a fall.

Keeping three-point-control for good support is critical while a worker is climbing, moving or working at an elevation. It is important to note, the three-point-control method is not a substitution for the use of fall protection equipment.

8. Which climbing strategy requires three of a worker's limbs for reliable, stable support when climbing a ladder?
   a. Three-Point-Break
   b. Three-Point-Contact
   c. Three-Point-Control
   d. Three-Point-Limb

Ladder Angle

A non-self-supporting ladder should have a set-up angle of about 75 degrees — a 4:1 ratio of the ladder’s working length to set-back distance.

Here’s how to do it:

- Stand at the base of the ladder with your toes touching the rails.
- Extend your arms straight out in front of you.
- If the tips of your finger just touch the rung nearest your shoulder level, the angle of your ladder has a 4:1 ratio.

The National Institute for Occupational Safety and Health (NIOSH) has developed an easy-to-use interactive ladder safety application for smartphones. The NIOSH Ladder Safety application features a multimodal indicator, which uses visual and sound signals to assist the user in positioning an extension ladder at an optimal angle.

The application provides graphic-oriented interactive reference materials, safety guidelines and checklists for extension ladder selection, inspection, accessorizing, and use. It is intended to help a wide range of ladder users, employers, and safety professionals, with their ladder-related safety needs.

Here is a link to download the phone application:
9. If a ladder working length is 12 feet, what should the ladders set back distance be?
   a. 2 feet
   b. 3 feet
   c. 4 feet
   d. 5 feet
Module 2: Fall Hazards Protective Measures

Basic Scaffold Safety

According to the BLS there are thousands of scaffold-related injuries – and about 40 scaffold-related deaths – every year in the U.S. If you are doing work on scaffolds, know how to work on them safely – it could save your life!

1. Training: Each employee who performs work while on a scaffold must be trained by a competent person qualified in the subject matter to recognize the hazards associated with the type of scaffold being used and to understand the procedures to control or minimize those hazards. The training shall include the following areas, as applicable:

   o The nature of any electrical hazards, fall hazards and falling object hazards in the work area;

   o The correct procedures for dealing with electrical hazards and for erecting, maintaining, and disassembling the fall protection systems and falling object protection systems being used;

   o The proper use of the scaffold, and the proper handling of materials on the scaffold;

   o The maximum intended load and the load-carrying capacities of the scaffolds used; and

   o Any other pertinent requirements of 1926.454, Training Requirements.

2. Supported Scaffolds: Every supported scaffold and its components must support, without failure, its weight and at least four times the intended load. The intended load is the sum of the weights of all personnel, tools and materials that will be placed on the scaffold. Don’t load the scaffold with more weight than it can safely handle. The working platforms/decks must be planked close to the guardrails. Planks are to be overlapped on a support at least six inches, but not more than 12 inches. Inspections must include:

   o Checking metal components for bends, cracks, holes, rust, welding splatter, pits, broken welds and non-compatible parts.

   o Covering and securing floor openings and labeling floor opening covers.
1. Which of the following is TRUE regarding supported scaffolds?
   a. Planks must be at least 12 inches from toeboards
   b. Intended load includes personnel only
   c. Planks must overlap between six inches and 12 inches
   d. The scaffold must support two times the intended load

3. **Suspended Scaffolds**: Each rope on a suspended scaffold must support the scaffold’s weight and at least six times the intended load. The following is also required:
   o Platforms must be at least 18 inches wide, (there are some exceptions), and guardrails and/or personal fall arrest systems must be used for fall protection any time you are working 10 feet or more above ground level.
   o Guardrails must be between 39 and 45 inches high, and midrails must be installed approximately halfway between the toprail and the platform surface.
   o Counterweights for suspended scaffolds must be able to resist at least four times the tipping moment (calculated by a qualified person). They must also be made of materials that cannot be easily dislocated (no sand, no water, no rolls of roofing, etc.).

4. **Fall Protection**. Fall protection is required when working on a scaffold 10 or more feet above the ground. OSHA requires the following:
   o The use of a guardrail OR a personal fall arrest system when working on a supported scaffold.
   o Both a guardrail and a personal fall arrest system when working on a single-point or two-point suspended scaffold.
   o A personal fall arrest system when working on an aerial lift.

5. **Lifelines**: The lifeline must be tied back to a structural anchorage capable of withstanding 5,000 lbs of dead weight per person tied off to it. Attaching your lifeline to a guardrail, a standpipe or other piping systems will not meet the 5,000 lbs. requirement and is not a safe move.
6. **Protection from falling objects:** Toe boards, screens, and debris nets must be in place to protect other people from falling objects.

7. **Climbing on cross braces** is not allowed! Ladders, stair towers, ramps, and walkways are some of the ways of providing safe access.

**SOURCE:** Adapted from Construction Safety & Health Fall Hazards, Central New York COSH, 2007, OSHA grant product.

| 2. Lifelines must be able to support _____.
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<td>a. the intended load plus 5,000 lbs.</td>
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<tr>
<td>b. 5,000 lbs. of dead weight per person tied to it</td>
</tr>
<tr>
<td>c. a total of 5,000 lbs. plus materials</td>
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<td>d. five times the intended load plus materials</td>
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</tbody>
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**Fall Protection for Workers**

Employees who are exposed to falls and required to use fall protection should:

1. Be familiar with and understand the company's written fall protection plan.

2. Attend and participate in all mandatory fall prevention training. Never use fall protection without first being fully trained including practice.

3. Use fall protection equipment if required for the job. Be sure the equipment is right for the task, fits properly and is in good condition.

4. Inspect fall protection equipment and devices before and after each use.

5. Make sure sturdy guardrails or covers protect floor holes, open shafts and riser penetrations.

6. Get specialized training before working on scaffolds, lifts or ladders.

7. When using scaffolds, make sure there is proper access, full planking, stable footing and guard railing.

8. Keep your feet firmly on the platform of a boom lift and tie-off at all times.
9. Choose the correct ladder for the task, read the instructions and be sure the ladder is in good condition. Check for surrounding hazards, stable footing and the proper angle.

10. Identify skylights and make sure they are properly protected with covers or guardrails.

11. Contact your supervisor if you see fall hazards or have any questions about fall prevention. Do not work until unsafe conditions have been corrected.

3. Each of the following are important guidelines to help prevent falls on construction sites, EXCEPT _____.
   a. make sure training includes an opportunity to practice
   b. be familiar with the fall prevention plan
   c. inspect fall protection equipment before and after use
   d. carefully climb cross members on scaffolds

Employer Requirements

Provide Fall Protection

OSHA’s fall protection standards require employers to provide fall protection for you when you are exposed to a fall hazard. The standards set the criteria and practices for fall protection systems and required training. The standards cover hazard assessment, fall protection and safety monitoring systems. The standards also address controlled access zones, safety nets, and guardrail, personal fall arrest, warning line and positioning device systems.

OSHA requires employers provide for "prompt rescue of employees in the event of a fall or shall assure that employees are able to rescue themselves.

Your employer is required to assess the workplace to determine if the walking/working surfaces on which you are to work have the strength and structural integrity to safely support workers.

The employer must not permit you to work on those surfaces until it has been determined that the surfaces have the strength and structural integrity to support all workers.

Once your employer has determined that the surface is safe for workers, they must select one of the permitted types of fall protection for the work operation if a fall hazard is present.
For example, if you are exposed to falling six feet or more over an unprotected side or edge, your employer must select a guardrail system, safety net system, or personal fall arrest system to protect you. There are similar requirements for other fall hazards.

If personal fall protection systems are used, your employer must pay particular attention to identifying attachment points and to ensuring workers know how to properly don and inspect the equipment.

4. If you are exposed to falling _____ over an unprotected side or edge, your employer must select a guardrail system, safety net system, or personal fall arrest system to protect you.
   
   a. four feet or greater  
   b. at least five feet  
   c. six feet or more  
   d. over ten feet

The following are some things your employer should do to prevent fall hazards at your worksite:

1. Develop a written fall protection plan.

2. Identify potential fall hazards prior to each project and during daily walk-around inspections. Pay attention to hazards associated with routine and non-routine tasks.

3. Pay attention to hazards associated with routine and non-routine tasks.

4. Ensure fall protection equipment is appropriate to the task, in good condition and used properly.

5. Conduct general fall prevention training on a regular basis.

6. Train workers about the specific fall hazards identified and the required personal protective equipment.

7. Conduct regular inspections of fall protection equipment in accordance with the manufacturer’s recommendations and OSHA’s requirements.
8. Emphasize fall hazards unique to the site, such as open floor holes or shafts, riser penetrations and skylights.

5. Which of the following is important for the employer to do to prevent fall hazards at your worksite?
   
   a. Pay attention to routine and non-routine tasks
   b. Emphasize generic hazards common to all worksites
   c. Focus on annual fall protection training
   d. Consider fall arrest devices as your primary fall protection strategy

Fall Protection Training

The employer must assure that each employee has been trained, as necessary, by a competent person qualified in the following areas:

- The nature of fall hazards in the work area;

- The correct procedures for erecting, maintaining, disassembling, and inspecting the fall protection systems;

- The use and operation of guardrail systems, personal fall arrest systems, safety net systems, warning line systems, safety monitoring systems, controlled access zones, and other protection to be used;

- The role of each employee in the safety monitoring system when this system is used;

- The limitations on the use of mechanical equipment during the performance of roofing work on low-sloped roofs;

- The correct procedures for the handling and storage of equipment and materials and the erection of overhead protection; and

- The role of employees in fall protection plans; and

- The standards contained in the employer's and OSHA's applicable fall protection standards.
6. Who must conduct fall protection training for the employer?
   a. Certified professional
   b. Experienced worker
   c. Designated person
   d. Competent person

**Proper Scaffold Construction**

The employer must ensure that a competent person is available to direct workers who are constructing, moving, changing, or dismantling scaffolds. The competent person must:

- train workers on how to construct, move, change and dismantle scaffolds,
- inspect the scaffold and its components before every work shift, and after any event that could affect the structural integrity of the scaffold.
- be able to identify unsafe conditions, and
- be authorized by the employer to take action to correct unsafe conditions, to make the workplace safe.

A **competent person** is capable of identifying existing and predictable hazards in the surroundings or working conditions which are unsanitary, hazardous, or dangerous to workers, and who has authorization to take prompt corrective measures to eliminate them. A **qualified person** is someone who has very specific knowledge or training, and is responsible for scaffold design and its rigging.

The employer must provide safe access to the scaffold when a platform is more than two (2) feet above or below the point of access, or when you need to step across more than 14 inches to get on the platform.

A guardrail system or a personal fall arrest system is required for scaffolds more than **10 feet** above a lower level. In addition, employers must provide safe access to scaffold platforms.

**Ladder Use and Condition**

Your employer is required to provide suitable ladders where necessary and maintain the ladders in proper condition. They must also train workers to recognize ladder and stairway hazards. They must ensure all defective ladders are tagged and placed out of service.
Worksite Maintenance

The employer must ensure the construction site is free of clutter and tripping hazards, and site equipment and machinery is in good working order.

Poor worksite maintenance can lead to clutter and debris on a construction site, creating additional slip, trip and fall hazards. Poor maintenance of ladders, scaffolds, and fall protection equipment can also lead to serious injuries. Your employer is required to keep worksites free from form and scrap lumber with protruding nails and other waste and trash, including combustible debris.

7. What is required if a defective ladder is found on the construction site?

   a. Use duct tape to fix the ladder and continue using
   b. Tag the ladder and remove it from service
   c. Place to the side as a spare ladder
   d. Warn users with a "Caution - Ladder defective" sign
Module 3: Caught-In or -Between Hazards

According to OSHA, caught-in or -between hazards are defined as: Injuries resulting from a person being squeezed, caught, crushed, pinched, or compressed between two or more objects, or between parts of an object. This includes individuals who get caught or crushed in operating equipment, between other mashing objects, between a moving and stationary object, or between two or more moving objects.

The key factor in making a determination between a Caught event and a Struck event is whether the impact of the object alone caused the injury. When the impact alone creates the injury, the event should be recorded as Struck. When the injury is created more as a result of crushing injuries between objects, the event should be recorded as Caught.

Events that should be classified as Caught include:

- cave-ins (trenching);
- being pulled into or caught in machinery and equipment (this includes strangulation as the result of clothing caught in running machinery and equipment); and
- being compressed or crushed between rolling, sliding, or shifting objects such as semitrailers and a dock wall, or between a truck frame and a hydraulic bed that is lowering.

Common Types of Caught-In or-Between Hazards in Construction

Some of the working conditions which contribute to caught-in or-between hazards include:

- machinery which has unguarded moving parts or is not locked out during maintenance;
- unprotected excavations and trenches;
- heavy equipment that tips over, collapsing walls during demolition; and
- working between moving materials and immovable structures, vehicles, or equipment.
1. Each of the following accidents would be classified as a "caught" accident, EXCEPT _____.
   a. being pulled into a chipper
   b. an excavation cave-in
   c. being hit by a piece of lumber
   d. being crushed by a rotating crane

Examples of Caught-in or Caught-Between Hazards

Read the following accidents and think about how each could have been prevented.

- A worker was ripping a 6-inch piece of wood on an unguarded compound miter saw. His left thumb was caught in the saw and amputated.

- An employee was performing diagnostic work on a water truck at a construction site. The worker crawled under the operating truck. The employee’s work shirt collar and coveralls became caught on a projecting set screw on the rotating pump shaft. The set screw pulled him into the pump shaft.

- A worker was cleaning an asphalt paving spreader. Another worker was repairing a pavement roller. The roller was accidentally put into motion and it rolled toward the spreader. The first employee was injured when he was pinned between the two machines.

- A worker was operating a road grader when the engine died, and the vehicle began to roll toward a small ravine. The employee jumped off the grader but was pulled under the grader as it overturned. He was killed when he was crushed underneath the tires.
Practice Identifying Hazards

Try to identify the hazards present in the picture below. Then continue to the next page to see if you correctly identified the hazards.
2. Construction workers may have exposure to _____ hazards if they operate unguarded saws.
   a. caught-between
   b. caught-in
   c. contact-with
   d. contact-by

Machinery with Unguarded Moving Parts

Almost all sites use machinery that has moving or rotating parts or that requires maintenance or repair at some point during construction. If machinery is not properly guarded or de-energized during maintenance or repair, injuries from caught-in or –between hazards may result, ranging from amputations and fractures to death.

When power tools are not properly guarded, workers can get their clothing, gloves, or parts of their body caught in the rotating parts of the tools. If machines are not de-energized (locked-
out) when they are being repaired, they may cycle or otherwise start up and catch a worker's body part or clothing and cause injury or death.

Workers can be trapped and crushed under heavy equipment that tips, especially if they are thrown from the equipment.

**Practice Identifying Hazards**

Try to identify the hazards present in the pictures below. Then, see if you correctly identified the hazards.

![Picture 1](image1.png)

Unguarded belt and pulley. Worker can get hand and/or clothing caught in running nip point.
Gloves, long sleeve shirts, jewelry, or loose fitting clothing can be hazardous if caught in moving parts.
3. Wearing gloves when operating a bench grinder may result in _____.
   a. electrocution
   b. an ergonomic injury
   c. a struck-with injury
   d. a caught-in injury

Buried-in or -by

On construction sites, the major hazard related to buried-in or -by is cave-ins of unprotected trenches and excavations. Cave-ins crush or suffocate workers.

In addition, trenches may contain:

- hazardous atmospheres;

- workers can drown in water, sewage, or chemicals in the trenches; and

- if working around underground utilities, workers may also face burns, electrocution or explosions from steam, hot water, gas, or electricity.

Workers who are working underneath large scaffolds may also be buried if the scaffolds collapse. Workers may be buried and crushed by walls that collapse during demolition.

Workers may also be buried or engulfed by grains and other materials while working in confined spaces such as tanks and silos.

Examples

Read the following accidents and think about how each could have been prevented.

- A worker was in the bottom of a 9.5-foot deep trench, setting grade for concrete pipe while the employer was installing additional shoring. During the shoring installation, the west wall at the south end of the excavation caved-in and covered the worker. There was no shoring or protective system at the location of the trench. The employee was dug out by coworkers and the fire department and survived.

- An employee and a co-worker were working in a 9-foot deep excavation installing water pipes, when the south side of the excavation caved in on the employee and buried him. The employee was killed.
4. In construction a major cause of buried-in or -by fatalities is _____.
   a. drowning in pits
   b. confined space engulfment
   c. building collapse
   d. excavation trench cave-ins

Pinned Between

You can be pinned between equipment and a solid object, such as a wall or another piece of equipment; between materials being stacked or stored and a solid object, such as a wall or another piece of equipment; or between shoring and construction materials in a trench. These types of hazards can result in multiple broken bones, asphyxiation, or death.

Examples

Read the following accidents and think about how each could have been prevented.

- An employee was working from an aerial lift, which was in the "up" position, under an I-beam. He accidentally came into contact with the "drive/steer" lever, which made the manlift move. The employee was killed when he was pinned between the I-beam and manlift control panel.

- Contractor was operating a backhoe when an employee attempted to walk between the swinging superstructure of the backhoe and a concrete wall. The employee approached the backhoe from the operator’s blind side; the superstructure crushed him against the wall.

- Four workers were in an excavation approximately 9 feet wide, 32 feet long and 7 feet deep. Steel plates being used as shoring, were placed vertically against the north and south walls of the excavation at a 30-degree angle [no horizontal braces between the plates]. The steel plate on the south wall tipped over, pinning (and killing) an employee between the steel plate and the pipe casing. The backhoe was being operated adjacent to the excavation.
Practice Identifying Hazards

Try to identify the hazards present in the picture below. Then continue to the next page to see if you correctly identified the hazards.
5. Which of the following would be considered a pinned-between injury?

a. Being crushed by a crane's rotating superstructure
b. Being engulfed by an excavation cave-in
c. An arm pulled into a machine's roller bar
d. Being asphyxiated by rotating parts
Module 4: Caught-In -Or Between Hazards Protective Measures

Clothing and Jewelry

Protective clothing and equipment can create hazards. A protective glove can get caught between rotating parts. Also, a respirator face piece which hinders the wearer’s vision requires alertness and continued attentiveness whenever they are used.

Other parts of the worker’s clothing may present additional safety hazards. For example:

- Loose-fitting shirts might become entangled in rotating spindles or other kinds of moving machinery.
- Jewelry, such as bracelets and rings, should not be worn because they can catch on machine parts or stock and lead to serious injury by pulling a hand into the danger area.

Machine Guarding

Reciprocating, rotating or moving parts of equipment must be guarded if they are exposed to contact by workers. Machine guards are barriers that prevent access to danger areas such as moving parts. There are four general types of guards:

1. **Fixed**: A fixed guard is a permanent part of the machine. It is not dependent upon moving parts to function.

2. **Interlocked**: When this type of guard is opened or removed, the tripping mechanism and/or power automatically shuts off or disengages, the moving parts of the machine are stopped, and the machine cannot cycle or be started until the guard is back in place.

3. **Adjustable**: Adjustable guards are useful because they allow flexibility in accommodating various sizes of stock.

4. **Self-adjusting**: The openings of these barriers are determined by the movement of the stock. As the operator moves the stock into the danger area, the guard is pushed away, providing an opening which is only large enough to admit the stock. The openings of these barriers are determined by the movement of the stock. As the operator moves the stock into the danger area, the guard is pushed away, providing an opening which is only large enough to admit the stock.

Guards must not be easy to defeat and they must now allow access to moving parts from any direction. Never remove a safety guard when a tool is being used. Hazardous moving parts of
power tools and equipment need to be safeguarded. Some examples of parts that need to be guarded are: belts, gear, shafts, and pulleys.

1. What is required if a worker is exposed to contact with moving parts of equipment or machinery?
   a. Trip wires
   b. Warning signs
   c. Machine guards
   d. Guardrails

Other Methods to Secure Machinery

Your employer should provide a lock-out/tag-out program or equivalent system to ensure equipment is not accidentally energized during maintenance or repair.

Lockout/tagout procedures are specifically required for equipment used in concrete and masonry operations. Bulldozer and scraper blades, end loader buckets, dump bodies, and similar equipment must be blocked or fully lowered when being repaired or not in use.

Make sure your equipment is de-energized and cannot be started accidentally.

- First, disconnect tools when not in use, before servicing, and when changing accessories such as blades, bits, and cutters.
- Turn off vehicles before you do maintenance or repair work.
- If possible, lockout the power source to the equipment. The type of power source may be electric, pneumatic, liquid fuel, hydraulic, or powder-actuated.
- Lower or block the blades of bulldozers, scrapers, and similar equipment before you make repairs or when the equipment is not in use.

For more information on Lockout/Tagout requirements, please see course 710 Energy Control Program (Lockout/Tagout).
2. What procedure is required to prevent accidental or unexpected startup of equipment?

   a. Warning tags
   b. Lockout/Tagout
   c. Taped on-off switches
   d. Caution signs or guards

**Crushed-by Heavy Equipment**

The best way to prevent workers from being crushed by heavy equipment that tips over is to prevent the equipment from tipping over in the first place. For example, cranes can tip over if the load capacity is exceeded, or the ground is not level or too soft. Therefore, cranes should be equipped with outriggers.

OSHA requires your employer to designate a competent person to inspect crane operations to identify hazardous working conditions, including ensuring the support surface is firm and able to support the load. Your employer must also make sure the material handling equipment is equipped with rollover protective structures.

OSHA standards also require motor vehicles, forklifts, and earthmoving equipment to be equipped with seat belts. Your employer must require their use. The use of seat belts will prevent workers from being thrown from a vehicle or equipment and being crushed when the vehicle or equipment tips over.

**Crushed-by Collapsing Walls**

During demolition, your employer must ensure any stand-alone wall more than one story must have lateral bracing unless the wall was designed to be stand-alone and is otherwise in a safe condition to be self-supporting.

Jacks must have a firm foundation. If necessary, the base of a jack must be blocked or cribbed. After a load has been raised, it must be cribbed, blocked, or otherwise secured at once.
3. What should be done to prevent cranes from rolling over?

a. Position crane 90 degrees from load
b. Chock all tires
c. Install seat belts
d. Extend outriggers

Pinned Between Equipment, Materials, or other Objects

To protect yourself from being pinned between equipment, materials, or objects you must:

• be aware at all times of the equipment around you and stay a safe distance from it;
• never place yourself between moving materials and an immovable structure, vehicle, or stacked materials;
• make sure all loads carried by equipment are stable and secured;
• stay out of the swing radius of cranes and other equipment; and
• wear a seat belt, if required, to avoid being thrown from a vehicle and then potentially being crushed by the vehicle if it tips over.

Your employer is required to take measures to prevent workers from being pinned between equipment and a solid object, such as a wall or another piece of equipment; between materials being stacked or stored and a solid object, between shoring and construction materials in a trench.

Other example situations are:

• During demolition operations, when balling or clamming is being performed, only the personnel absolutely necessary to the work must be allowed in the work area.
• Your employer must make sure that proper bracing is used between heavy plates used as shoring in a trench.
• Your employer must carefully arrange the path of travel when loading/unloading, stacking, and storing materials so that no workers will be caught between materials and moving equipment or between materials and a wall.
4. All the following are safety measures to take to prevent being pinned, EXCEPT _____.
   a. make sure loads are stable and secure
   b. do not place yourself between moving and stationary objects
   c. stay out of the swing radius of cranes
   d. do not wear a seat belt for quick escape

**Excavation Sites**

OSHA standards on trenching and excavation require your employer to designate a competent person to inspect the trenching operations. The competent person must be trained in and knowledgeable about soils classification, the use of protective systems, and the requirements of the OSHA standard. The competent person must be capable of identifying hazards, and authorized to immediately eliminate hazards.

Your employer must make sure all excavations and trenches **five feet** deep or more, but less than **20 feet**, are protected by sloping or benching, trench box or shield, or shoring. There must also be adequate means of access and egress from the excavation. If an excavation is **more than 20 feet deep**, a professional engineer must design the system to protect the workers.

You must be protected from equipment or materials that could fall or roll into excavations. This could include spoils that could fall into the trench and bury the workers. Mobile equipment used near or over an excavation presents a hazard. A warning system must be utilized (such as barricades, hand or mechanical signals, or stop logs), when mobile equipment is:

- operated next to an excavation or
- is required to approach the edge of an excavation, and
- the operator does not have a clear and direct view of the edge of the excavation. If possible, the grade should be away from the excavation.

If a crane or earthmoving equipment is operating directly over the top of a trench, workers should not be working underneath.
5. All excavations _____ require sloping, benching, trench box or shield, or shoring.
   a. five feet deep or more, but less than 20 feet deep
   b. over four feet deep, but less than 10 feet deep
   c. between four and 20 feet deep
   d. less than 10 feet deep, but over 10 feet deep

**Buried-by Structures**

Anytime there is inadequate support, improper construction, or a shift in the components of a scaffold (including the base upon which the structure is built); there is danger of collapse. Measures need to be taken by your employer to avoid the collapse of structures, such as scaffolds, that could bury workers underneath them.

- Designate a collapse zone and prohibit entry.
- Cinder blocks or other similar materials, that can easily collapse, should not be used to support a scaffold or other structures.

OSHA standards require that scaffolds can only be erected, moved, dismantled or altered under the supervision of a competent person. The competent person selects and directs the workers who erect the scaffold. The selected workers must be trained by a competent person on correct procedures and hazards of scaffold erection.

6. Which of the following would NOT normally result in the collapse of a scaffold or other structure?
   a. Metal plates used for supports
   b. Untrained scaffold erectors
   c. Improper construction
   d. Use of cinder block supports

**Designate a Competent Person**

OSHA defines a competent person as:

"**one who is capable of identifying existing and predictable hazards in the surroundings or working conditions which are unsanitary, hazardous, or dangerous to employees, and who has authorization to take prompt corrective measures to eliminate them.**"
Your employer must designate a competent person for certain construction activities that may have caught-in or-between hazards. Competent person duties include:

- training workers in heavy equipment, materials handling, excavation, and scaffold erection, moving, and dismantling;
- inspecting scaffolds and excavations, the adjacent areas, and protective systems;
- conducting engineering surveys prior to demolition of a structure (and any adjacent structure where workers may be exposed) to determine the condition of the framing, floors, and walls, and possibility of unplanned collapse; and
- inspecting during demolition to detect hazards resulting from weakened or deteriorated floors, or walls, or loosened material

### 7. Who is responsible for training workers in heavy equipment, materials handling, excavation, and scaffold safety?

- a. Authorized person
- b. Competent person
- c. Authorized trainer
- d. Third-party consultant

### Training

Make sure you have the proper training on the equipment and hazards of your job so you can work safely. Specific and detailed training is a crucial part of any effort to safeguard employees from worksite hazards.

OSHA’s general training requirement for construction workers is:

The employer shall instruct each employee in the recognition and avoidance of unsafe conditions and the regulations applicable to his work environment to control or eliminate any hazards or other exposure to illness or injury.

Your employer must train you to perform your job and use the provided equipment safely. OSHA's training requirements are summaries in [Publication 2254, Training Requirements in OSHA Standards](https://www.osha.gov/Publications/2254.html).
8. Employers must instruct each employee on all the following topics, EXCEPT ____.

   a. enforcing compliance with rules
   b. recognizing unsafe conditions
   c. avoiding unsafe conditions
   d. applicable safety regulations
Module 5: Struck-By Hazards

Definition

There are actually two types of struck hazards: Struck-by and Struck-against. In either type, the injury is produced by forcible contact or impact between the injured person and an object or piece of equipment.

- In a Struck-by accident, the object strikes the worker.
- In a Struck-against accident, the worker strikes the object.

In this module, we'll focus on Struck-by hazards because they occur more frequently and are one of OSHA's Focus-Four hazard types. It is important to point out that in construction, struck-by hazards can resemble caught–in or–between hazards.

To determine whether an event is a Caught event or a Struck event, ask yourself: Was it the impact of the object alone that caused the injury?

When the impact alone creates the injury, the event is considered as "Struck" event. On the other hand, when the injury is created more as a result of crushing injuries between objects, the event is considered as "Caught."

Struck-by hazards are categorized as follows:

- struck by flying object
- struck by falling object
- struck by swinging object
- stuck by rolling object

1. When the impact alone causes an injury, the accident is considered a _____ event.
   a. contact
   b. crush
   c. struck
   d. caught
Examples

Struck-by hazards in construction cause accidents such as the following:

- Four workers were installing signs on a highway when a pick-up truck changed several lanes and entered the work area. The truck struck one of the workers, knocking him off the road and over a bridge rail. He fell approximately 18 feet and died.

- Four workers were struck by an exterior wall while attempting to lift it in place. Three of the workers received bruises and contusions. One of the workers received a fractured leg and was hospitalized.

- A construction inspector was crossing an equipment vehicle route at an interstate highway bridge construction site. He walked into the path of the end loader traveling the route, was run over, and killed. The loader operator was unaware that he struck the inspector.

- A worker was struck by the counterweight and revolving superstructure of an excavator when he walked between the excavator and a hillside.

- Workers were pulling 60-foot sections of pipe out of a hole, using a hoist to stack them on the derrick floor. One of the workers let go of a pipe section before it was secured. As he bent over, the pipe swung around and struck him on the head, killing him.

- A worker was maneuvering an overhead crane when a metal plate, weighing approximately 7,330 lbs., separated from the lifting clamp and fell, striking and killing the worker.

2. Which of the following is considered a Struck-by accident?

   a. A worker runs into a metal column
   b. A metal plate fell on a worker
   c. A worker is pulled into a chipper
   d. A worker falls to a lower level
**Struck by Flying Objects**

Flying object hazard exists when something has been thrown, hurled, or is being propelled through space. It can include instances when a piece of material separates from a tool, machine or other equipment, striking a worker, resulting in injuries or fatalities.

Also, a hazard exists if an object is ejected under power by a tool or equipment. Examples include:

- A nail gun, probably the tool causing the greatest number of serious injuries on the construction site, propels a nail from the gun by force. This force can be either pneumatic or powder-actuated.

- A bench grinder may cause injury when a disintegrating wheel strikes a worker. In Oregon, USA, some years ago, a worker was killed when a chunk of a broken grinder wheel hit his femoral artery in his upper leg.

Powder-actuated tools are particularly hazardous due to the force behind the fastener. These fasteners are designed to go through wood, concrete and steel, and they can certainly go through a worker. To learn more about nail gun safety, see course [611 Nail Gun Safety](#).

Using compressed air can also cause flying object hazards. Compressed air is commonly used to power tools and clean surfaces.
Practice Identifying Hazards

Try to identify the hazards present in the pictures below. Then, see if you correctly identified the hazards.

Grinding or striking materials can create flying object hazards. This worker is protected by equipment guarding and faceshield, but should have safety glasses/goggles.
Unsecured gas cylinders are being transported, exposing workers to struck-by hazard from flying projectiles.
3. Which power tool is most frequently the cause of a serious Struck-by injury or fatality?
   a. Nail gun
   b. Drill
   c. Sander
   d. Saw

Struck by Falling Objects

A person is struck-by a falling object when crushed, pinned, or caught under an object that has fallen from above. This does not include the collapse of material or structures.

Examples:

- A worker was tearing down a transmission structure using a digger-derrick when a pole broke and struck him on the head.

- A worker was struck by a load of wall panels that fell off his truck.

- Four workers rebuilding a bridge that had washed out by floods were injured when a crane boom cable broke, and the boom fell on them.

- A worker was engaged in cutting an 8,000-lb boiler in sections with a cutting torch. The section being cut fell off allowing the remaining 5000-lb section, to flip over onto its bottom and land on the worker.

- A worker was assisting a rigger who had attached a load to the block hook of a wheel mounted crane. The crane operator was positioned in the cab and waiting for the hand signal to make the lift. During this process, the jib of the crane fell from its stowed position on the boom and struck the worker. The worker died later at the scene. It was discovered that the pin used to secure the jib to the boom was missing thus allowing the jib to be displaced. The crane was not inspected prior to use.
Practice Identifying Hazards

Try to identify the hazards present in the pictures below. Then, see if you correctly identified the hazards.
Avoid working below suspended overhead materials. Worker is exposed to falling and swinging struck-by hazards.
4. Which of the following situations will NOT result in being struck by a falling object?

   a. Working under a suspended load
   b. Working under bridge construction
   c. Working on the first floor of a multi-floor structure
   d. Working on a roof installing vents

Struck by Swinging Objects

When the source of injury has been referred to objects that are not free standing, they are attached at some point or are being held by the worker. This includes instances where a hinge-like motion retracts creating swinging motion in which the worker is struck-by a slamming or swinging motion.

When materials are mechanically lifted, they have the potential to swing and strike workers. As the load is lifted, the materials may swing, twist or turn.

This movement can catch workers by surprise, and the swinging load could hit them. Windy conditions are especially hazardous because the load will swing more. Depending on where the worker is standing and the force behind the load, the worker may fall to another level after being struck and sustain even greater injuries. In addition to swinging, loads can slip from their riggings and strike workers. Loads must be rigged properly to prevent slipage.
Practice Identifying Hazards

Try to identify the hazards present in the picture below. Then continue to the next page to see if you correctly identified the hazards.
5. What is an especially hazardous condition that makes being struck by swinging objects more likely?

   a. Size and shape of a load
   b. Windy conditions
   c. Hoisted loads with tag line
   d. The weight of the load

**Struck by Rolling Object**

Struck-by rolling object is when an object is rolling, moving, or sliding on the same level at which the worker is located. It includes instances in which the worker is struck or run over by a moving vehicle without being caught under it or instances in which the worker is struck-by a sliding object or equipment on the same level.
Examples

- While walking along the track, a worker was struck by an unmanned rail car at an airport.

- A worker (security guard) was struck by a tractor trailer and dragged, resulting in fatal injuries.

- A worker suffered fatal injuries after being struck by a moving semi-truck while loading/unloading freight.

- A worker was performing repair operations on an impact attenuator and was struck by a truck.

- A worker was flagging traffic and was struck by a truck.

- A four-person ground crew was working with a mobile under-hung bridge crane. The crane ran over one of the crew members, who had walked too close to the wheel of the crane. The employee died from his injuries.

- A worker was setting traffic cones for a paving project. A steel wheel roller was compressing the asphalt, and the traffic cones were being moved so that they would be in the path of the roller. The worker was injured when he was struck by an automobile. He was thrown over the hood of the car and into another lane of traffic, where he was struck by another automobile. He was dragged 141 ft by the second vehicle. He was pronounced dead at the hospital.
Practice Identifying Hazards

Try to identify the hazards present in the picture below. Then continue to the next page to see if you correctly identified the hazards.
6. What type of Fatal-Four hazard is most likely to cause injuries or fatalities to workers exposed to traffic on a construction site?

   a. Struck by flying objects
   b. Struck by falling objects
   c. Struck by rolling objects
   d. Struck by stationary objects
Module 6: Struck-By Hazard Protective Measures

Heavy Equipment

Properly securing any load with appropriate rigging is crucial to any lifting being done by machinery on the job-site. If the rigging fails, the results can cause serious injury and even death. Before any load is lifted all components of the rigging hardware should be evaluated to ensure they can withstand the forces of the load. There are also many other circumstances that you will need to be aware of when working around heavy equipment. Following the safe work practices listed below will greatly enhance your ability to remain safe while working around heavy equipment.

- Guard all exposed gears, rotating shafts, pulleys, sprockets or other moving parts to prevent contact with employees.
- Stay away from heavy equipment when it’s operating – In fact, be alert to the location of all heavy equipment whether in use or not.
- Be aware of the swing radius of cranes and backhoes and do not enter that zone.
- Inspect all rigging equipment prior to each lift, this should include all slings, chains, ropes, and like materials used to support and lift materials.
- Remove from service any defective equipment immediately.
- Inspect all hooks, clamps, and other lifting accessories for their rated load.
- Stay clear of lifted loads and never work under a suspended load.
- The person responsible for signaling the crane operator needs to stay in visual contact with the operator and is trained to use the correct signals.
- Beware of unbalanced loads.
- Workers should confirm and receive acknowledgment from the heavy equipment operator that they are visible.
- Drive equipment [or vehicles] on grades or roadways that are safely constructed and maintained.
- Make sure all workers and other personnel are in the clear before using dumping or lifting devices.
• Lower or block bulldozer and scraper blades, end loader buckets, dump bodies, etc., when not in use, and leave all controls in neutral position.

• Haulage vehicles that are loaded by cranes, power shovels, loaders etc., must have a cab shield or canopy that protects the driver from falling materials.

• Do not exceed a vehicle's rated load or lift capacity.

• Do not carry personnel unless there is a safe place to ride.

1. What should be done with heavy equipment blades, buckets and dump bodies are not in use?

   a. Keep all equipment properly engaged and tagged
   b. Lockout and tagout the equipment controls
   c. Block and lower, and leave controls in neutral position
   d. Keep blades raised, buckets lowered, and leave in off position

Cranes, Excavators, and More

There are also many things your employer must do to ensure your safety around heavy equipment as well, such as:

• determining whether the ground is sufficiently level and firm to support the anticipated weight of hoisting equipment and associated loads;

• assessing hazards within the work zone that would affect the safe operation of hoisting equipment such as, power lines and objects or personnel that would be within the swing radius of the hoisting equipment;

• erecting barriers to mark the area covered by the rotating superstructure to warn workers of the danger zone;

• ensuring equipment is in safe operating condition via required inspections;

• complying with all manufacturer procedures regarding proper operational functions of equipment, including its use with attachments;

• ensuring safe attachment of rigging devices such as shackles, hooks, eyebolts, spreader beams and slings, wedge socket and wire rope clips;

• providing seat belts when required;
• ensuring roadways and grades are maintained to accommodate the safe movement of equipment and vehicles; and

• ensuring all earthmoving/compacting equipment with obstructed view does not operate in reverse gear unless the equipment has a reverse signal alarm, or a worker has been designated to signal when it is safe.

To learn more about cranes and rigging safety please click here. For more comprehensive information please consider reviewing course 820 Crane and Derrick Safety I, and 821 Crane and Derrick Safety II.

2. Proper equipment operation should be in compliance with _____.
   a. industry standards
   b. manufacturer procedures
   c. OSHA instructions
   d. Operator best practices

Motor Vehicles – Trucks, Cars, and More

Workers often deal with low lighting, low visibility, inclement weather, multiple vehicles, and numerous distractions at worksites. Moving construction vehicles and passing motor vehicle traffic can both cause problems for construction workers. Vehicle safety practices must be observed at construction sites to limit worker exposure to struck-by hazards such as struck-by swinging backhoes, struck-by falling/overturning vehicles, and struck-by trucks or cars.

To avoid these types of hazards, workers should:

• wear seat belts when provided;

• check vehicles before each shift to assure that all parts and accessories are in safe operating condition;

• do not drive a vehicle in reverse gear with an obstructed rear view, unless it has an audible reverse alarm, or another worker signals that it is safe;

• set parking brakes when vehicles and equipment are parked, and chock the wheels if they are on an incline;

• all vehicles must have adequate braking systems and other safety devices;
• use traffic signs, barricades or flaggers when construction takes place near public roadways; and

• workers must be highly visible in all levels of light. Warning clothing, such as red or orange vests, are required, and if worn for night work, must be of reflective material.

3. If a vehicle has an obstructed rear view, what must the operator have in order to back up the vehicle?

   a. Audible reverse alarm, or another worker to signal it’s safe
   b. A designated flagger or signal-person to direct traffic
   c. A jury-rigged backup mirror, or visible signal
   d. A hand-held high-lumen flashlight, or audible alarm

When working on or near any construction zone:

• wear high-visibility reflective clothing;

• do not put yourself at risk of being struck by a vehicle and do not get caught in a situation where there’s no escape route;

• do not direct traffic unless you are the flagger;

• flaggers must be visible by both motorists and equipment operators;

• check that necessary warning signs are posted;

• never cross the path of a backing vehicle;

• if equipment doesn’t have a reverse signal alarm loud enough to be heard against the surrounding noise level, and the operator has an obstructed view to the rear, the employer will designate a worker to signal when it’s safe to back up; and

• follow "Exit" and "Entry" worksite traffic plan.

Flaggers and other workers on foot are at greater risk of exposure to being struck; therefore, they must be visible by both motorists and equipment operators.

Your employer is required to:

• conduct a hazard assessment of the worksite using the job-site coordinator (supervisor or foreman) who should:
To make a thorough assessment of potential worksite safety hazards,
- plan for work being conducted in close proximity to a public road or highway and for the safe handling of intermittent roadway traffic stoppages, such as a truck entering a roadway, and
- plan the entry and exit to and from the worksite to reduce exposure to traffic;
  - post-construction areas with legible traffic signs at points of hazard;
  - erect barricades that conform to the MUTCD;
  - place necessary warning signs along the road; and
  - all workers on site should have a safety and operations orientation.

If you’re interested in learning more about work zone traffic safety, please review course 612 Work Zone Traffic Safety.

4. To protect against being injured by moving vehicles, do each of the following, EXCEPT ________.
   a. wear high-visibility clothing
   b. never cross the path of a backing vehicle
   c. check for posted warning signs
   d. do not direct traffic if you are a flagger

**General Safe Work Practices**

As an employee, you are your own best advocate for keeping yourself safe. Below is a list of safe work practices to help you.

When working with **compressed air**:
- reduce air pressure to 30 psi if used for cleaning, and use only with appropriate guarding and proper protective equipment; and
- never clean clothing with compressed air.

When working with **hand tools**:
- do not use tools with loose, cracked or splintered handles; and
• do not use impact tools with mushroomed heads.

When working with **machines, such as jack hammers, pavement saws:**

• be sure to be trained on safe operation of machinery;
• inspect machinery and ensure all guards are in place and in working order;
• protect feet, eyes, ears and hands; and
• wear hearing protection.

When performing **overhead work:**

• secure all tools and materials;
• use toeboards, screens, guardrails and debris nets;
• barricade the area and post signs; and
• be sure materials stored in buildings under construction are placed further than 6 feet of hoist way/floor openings and more than 10 feet from an exterior wall.

5. How far from hoist ways/floor openings must materials be stored?
   a. Two feet or farther
   b. At least 6 feet
   c. No closer than 4 feet
   d. Between 4 and 6 feet

When working with **powder-actuated tools** you must be trained and licensed to operate them if required.

When working with **power tools, such as saws, drills, and grinders:**

• be sure to be trained on how to safely use the power tool;
• inspect tools before each use;
• wear safety goggles;
• operate according to manufacturer’s instructions; and
• ensure all required guards are in place.
When pushing or pulling objects that may become airborne:

- stack and secure materials to prevent sliding, falling or collapse;
- keep work areas clear; and
- secure material against wind gusts.

6. Which of the following tools require workers to be trained and licensed, if required?

   a. Hydraulic tools
   b. Electrical tools
   c. Pneumatic tools
   d. Powder-actuated tools

Your employer is responsible for ensuring:

- all hand tools are maintained in good condition;
- the use of unsafe hand tools is not permitted (i.e., no sprung jaws on wrenches, no mushroomed heads, no splinters or cracks in wooden handles, no loose parts/heads of tools);
- saws are equipped with guards and have a constant pressure switch that will shut off the power when the pressure is released;
- safety guards are on all abrasive wheel bench and stand grinders;
- all powder-actuated tools are tested daily before use and all defects discovered before or during use are corrected;
- powder-actuated tools are not loaded until immediately before use and loaded tools are not left unattended;
- compressed air used for cleaning purposes is reduced to less than 30 pounds per square inch (psi) and provide effective chip guarding and PPE;
- all materials stored in tiers are secured to prevent sliding, falling, or collapsing; and
- toeboards are erected along the edge of overhead walking/working surfaces.
7. Compressed air used for cleaning purposes is must be reduced _____.
   a. to no more than 50 pounds per square inch (psi)
   b. to less than 30 pounds per square inch (psi)
   c. prior to first use during the workshift
   d. to no more than a 20% oxygen level

Personal Protective Equipment (PPE)

Personal Protective Equipment must be worn and used in a manner that will make full use of its protective qualities.

Personal Protective Equipment must be worn and used in a manner that will make full use of its protective qualities. Personal protective equipment used incorrectly potentially exposes an employee to hazards, which defeats the reason for using PPE. To review a "PPE for Workers Checklist" click here.

Eye and face protection should be used based on anticipated hazards. Safety glasses or goggles should be worn any time work operations present an eye hazard. For example, safety glasses or goggles should be worn during welding, cutting, grinding, nailing (or when working with concrete and/or harmful chemicals or when exposed to flying particles).

Head protection (i.e., hard hats) should be used where there is a potential for objects falling from above, and bumps to the head from fixed objects. Hard hats should be routinely inspected for dents, cracks or deterioration. Replace your hard hat after a heavy blow and ensure it is maintained and in good condition.

When worn alone, face shields do not protect employees from impact hazards. Workers should use face shields in combination with safety spectacles or goggles, even in the absence of dust or potential splashes, for additional protection beyond that offered by spectacles or goggles alone.

Your employer must do the following:

- Pay for PPE as required by OSHA.
- Provide and require the use of appropriate PPE in all operations where there is an exposure to hazardous conditions.
- Ensure the adequacy of PPE including proper maintenance and sanitation.
• Provide head protection (e.g., hard hats, helmets) whenever there is possible danger of head injuries from impact, flying or falling objects.

• Provide eye and face protection when machines or operations present eye or face injury.

• Provide workers involved in welding operations with filter lenses or plates of proper shade number.

• Ensure eye, face, and head protective equipment meets ANSI requirements.

**8. When worn alone, using face shields _____ employees from impact hazards.**

a. are better than goggles in protecting  
b. will adequately protect  
c. will not protect  
d. is the best choice to protect

**Training**

To help protect you from struck-by hazards your employer must:

• Train workers in the work zone to recognize hazards associated with the use of the equipment and any related duties that they are assigned to perform.

• Ensure crane operators are qualified or certified according to OSHA standards.

• Ensure signal person meets qualification requirements according to OSHA standards.

• Instruct workers in the recognition and avoidance of unsafe conditions and the regulations applicable to his/her work environment to control or eliminate any hazards or other exposure to illness or injury.

• Ensure qualified operators and riggers have been trained on rigging safety, such as:
  
  o the weight [of load] the rigging is expected to support  
  o the capacity of the strength of the rigging (type and method of use)  
  o how to retain the load – know which hitches work best for certain types of loads  
  o how to control the load – know which hitches provide good load control and where the center of gravity of the load is
9. Employers must train workers in the construction site work zone to _____.

   a. enforce the employer's safety rules
   b. recognize hazards and their related duties
   c. control the movement of employees at all times
   d. anticipate and report suspicious behaviors
Module 7: Electrocution Hazards

Electrocution results when a person is exposed to a lethal amount of electrical energy. An electrical hazard can be defined as a serious workplace hazard that exposes workers to the following:

Therefore, **BE SAFE** by recognizing, avoiding, and protecting against all of these electrical hazards. These **BE SAFE** terms are defined as:

**B = Burns:** A burn is the most common shock-related injury. Burns from electricity are caused by electrical, arc flash, or thermal contact.

**E = Electrocution:** Electrocution is fatal; it means to kill with electricity. Electrocution results when a human is exposed to a lethal amount of electrical energy.

**S = Shock:** Shock results when the body becomes part of the electrical circuit; current enters the body at one point and leaves at another. Electrical shock is defined as a reflex response to the passage of electrical current through the body.

**A = Arc Flash:** An arc flash is the sudden release of electrical energy through the air when a high-voltage gap exists, and there is a breakdown between conductors. An arc flash gives off thermal radiation (heat) and bright, intense light that can cause burns. Temperatures have been recorded as high as 35,000 °F. High-voltage arcs can also produce considerable pressure waves by rapidly heating the air and creating a blast.

An arc flash can be spontaneous or result from inadvertently bridging electrical contacts with a conducting object. Other causes may include dropped tools or the buildup of conductive dust or corrosion. For more information on arc flash/blast, including best practices in electrical safety, refer to **NFPA 70E: Standard for Electrical Safety in the Workplace**

**F = Fire:** Most electrical distribution fires result from problems with "fixed wiring" such as faulty electrical outlets and old wiring. Problems with cords (such as extension and appliance cords), plugs, receptacles, and switches also cause electrical fires.

**E = Explosion:** An explosion can occur when electricity ignites an explosive mixture of material in the air.
1. What is the sudden release of electrical energy through the air when a high-voltage gap exists?
   
a. Electrocution  
b. An explosion  
c. An arc flash  
d. A shock  

Examples

- Two workers were moving an aluminum ladder. The ladder came in contact with the overhead power lines and electrocuted one of the workers.

- When a worker raised the mast on his water well drilling truck, it came into contact with high voltage overhead lines and electrocuted him.

- The boom of a rotary drilling truck contacted an overhead power line and electrocuted the worker. The victim and another worker had just finished drilling a water well on a residential property. The victim moved the truck away from the well. The victim was standing at the controls, lowering the boom and was thrown several feet away from the truck.

- A worker fell to the concrete floor while working from an 8’ fiberglass step ladder. He was fatally injured and electrocuted. The worker was changing an energized ballast on a two bulb fluorescent light fixture, located approximately 11’ 6” off the ground.

- A worker was electrocuted while connecting a replacement electrical service box to the electrical service drop to the building.

2. In a worse-case scenario, what is likely to happen to a worker if he or she contacts a high voltage overhead power line with a metal ladder or pole?
   
a. Arc flash  
b. Electrocution  
c. Burns  
d. Shock
Contact with Power Lines
Overhead and buried power lines are especially hazardous because they carry extremely high voltage.

Practice Identifying Hazards
Try to identify the hazards present in the picture below. Then continue to the next page to see if you correctly identified the hazards.
3. OSHA requires that equipment be kept _____ away from power lines with voltages up to 50 kilovolts (kV).
   a. a minimum of 5 feet  
   b. 8 feet or more  
   c. 3 feet for every 10 Kv  
   d. at least 10 feet

**Contact with Energized Sources**

The major hazards regarding contact with energized sources are electrical shock and burns. Electrical shock occurs when the body becomes part of the electric circuit. This occurs when an individual comes in contact with both wires of an electrical circuit (one wire of an energized circuit and the ground, or a metallic part that has become energized by contact with an electrical conductor).
The severity and effects of an electrical shock depend on a number of factors, such as:

- the pathway through the body,
- the amount of current,
- the duration of the exposure, and
- whether the skin is wet or dry.

Water is a great conductor of electricity, allowing current to flow more easily in wet conditions and through wet skin. The table below discusses the effects of electrical shock.

Electrical burns can be arc burns, thermal contact burns, or a combination of burns. Electrical burns are among the most serious burns and require immediate medical attention. They occur when an electric current flow through tissue or bone, generating heat that causes tissue damage. The body cannot dissipate the heat generated by current flowing through the resistance of the tissue. Therefore, burns occur.

<table>
<thead>
<tr>
<th>Current</th>
<th>Reaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 milliamp</td>
<td>Just a faint tingle.</td>
</tr>
<tr>
<td>5 milliamps</td>
<td>Slight shock felt. Disturbing, but not painful. Most people can &quot;let go.&quot; However, strong involuntary movements can cause injuries.</td>
</tr>
<tr>
<td>6-25 milliamps (women)†</td>
<td>Painful shock. Muscular control is lost. This is the range where “freezing currents” start. It may not be possible to &quot;let go.&quot;</td>
</tr>
<tr>
<td>9-30 milliamps (men)</td>
<td></td>
</tr>
<tr>
<td>50-150 milliamps</td>
<td>Extremely painful shock, respiratory arrest (breathing stops), severe muscle contractions. Flexor muscles may cause holding on; extensor muscles may cause intense pushing away. Death is possible.</td>
</tr>
</tbody>
</table>
### Effects of Electrical Shock

<table>
<thead>
<tr>
<th>Current Level</th>
<th>Effect Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,000-4,300 milliamps</td>
<td>Ventricular fibrillation (heart pumping action not rhythmic) occurs. Muscles contract; nerve damage occurs. Death is likely.</td>
</tr>
<tr>
<td>10,000 milliamps</td>
<td>Cardiac arrest and severe burns occur. Death is probable.</td>
</tr>
<tr>
<td>15,000 milliamps</td>
<td>Lowest overcurrent at which a typical fuse or circuit breaker opens a circuit!</td>
</tr>
</tbody>
</table>

*Effects are for voltages less than about 600 volts. Higher voltages also cause severe burns.
†Differences in muscle and fat content affect the severity of shock.

(1,000 milliamperes = 1 amp; therefore, 15,000 milliamperes = 15 amp circuit)

### 4. The severity and effects of an electrical shock depend on all of listed factors, EXCEPT _____.

- a. the pathway through the body
- b. the induced reluctance
- c. the duration of exposure
- d. the amount of current

### Examples

To further illustrate how easily a person can receive a fatal shock, consider a voltage that is common to every location in the United States, 120-volts. Under average working conditions where a person is perspiring, they have a resistance of only 1000 ohms from hand-to-hand. Using the simple **Ohm’s Law formula** (current equals the voltage divided by the resistance), the current flow will be 0.12 amperes or 120 mA. From the table in the previous section, we can see that the reaction can be a painful shock to possible death.

A fault current may travel through a worker's body, causing electrical burns or death if:

- the power supply to the electrical equipment is not grounded, or
• the path has been broken, or
• if there are live parts or bare wires.

Even when the power system is properly grounded, electrical equipment can instantly change from safe to hazardous because of extreme conditions and rough treatment.

**Practice Identifying Hazards**

Try to identify the hazards present in the pictures below. Then, see if you correctly identified the hazards.
5. Under average working conditions (120 vac) where a person is perspiring, they have a resistance of only _____ ohms hand-to-hand which can result in death.

a. 1000  
b. 2100  
c. 2400  
d. 3600

**Improper Use of Extension and Flexible Cords**

The normal wear and tear on extension and flexible cords can loosen or expose wires, creating a hazardous condition. Cords that are not 3-wire type, not designed for hard-usage, or that have been modified, increase the risk of contacting electrical current. With the wide use of power tools on construction sites, flexible extension cords are often necessary.

Because they are exposed, flexible, and unsecured, they are more susceptible to damage than fixed wiring. Hazards are created when cords, cord connectors, receptacles, and cord- and plug-connected equipment are improperly used and maintained.

To reduce hazards, flexible cords must connect to devices and fittings in ways that prevent tension at joints and terminal screws. A flexible cord may be damaged by door or window edges, staples and fastenings, abrasion from adjacent materials, or simply by aging. If the electrical conductors become exposed, there is a danger of shocks, burns, or fire.
When a cord connector is wet, electric current can leak to the equipment grounding conductor, and to anyone who picks up that connector if they provide a path to ground. Such leakage can occur not just on the face of the connector, but at any portion that is wet.

6. How do you reduce the electrical hazards posed by flexible cord connections?
   a. Ground all cords at their source
   b. Wrap the cords with duct tape
   c. Reduce tension at joints and terminal screws
   d. Use bonding insulators with the cords

Let's review an example of an actual accident:

A fan connected to a 120-volt electrical system via an extension cord provided ventilation for a worker performing a chipping operation from an aluminum stepladder. The insulation on the extension cord was cut through and exposed bare wires and energized conductors made contact with the ladder. The ground wire was not attached on the male end of the cord's plug. When the energized conductor made contact with the ladder, the path to ground included the worker's body, resulting in death.

What would you recommend?

Recommendation

Though it is possible to properly repair the extension cord, it is always best to replace an extension cord that is damaged. Yes, it may cost a little money to replace the extension cord. However, if you don't replace the extension cord, and it is not repaired properly a life can be lost and the company will be put at risk.

7. What is the best strategy to eliminate the hazard from an extension cord that is damaged with a section of exposed wire?
   a. Wrap the exposed wire with electrical tape
   b. Replace the cord
   c. Use shrink tubing around the exposed wire
   d. Dip the exposed wire into an insulated liquid and dry
Module 8: Electrocution Hazards Protective Measures

Maintain Safe Distance from Overhead Power Lines

Staying away from power lines is the best option. The following table shows the safe power line clearance distance for various line voltages.

Power Line Clearance Distances

**Table A - Minimum Clearance Distances**

<table>
<thead>
<tr>
<th>Voltage (nominal, kV, alternating current)</th>
<th>Minimum clearance distance (feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to 50</td>
<td>10</td>
</tr>
<tr>
<td>Over 50 to 200</td>
<td>15</td>
</tr>
<tr>
<td>Over 200 to 350</td>
<td>20</td>
</tr>
<tr>
<td>Over 350 to 500</td>
<td>25</td>
</tr>
<tr>
<td>Over 500 to 750</td>
<td>35</td>
</tr>
<tr>
<td>Over 750 to 1000</td>
<td>45</td>
</tr>
<tr>
<td>Over 1000</td>
<td>(As established by the power line owner/operator or registered professional engineer who is a qualified person with respect to electrical power transmission and distribution)</td>
</tr>
</tbody>
</table>

Safe Practices Working Near Powerlines

The following are preventive measures for workers.

**Before work begins, make sure:**

- equipment/activity is located within a safe working distance from power lines;
• the utility company has de-energized and visibly grounded the power lines or installed insulated sleeves on power lines;

• flagged warning lines have been installed to mark horizontal and vertical power line clearance distances; and

• tools and materials used are nonconductive.

1. Before working near power lines, each of the following is necessary, except _____.
   a. work is within safe working distances
   b. flagged warning lines are installed
   c. tools and equipment are semi-conductive
   d. the power lines have been grounded and de-energized

Cranes and Other High-Reaching Equipment

Be sure the utility company has confirmed the voltage and, therefore, the safe working distance from the power lines. Also, if applicable and feasible, use a/an: observer; insulated link; boom cage guard; proximity device.

Mobile Heavy Equipment

If provided, use installed rider posts under power lines to avoid working too close to the power lines.

Ladders

Use nonconductive ladders and be sure to retract them before moving.

Material Storage

• Ensure no materials are stored under power lines.

• Use caution tape and signs to cordon off area under power lines.

Excavations

• Locate and understand the markings the local underground line locator service has marked before digging.
• Hand dig within three feet of cable location (be aware that more than one underground cable may be buried in area of locator markings).

2. What should be done after using extension ladders while working around power lines?
   a. Fully retract the ladder
   b. Carry the ladder using the two-point method
   c. Place the ladder against the power line pole
   d. Lean the ladder before carrying

Employer Responsibilities

Before working on overhead power lines, employers must make sure they are de-energized and grounded by the owner/operator of the power lines, or other protective measures provided.

Employers must provide other protective measures, such as PPE (rubber insulating gloves, hoods, sleeves, matting, blankets, line hose, and industrial protective helmets).

Protective measures (such as guarding or insulating the lines) must be designed to prevent contact with the lines.

The three primary methods your employer should control power line hazards are:

1. maintaining a safe distance from lines;
2. having the power company de-energize and ground the power line(s) (have a power company representative at the site); and
3. having the power company install insulated sleeves (also known as "eels") over power lines.

Your employer should train workers regarding power line hazards and about the available protective measures. Employers need to fully warn workers about what jobs may have electrical hazards, and the measure(s) they will take to control the hazards. Also, workers should be reminded they should always ask questions if they have any doubts about maintaining safe working conditions.
3. Which of the following is one of the three primary methods to ensure employees are safe working around power lines?

   a. Coordinate power line work with local OSHA offices
   b. Make sure employees buy proper personal protective equipment
   c. Ensure utility companies de-energize and ground power lines
   d. Make sure workers install rubber sleeves around poles

**Use Ground-Fault Circuit Interrupters (GFCI)**

A "GFCI" is a ground fault circuit interrupter designed to protect people from severe and sometimes fatal electrical shock. A GFCI detects ground faults and interrupts the flow of electric current and is designed to protect the worker by limiting the duration of an electrical shock.

**A Classic Example of the GFCI at Work**

A homeowner is using an old drill with a loose bare wire inside it touching the outer metal housing. With the drill plugged in, the housing is charged with electricity. If it is used outside in the rain and the worker is standing on the ground, there is a path from the hot wire inside the drill through the worker to the ground. If electricity flows from hot to ground through the worker, it could be fatal. The GFCI can sense the current flowing through you because not all of the current is flowing from hot to neutral as it expects because some of the current is flowing through the worker to the ground. As soon as the GFCI senses a decrease in expected current, it trips the circuit and cuts off the electricity.

4. What causes a ground fault current interrupter (GFCI) to trip?

   a. It senses a change in voltage
   b. It senses an increase in resistance
   c. It senses a decrease in resistance
   d. It senses a decrease in expected current

**Types of GFCIs**

**Receptacle GFCI:** Often found on construction work sites, outdoor areas and other locations where damp conditions do or could exist. The receptacle GFCI fits into the standard outlet box and protects users against ground faults when an electrical product is connected to the GFCI protected outlet.

These should be tested after installation and once a month by:
• Plug in a test light or power tool and turn "On."

• Push the "Test" button on the receptacle; the "Test" button should pop up, and the power to the light or tool should be "Off."

• Push "Reset" to restore power to the outlet.

• If the above steps worked, the GFCI passed the test and is functioning properly; if the GFCI failed the test, remove it from service.

If a light or power tool remains "ON" when the "Test" button is pushed, the GFCI is not working properly or has been incorrectly installed (miswired). If this is the case, a qualified electrician needs to be contacted to properly wire or replace the GFCI device.

Temporary/portable GFCI: A portable GFCI is an extension cord combined with a GFCI. It adds flexibility in using receptacles that are not protected by GFCIs. Extension cords with GFCI protection incorporated should be used when permanent protection is unavailable.

These should be tested prior to each and every use by:

• visually inspecting the device for obvious defects and/or broken parts;
• plugging in a test light/tool to the extension cord;
• pushing the "Reset" button on the GFCI device;
• pushing the "Test" button to verify no voltage at outlet (e.g., the light or tool shuts off); and
• pushing the "Reset" button to verify the power is restored.

Circuit Breaker GFCI: The GFCI circuit breaker controls an entire circuit and is installed as a replacement for a circuit breaker on the main circuit board. Rather than install multiple GFCI outlets, one GFCI circuit breaker can protect the entire circuit. At sites equipped with circuit breakers, this type of GFCI might be installed in a panel box to give protection to selected circuits.

Circuit breaker GFCIs should be tested monthly. Keep in mind that the test will disconnect power to everything on the circuit.
5. Rather than install multiple GFCI outlets, one _____ can protect the entire circuit.

   a. receptacle GFCI
   b. portable in-line GFCI
   c. GFCI circuit breaker
   d. Magnetic type circuit breaker

What Must Your Employer do to Protect You?

OSHA ground-fault protection rules and regulations have been determined necessary and appropriate for worker safety and health. It is your employer's responsibility to provide either:

- GFCIs on construction sites for receptacle outlets in use and not part of the permanent wiring of the structure; or
- a scheduled and recorded assured equipment grounding conductor program on construction sites.

GFCIs must protect receptacles on the ends of extension cords. Also, an employer may use GFCI circuit breakers. These protected circuit breakers are installed on the main circuit board. GFCI circuit breakers protect an entire circuit.

GFCIs monitor the current-to-the-load for leakage to ground. When this leakage exceeds 5 mA ± 1 mA, the GFCI interrupts the current. They are rated to trip quickly enough to prevent electrocution. They should be inspected and tested monthly.

Assured Equipment Grounding Conductor Program (AEGCP)

The AEGCP covers all cord sets, receptacles that are not a part of the permanent wiring of the building or structure, and equipment connected by cord and plug that are available for use or used by employees. OSHA requires a written description of the employer's AEGCP, including the specific procedures adopted, be kept at the job site. This program should outline the employer's specific procedures for the required equipment inspections, tests, and test schedule.

Electrical equipment noted in the AEGCP must be visually inspected for damage or defects before each day's use. The employee must not use any damaged or defective equipment until it is repaired.

OSHA requires two tests:
1. **Continuity Test**: The continuity test ensures that the equipment grounding conductor is electrically continuous. Perform this test on all cord sets, receptacles that are not part of a building or structure's permanent wiring, and cord- and plug-connected equipment required to be grounded. This test can be accomplished with various test equipment.

2. **Terminal Connection Test**: The terminal connection test ensures that the equipment grounding conductor is connected to its proper terminal at receptacles and cord plugs. Perform this test with the same equipment used in the first test, or for receptacles use receptacle testers.

The required tests must be recorded, and the record maintained until replaced by a more current record.

6. Under the Assured Equipment Grounding Conductor Program (AEGCP), electrical equipment noted in the program must be _____.
   
   a. inspected before each day's use
   b. listed in the approved UL equipment list
   c. designed with the latest technology available
   d. less than five years old

**Inspect Portable Tools and Extension Cords**

Workers need to inspect extension cords prior to their use for any cuts or abrasion. Extension cords may have damaged insulation. Sometimes the insulation inside an electrical tool or appliance is damaged. When the insulation is damaged, exposed metal parts may become energized if a live wire inside touches them. Electric hand tools that are old, damaged, or misused may have damaged insulation inside.

**Wire Size and Ampacity**

In terms of conducting electrical current, size matters (the size of the electrical conductor). Take a look at the following table regarding ampacity, the current-carrying capacity of a conductor in amps. You'll notice two things: the **amount of current** a wire can safely carry **increases** as the **diameter** (and area) of the wire increases and as the number of the **wire size decreases**.
AWG Copper Wire Table

<table>
<thead>
<tr>
<th>Copper Wire Size (AWG)</th>
<th>Diameter (Mils)</th>
<th>Area (Circular mils)</th>
<th>Ampacity in Free Air</th>
<th>Ampacity as Part of 3-conductor Cable</th>
</tr>
</thead>
<tbody>
<tr>
<td>14 AWG</td>
<td>64.1</td>
<td>4109</td>
<td>20 Amps</td>
<td>15 Amps</td>
</tr>
<tr>
<td>12 AWG</td>
<td>80.8</td>
<td>6529</td>
<td>25 Amps</td>
<td>20 Amps</td>
</tr>
<tr>
<td>10 AWG</td>
<td>101.9</td>
<td>10,384</td>
<td>40 Amps</td>
<td>30 Amps</td>
</tr>
<tr>
<td>8 AWG</td>
<td>128.5</td>
<td>16,512</td>
<td>70 Amps</td>
<td>50 Amps</td>
</tr>
</tbody>
</table>

Notice that a #8 wire is twice the diameter, but four times the area of a #14 wire. The gauge of the wire determines the rating of a fuse or circuit breaker in amps. For example, a circuit wired with #14 copper will get a 15 amp circuit breaker and a circuit with #12 copper can get a 20 amp breaker.

It is also possible to create a fire hazard by overloading an extension cord. This occurs when too much current is flowing in a conductor that is not heavy enough for the electrical load in amps.

**What must your employer do to protect you?**

The OSHA construction standard requires flexible cords to be rated for hard or extra-hard usage. These ratings are derived from the National Electrical Code, and your employer is required to make sure the cord is indelibly marked approximately every foot along the length of the cord.

- Examples of these codes are S, ST, SO, and STO for hard service, and SJ, SJO, SJT, and SJTO for junior hard service.
- Extension cords must be 3-wire type so they may be grounded, and to permit grounding of any tools or equipment connected to them.
- Limit exposure of connectors and tools to excessive moisture by using watertight or sealable connectors.
7. As the AWG wire size _____, the ampacity of the wire, as part of a 3-conductor cable _____.
   a. decreases, increases
   b. decreases, remains the same
   c. increases, remains the same
   d. decreases, decreases

Use Power Tools and Equipment as Designed

Workers using power tools and equipment should follow tool safety tips to avoid misusing equipment.

- Never carry a tool by the cord.
- Never yank the cord to disconnect it.
- Keep cords away from heat, oil, and sharp edges.
- Disconnect when not in use and when changing accessories such as blades and bits.
- Avoid accidental starting (do not hold fingers on the switch button while carrying a plugged-in tool).
- Use gloves and appropriate footwear.
- Store tools in a dry place when not using.
- Don't use tools in wet/damp environments.
- Keep working areas well lit.
- Ensure cords do not cause a tripping hazard.
- Remove damaged tools from use.
- Use double-insulated tools.

Common Examples of Misused Equipment

- using multi-receptacle boxes designed to be mounted by fitting them with a power cord and placing them on the floor
- fabricating extension cords with ROMEX® wire
- using equipment outdoors that is labeled for use only in dry, indoor locations
- attaching ungrounded, two-prong adapter plugs to three-prong cords and tools
- using circuit breakers or fuses with the wrong rating for over-current protection
- using modified cords or tools
- using cords or tools with worn insulation or exposed wires

Workers need to know even when the power system is properly grounded, electrical equipment can instantly change from safe to hazardous because of extreme conditions and rough treatment.

What Must Your Employer do to Protect You?

Your employer needs to ensure employees are properly trained and that all power tools, systems, and equipment are inspected and maintained in a safe condition.

8. Which of the following is an example of safe electrical equipment use?

   a. Using cords and equipment in damp locations
   b. Placing plugs with missing ground prongs out of service
   c. Fabricating extension cords with ROMEX® wire
   d. Modifying cords or electrical-powered tools

Follow Lockout/Tagout Procedures

Lockout/tagout is an essential safety procedure to protect workers from injury while working on or near electrical circuits and equipment. In addition, lockout/tagout prevents contact with operating equipment parts such as blades, gears, shafts, etc. Also, lockout/tagout prevents the unexpected release of hazardous gases, fluids, or solid matter in areas where workers are present. You can learn more about using lockout/tagout procedures in course 710 Energy Control Program (Lockout/Tagout).

What Must Your Employer do to Protect You?

Your employer must enforce LOTO safety-related work practices by ensuring:
controls that are to be deactivated during the course of work on energized or de-energized equipment or circuits are locked out, tagged or both;

- equipment or circuits that are de-energized shall be rendered inoperative and post tags attached at all points where such equipment or circuits can be energized;
- tags are placed to plainly identify the equipment or circuits being worked on; and
- all circuits used to energize equipment are locked out/tagged out if any worker is exposed to contact with parts of fixed electric equipment that has been de-energized.

**Energized circuits:** Only qualified persons may work on electric circuit parts or equipment that has not been de-energized. Qualified persons must be capable of working safely on energized circuits and must be familiar with the proper use of special precautionary techniques, PPE, insulating and shielding materials, and insulated tools.

<table>
<thead>
<tr>
<th>9. Who is allowed to work on energized circuits?</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Authorized persons</td>
</tr>
<tr>
<td>b. Competent persons</td>
</tr>
<tr>
<td>c. Qualified persons</td>
</tr>
<tr>
<td>d. Designated persons</td>
</tr>
</tbody>
</table>

**Protecting Workers**

Your employer must also ensure equipment is guarded appropriately, electrical parts are isolated appropriately, and that employees are properly trained about electrocution hazards at their worksite.

**Isolate Electrical Parts**

Electrical parts, conductors entering boxes, cabinets, or fittings must be protected from abrasion. Openings, whether used or not, through which conductors enter must be effectively closed.

All pull boxes, junction boxes, and fittings must have covers. Metal covers need to be grounded. In energized installations, each outlet box needs to have a cover, faceplate, or fixture canopy. Covers of outlet boxes having holes through which flexible cord pendants pass shall be provided with bushings designed for the purpose or shall have smooth, well-rounded surfaces on which the cords may rest.
Ensure Proper Guarding

Guarding involves locating or enclosing electrical equipment to ensure workers do not accidentally come into contact with its live parts. Effective guarding requires equipment with exposed parts operating at 50 volts or more to be placed where they are accessible only to authorized people qualified to work with/on the equipment. Recommended locations are a:

- room, vault, or similar enclosure;
- balcony, gallery, or elevated platform; or
- site elevated 8 feet or more above the floor.

Sturdy, permanent screens can also serve as effective guards.

Train Employees

Workers need be trained in and familiar with the safety-related work practices that pertain to their respective job assignments. Employers should train their employees to:

- de-energize electric equipment before inspecting or repairing;
- use cords, cables, and electric tools that are in good repair;
- know and understand lockout/tagout recognition and procedures; and
- use appropriate protective equipment.

10. Effective guarding requires equipment with exposed parts operating at _____ to be placed where they are accessible only to authorized people qualified to work with/on the equipment.

   a. 10 volts or higher
   b. 50 volts or more
   c. in excess of 120 volts
   d. between 120 volts and 240 volts
**Additional Resources**

1. [Construction Industry Digest](#) - OSHA
2. [OSHA Website](#)
3. [BLS Website](#)
4. [CDC/NIOSH Website](#)
5. [OSHAcademy Course 611: Nail Gun Safety](#)
6. [OSHAcademy Course 612: Work Zone Traffic Safety](#)
7. [OSHAcademy Course 709: Personal Protective Equipment (PPE)](#)
8. [OSHAcademy Course 710: Energy Control Program (Lockout/Tagout)](#)
9. [OSHAcademy Course 715: Electrical Safety Basics](#)
10. [OSHAcademy Course 726: Introduction to Machine Guarding](#)
11. [OSHAcademy Course 802: Trench and Excavation Safety](#)
12. [OSHAcademy Course 810: Hand and Power Tool Safety](#)
13. [OSHAcademy Course 813: Construction Worksite Safety](#)
14. [OSHAcademy Course 814: Heavy Equipment Safety](#)
15. [WorkSafe BC](#)