

MODULE 2: FALL ARREST SYSTEM

Overview

- Difference between Fall Prevention and Fall Protection
- What makes up a Personal Fall Arrest System (PFAS)
- How far can you fall while using a PFAS
- How to rescue a falling worker
- Inspection and maintenance of PFAS

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23

Upon completion of this module the student will be able to explain:

- Explain Fall Prevention and Fall Protection
- Identify the components of a Personal Fall Arrest System
- Calculate the total fall protection clearance distance
- Describe fallen worker rescue
- Describe the inspection and maintenance process for the Personal Fall Arrest Systems

What is Fall Prevention/ Fall Protection?

- **Fall prevention** is preventing workers from falling by using engineering controls (e.g., guardrails and hole covers) or restraint systems.
- **Fall arrest or protection** is preventing injury during and after a fall by using Personal Fall Arrest Systems (PFAS) or safety nets and having an effective rescue plan in place.



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24

There are several ways employers can protect workers from falls, including using conventional means such as guardrail systems, safety net systems and personal fall protection systems, the adoption of safe work practices, and the provision of appropriate training. The use of warning lines, designated areas, control zones and similar systems are permitted by OSHA in some situations and can provide protection by limiting the number of workers exposed.

Whether conducting a hazard assessment or developing a comprehensive fall protection plan, thinking about fall hazards before the work begins will help the employer to manage fall hazards and focus attention on prevention efforts. If personal fall protection systems are used, attention should be given to identifying attachment points and to ensuring that employees know how to properly use and inspect the equipment.

Conventional and Alternative Fall Protection Systems

Conventional and Alternative fall protection systems may be separated into two categories:

- Active Fall Protection Systems
- Passive Fall Protection Systems



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25

Introduce the two categories of fall protection systems.

Fall Protection Systems

ACTIVE

- Personal Fall Arrest Systems (PFAS)
- Positioning Device Systems
- Restraint System
- Warning Line Systems
- Controlled Access Zones
- Controlled Decking Zone
- Safety Monitoring Systems

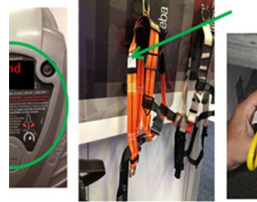
PASSIVE

- Safety Net Systems
- Protection from Falling Objects
- Guardrails*
- Hole Covers*
- * Eliminates Fall Hazards

Ask the class to explain why these examples are “active” or “passive.”

Personal Fall Protection Equipment for Personal Fall Arrest Systems (PFAS)

- A PFAS is a system with components that work together to protect workers when they fall from elevated heights.
- PFAS components include an anchorage, connectors, and a full-body harness, and may include a shock-absorbing lanyard, a retractable lifeline, and/or a deceleration device.



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27

Personal Fall Protection Equipment for Personal Fall Arrest Systems

Be sure to point out the PFAS acronym!

A PFAS is a system with components that work together to protect workers when they fall from elevated heights. PFAS components include an anchorage, connectors, and a full-body harness, and may include a shock-absorbing lanyard, a retractable lifeline, and/or a deceleration device (see 29 CFR 1926.500(b)).

PFAS components will be marked by the manufacturer with pertinent information specific to the equipment, such as warnings, serial/model number, capacity, and the materials used to make the component. Information (e.g., proper use, maintenance, inspection) about fall protection components is typically provided in equipment manuals.

Although some components may look the same, they may not be interchangeable if they are from different manufacturers or from different equipment series made by the same manufacturer.

Personal Fall Arrest System

- Harnesses
- The dorsal D-ring
- Fit is adjusted so that all straps are snug
- No dangling leg straps or arm straps



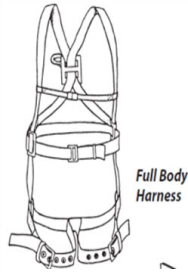
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28

- **Harnesses** include shoulder straps and leg straps, a sub-pelvic assembly, adjustable buckles or fasteners, and one or more D-rings to connect to a lanyard.
- **The dorsal D-ring** (between the worker's shoulder blades) is used with a fall arrest system.
- D-rings in other positions are sometimes included for use with ladder safety devices.
- Some harnesses come with D-rings on the front, sides, and lower back.

Full Body Harness



- A full body harness is required for fall arrest.
- Safety harnesses distribute fall-arrest impact through the thighs and buttocks.
- Safety belts (waist belts) are no longer permitted for use as personal fall arrest equipment.
 - In a fall arrest, they can cause serious damage to internal organs such as the spleen and pancreas.






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29

Discuss the features of a full body harness and explain why safety belts are no longer allowed.

Simple Steps to Fitting a Full Body Harness

<p><i>Simple steps to fitting a full body harness</i></p>  <p>Inspect</p>	 <p>Position back D-ring between shoulder blades</p>	 <p>Buckle up legs</p>	 <p>Buckle up front</p>	 <p>Adjust so the harness fits snugly and D-ring remains in the correct position</p>
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Use the illustrations or demonstrate how to properly fit a full body harness system.

Inspection and Maintenance of Personal Fall Arrest Systems

- To maintain their service life and high performance, all belts and harnesses shall be inspected frequently.
- Visual inspection before each use is required as is a routine inspection by a competent person.
- We will discuss specific conditions where the equipment should be removed from service and replaced.

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31

Introduce the concept of inspection and maintenance of PFAS.

Point out that the visual inspection before use is required, and routine inspections by a competent person are required.

Introduce the discussion of specific conditions where equipment must be removed from service and replaced.

Harness Inspection

- Begin at one end, hold the body side of the belt toward you, grasping the belt with your hands six to eight inches apart.
- Bend the belt in an inverted "U."
- Watch for frayed edges, broken fibers, pulled stitches, cuts or chemical damage. Check D-rings and D-ring metal wear pads for distortion, cracks, breaks, and rough or sharp edges.
- The D-ring bar should be at a 90 degree angle with the long axis of the belt and should pivot freely.

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32

Describe the steps for harness inspection.

Lifeline Anchors

- Anchorage points should be able to support 5000 pounds.
 - ****Remember: fall-arrest loads can be as high as 2000 pounds, depending on body weight and fall distance.***
- Suitable anchorages include:
 - Designed systems for repair or maintenance work.
 - Concrete or structural steel columns and beams.

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33

Emphasize the requirements for lifeline anchors.

Attaching Anchors

- Anchors for PFAS be able to hold at least 5,000 pounds.
- Always follow the anchor manufacturer's instructions or consult a qualified person.

Never anchor a fall arrest system to stink pipes, scupper drain covers, handrails, roof hatches, fixed ladders or stairs, vent pipes, formwork, shoring jacks, old masonry, or light structural parapets.

Point out the safety factor for anchor attachments and refer to the illustrations in the student text.

Lanyards

- Lanyards connect the harness directly to an anchorage.
- Lanyards should be either rope or synthetic web straps.
- Lanyards should have spliced eyes with thimbles and be fitted with locking snap hooks or D-clips.
- Lanyards with shock absorbers are strongly recommended.
 - Never shorten a lanyard by tying knots in it.



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35

Describe acceptable lanyards.

Lanyard Inspection

- When inspecting lanyards, begin at one end and work to the opposite end.
- Slowly rotate the lanyard so that the entire circumference is checked.
- Spliced ends require attention.

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36

Hardware

Snaps: Inspect closely for hook and eye distortion, cracks, corrosion, or pitted surfaces. The keeper or latch should seat into the nose without binding and should not be distorted or obstructed. The keeper spring should exert sufficient force to firmly close the keeper. Keeper locks must provide the keeper from opening when the keeper closes.

Thimbles: The thimble (protective plastic sleeve) must be firmly seated in the eye of the splice, and the splice should have no loose or cut strands. The edges of the thimble should be free of sharp edges, distortion, or cracks.

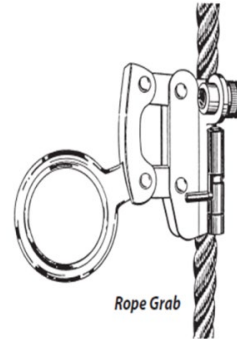
Steel Lanyards: While rotating a steel lanyard, watch for cuts, frayed areas, or unusual wear patterns on the wire. The use of steel lanyards for fall protection without a shock-absorbing device is not recommended. Do not use steel lanyards in the presence of electrical hazards.

Web Lanyard: While bending webbing over a piece of pipe, observe each side of the webbed lanyard. This will reveal any cuts or breaks. Due to the limited elasticity of the web lanyard, fall protection without the use of a shock absorber is not recommended.

Rope Lanyard: Rotation of the rope lanyard while inspecting from end to end will bring to light any fuzzy, worn, broken or cut fibers. Weakened areas from extreme loads will appear as a noticeable change in original diameter. The rope diameter should be uniform throughout, following a short break-in period. When a rope lanyard is used for fall protection, a shock-absorbing system should be included.

Rope Grabs

- Mechanical rope grabs are used to attach lanyards to vertical lifelines.
- Most rope grabs employ a device that locks on the lifeline when the lanyard is sharply tugged or pulled.
- Rope grabs must be installed in the right direction.



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37

Describe rope grabs.

Visual Indication of Damage to Webbing and Rope Lanyards

- Heat
- Chemical
- Ultraviolet Rays
- Molten Metal or Flame
- Paint and Solvents

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38

Heat-In excessive heat, nylon becomes brittle and has a shriveled brownish appearance. Fibers will break when flexed and should not be used above 180 degrees Fahrenheit.

Chemical - Change in color usually appears as a brownish smear or smudge. Transverse cracks appear when belt is bent over tight. This causes a loss of elasticity in the belt.

Ultraviolet Rays - Do not store webbing and rope lanyards in direct sunlight, because ultraviolet rays can reduce the strength of some material.

Molten Metal or Flame - Webbing and rope strands may be fused together by molten metal or flame. Watch for hard, shiny spots or a hard and brittle feel. Webbing will not support combustion, nylon will.

Paint and Solvents - Paint will penetrate and dry, restricting movements of fibers. Drying agents and solvents in some paints will appear as chemical damage.

Shock Absorbers

- Shock absorbers are strongly recommended for use in fall- arrest systems.
- Shock absorbers can reduce fall-arrest loads by as much as 50%
- Some shock absorbers are built into the lanyard.
- The tear-away type also gives clear indication that fall arrest has occurred and that the system should be replaced.
- Any fall arrest component involved in a fall arrest should be taken out of service to prevent reuse.

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39

Describe shock absorbers and explain how they are used.

Shock-absorbing Packs Inspection

- The outer portion of the shock-absorbing pack should be examined for burn holes and tears.
- Stitching on areas where the pack is sewn to the D-ring, belt or lanyard should be examined for loose strands, rips and deterioration.

Explain the process for inspecting shock-absorbing packs.

Cleaning of Equipment

- Basic care for fall protection safety equipment
- Nylon and polyester
- Drying

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41

- Basic care for fall protection safety equipment will prolong and endure the life of the equipment and contribute toward the performance of its vital safety function.
 - Proper storage and maintenance after use is as important as cleaning the equipment of dirt, corrosives or contaminants.
 - The storage area should be clean, dry and free of exposure to fumes or corrosive elements.
- Nylon and Polyester - Wipe off all surface dirt with a sponge dampened in plain water.
 - Squeeze the sponge dry. Dip the sponge in a mild solution of water and commercial soap or detergent.
 - Work up a thick lather with a vigorous back and forth motion. Then wipe the belt dry with a clean cloth. Hang freely to dry but away from excessive heat.
- Drying - Harness, belts and other equipment should be dried thoroughly without exposure to heat, steam or long periods of sunlight.

Lifelines

Vertical Lifelines	Horizontal Lifelines
<ul style="list-style-type: none">• Capable of sustaining a 5000 pound load and used by one worker• Free of defects and protected from abrasion• Anchored and long enough to reach safe landing level• Knotted at bottom to prevent grab from sliding off the end	<ul style="list-style-type: none">• Can increase the area in which a worker is protected• Automatic pass through allows worker to keep both hands free

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Vertical lifelines must be:

- capable of sustaining a 5000 pound load
- used by only one worker at a time
- free of cuts, abrasions, and other defects
- protected from chafing and abrasion
- long enough to reach the ground (or a safe landing level above ground)
- knotted at the bottom to prevent the grab from sliding off the end anchored to a fixed support capable of sustaining a 5000 load

Horizontal lifelines:

- can increase area where worker is protected
- use automatic pass through to allow workers to keep hands free

Using Fall Arrest Systems Safely

Ensure that personal fall arrest systems will, when stopping a fall:

- Limit maximum arresting force to 1,800 pounds.
- Be rigged such that an employee can neither free fall more than 6 feet nor contact any lower level.
- Bring an employee to a complete stop and limit maximum deceleration distance to 3½ feet.

Describe points on the slide for using fall arrest systems safely.

Measurements for Assessing Fall Hazards and Controls

Distance of Fall

The diagram shows a worker on a platform. A lanyard of 6 ft. length is attached to an anchorage point above the platform. The worker falls 6 ft. from the platform. The deceleration distance is 3 1/2 ft. The safety factor is 3 ft. The total distance from the anchorage to the ground is 18 1/2 ft.

- A few basic measurements and equations can aid in evaluating:
 - The necessary total fall clearance distance for PFASs
 - Swing fall hazards for PFASs

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Explain the diagram.

Total Fall Distance for PFAS

- The total fall clearance distance is the minimum vertical distance between the worker and the lower level.
- The total fall clearance distance is calculated *before* a decision is made to use a PFAS.

Please note *If the available distance is not greater than the total fall clearance distance, it is inappropriate to use the PFAS and a fall restraint system might be used instead.

Introduce the calculations needed to determine fall clearance distance.

Total Fall Clearance Distance Calculations

- Simple to perform based on several factors, including:
 - Lanyard length;
 - The height at which the lanyard is anchored relative to where the other end attaches to the worker's harness;
 - The distance the worker will travel as the deceleration device absorbs the energy from the fall (i.e., slows it down);
 - The worker's height;
 - D-ring shift; and
 - A safety factor.

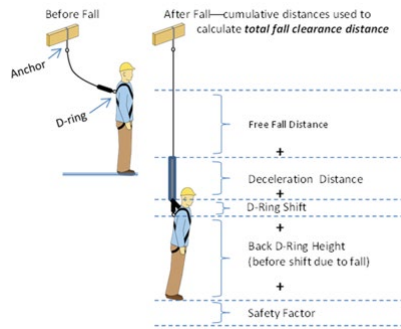
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46

Describe each factor.

Calculating Total Fall Clearance



- Free fall distance must be 6 feet or less and prevent the worker from contacting a lower level.
- Deceleration distance must be no greater than 3.5 feet.
- D-ring shift is often assumed to be one foot.
- Back D-ring height is often standardized as five feet for six-foot-tall workers.
- Safety factor is typically 2 feet.

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47

Use the illustration to make sure the students understand the calculation.

Total Fall Distance Equation

- A fall arrest system will not protect a falling worker if the calculated clearance distance is greater than the actual distance available below the elevated work area.

Clearance Distance	=	Free Fall Distance	+	Deceleration Distance (lanyard/lifeline stretch/elongation)	+	D-Ring Shift (harness slip)	+	Back D-Ring Height	+	Safety Factor
<i>Calculate</i>	=	<i>See chart below</i>	+	<i>Assume 3.5 feet*</i>	+	<i>Assume 1 foot*</i>	+	<i>Assume 3 feet*</i>	+	<i>Typically 2 feet</i>

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48

The equation shows how to add the various values in order to calculate total fall clearance distance.

Exhibit 2-1: Fall Distance Calculations Exercise (pp. 2-12, 2-13)

Calculating free fall distance based on D-ring location:

D-ring ABOVE Anchor

- Free fall distance = Lanyard length + Distance from D-ring to anchor

D-ring BELOW anchor

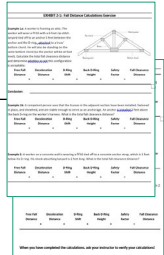
- Free fall distance = Lanyard length - Distance from D-ring to anchor

D-ring LEVEL with anchor

- Free fall distance = Lanyard length

Workers using a **shock-absorbing lanyard (e.g., ripstitch lanyard)**

- Self-retracting lanyards typically activate, and thus limit free fall distance, within 2 feet



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Slide is shown during Module 2a exercise. Make sure each student fills in the correct answers in their Student Manual.

Example 1a: Free fall distance = 6-foot lanyard + 5 feet between the anchor and D-ring = 11 feet

Answer 1a: The free fall distance (11 feet) is greater than the 6-foot maximum.

(The free fall distance can be reduced by moving the anchor above the D-ring. For example, if a section of truss has been stabilized and sheathed, the anchorage point might be moved above the worker's head.)

Example 1b: Free fall distance = 6-foot lanyard – 2 feet between the anchor and D-ring = 4 feet, Deceleration distance = 3.5 feet, D-ring shift = 1 foot, Back D-ring height = 5 feet, Safety factor = 2 feet. **Answer 1b:** total necessary fall clearance distance = 4 + 3.5 + 1 + 5 + 2 = 15.5 feet.

Example 2: Free fall distance = 2-foot lanyard + 1 foot between the anchor and D-ring = 3 feet, Deceleration distance = 3.5 feet, D-ring shift = 1 foot, Back D-ring height = 5 feet, Safety factor = 2 feet. **Answer 2:** total fall clearance distance = 3 + 3.5 + 1 + 5 + 2 = 14.5 feet. In this case the free fall distance is 3 feet (less than OSHA's 6-foot maximum); however, the total fall distance is 14.5 feet. There needs to be at least 14.5 feet of clear space below the worker. Where guardrails cannot be used, fall restraint is a better option than fall arrest for a work area with limited clearance below.

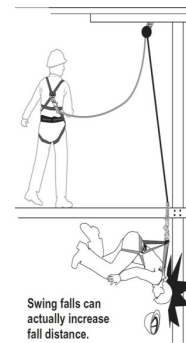
Example 3: Free fall distance = 4-foot lanyard, Deceleration distance = 3.5 feet, D-ring shift = 1 foot, Back D-ring height = 5 feet, Safety factor = 2 feet. **Answer 3:** total fall clearance distance = 4 + 3.5 + 1 + 5 + 2 = 15.5 feet.

Example 4: Free fall distance = 6-foot lanyard – 4 feet between the D-ring and the anchor = 2 feet, Deceleration distance = 3.5 feet, D-ring shift = 1 foot, Back D-ring height = 5 feet, Safety factor = 2 feet. **Answer 4:** total fall clearance distance = 2 + 3.5 + 1 + 5 + 2 = 13.5 feet.

Example 5: Free fall distance = 2 feet (This self-retracting lanyard automatically limits free fall distance to 2 feet as stated in the Example 5 problem statement (see [29 CFR 1926.502\(d\)\(12\)](#)). Deceleration distance = 3.5 feet, D-ring shift = 1 foot, Back D-ring height = 5 feet, Safety factor = 2 feet. **Answer 5:** total fall clearance distance = 2 + 3.5 + 1 + 5 + 2 = 13.5 feet. This value can then be compared to the vertical clearance actually available at the work location.

How To Evaluate The Swing Fall Hazard

- The swing fall hazard is created by the pendulum effect.
- A worker who falls while connected to an anchor (unless it is directly overhead) will swing back and forth like a pendulum.
- Workers can be seriously injured if they strike objects during a swing fall.



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50

- The swing fall hazard is created by the pendulum effect, which can swing a fallen worker into a nearby surface, such as a wall or protruding beam.
- In addition to calculating the total fall clearance distance before beginning work on an elevated level, it is important to evaluate the swing fall hazard at the edges where a worker might fall.
- A worker who falls while connected to an anchor (unless it is directly overhead) will swing back and forth like a pendulum.
- Workers can be seriously injured if they strike objects during a swing fall.

NOTE: Installing the anchorage point directly above the work area (i.e., connected to an overhead attachment point with sufficient strength) will help prevent injury

Fallen Worker Rescue

Aided Rescue

- Worker who is suspended from a lifeline and cannot perform a self-rescue
- Will need help from trained rescuers using appropriate equipment
- Off-site emergency response personnel may rescue suspended workers

***Note: Most 911 responders are not trained in how to do so**

Self-Rescue

- Worker can take steps to minimize suspension trauma
- Self-rescue methods allow fallen worker to temporarily relieve pressure on the legs
- Worker may be able to lower himself or herself to the lower level

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51

Rig fall arrest systems to allow movement of the worker only as far as the edge of the walking/working surface, when used at hoist areas. An effective fallen worker rescue plan addresses the procedures, equipment, and personnel needed to ensure that a rescue proceeds quickly and efficiently when a fall occurs.

Even when a PFAS works properly, the fallen worker is still in danger. The worker's body weight places pressure on the harness straps, which can compress the veins, and cause blood to pool, in the lower extremities and reduce blood return to the worker's heart.

This condition is called suspension trauma, also known as harness hang syndrome. In medical terms, this results in orthostatic intolerance. If the pressure is not reduced promptly, the worker can lose consciousness within minutes. To delay post suspension trauma, activate the rescue plan immediately.

Self-rescue and aided rescue are two techniques for rescuing a suspended worker. Rescuing the worker promptly (i.e., aided rescue) or ensuring the worker can self-rescue is imperative to preventing injury or a fatality.

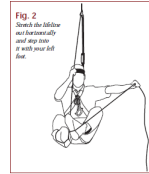
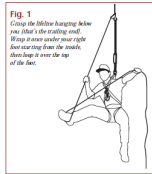
How To Self-Rescue

- The first thing you should do is relieve the harness pressure.
- The foot wrap will relieve the pressure and allow you to climb up or down for short distances.

Introduce the initial step for self-rescue.

How To Do A Foot Wrap: Figure 1 & Figure 2

- Step 1 - Grasp the lifeline hanging below you (that's the trailing end). Wrap it once under your right foot starting from the inside, then loop it over the top of the foot.
- Step 2 - Stretch the lifeline out horizontally and step into it with your left foot.



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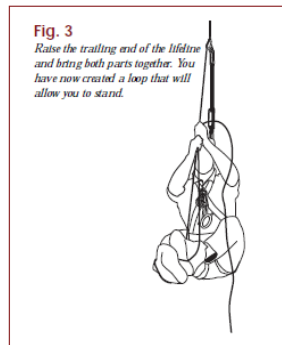
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53

Explain how to do a Foot Wrap.

How To Do A Foot Wrap: Figure 3

- *Step 3 - Raise the trailing end of the lifeline and bring both parts together. You have now created a loop that will allow you to stand.*



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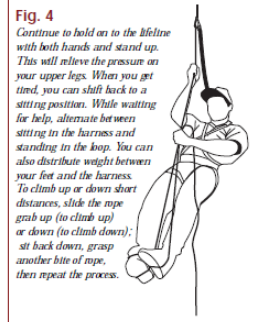
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54

Explain how to do a Foot Wrap (continued).

How To Do A Foot Wrap: Figure 4

- *Step 4 - Continue to hold on to the lifeline with both hands and stand up.*
- *This will relieve the pressure on your upper legs. When you get tired, you can shift back to a sitting position.*
- *While waiting for help, alternate between sitting in the harness and standing in the loop. You can also distribute weight between your feet and the harness.*
- *To climb up or down short distances, slide the rope grab up (to climb up) or down (to climb down); sit back down, grasp another bite of rope, then repeat the process.*



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55

Explain how to do a Foot Wrap (continued).

Hands-on Exercises

- Practice the following skills
- Skill Set #1 Inspection of complete PFAS System
- Skill Set #2 Don full body harness
- Skill Set #3 Identifying the proper steps in determining how and when to use a personal fall protection system
- Skill Set #4 Perform a foot wrap for self-rescue

Work in Groups of 2 to 6

Instructors must complete a skill check-off for each skill set.

MODULE 2 NOW YOU KNOW...

- Difference between Fall Protection and Fall Prevention
- Order of fall protection: engineering controls, a fall restraint system, followed by a fall arrest system
- “*Personal fall arrest system*” (PFAS): body harness, an anchorage, and connectors (may include a lanyard, deceleration device, lifeline, or suitable combination)
- Safety belts (waist belts) no longer permitted for use as personal fall arrest equipment

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57

- Preventing workers from falling by using engineering controls (e.g., guardrails and hole covers) or restraint systems is known as fall prevention . Preventing injury during and after a fall by using Personal Fall Arrest Systems (PFAS) or safety nets and having an effective rescue plan in place is known as Fall arrest/protection
- The preferred order of fall protection is; engineering controls, a fall restraint system, followed by a fall arrest system
- “*Personal fall arrest system*” (PFAS) means a system used to arrest an employee in a fall from a working level. It consists of a body harness, an anchorage, and connectors and may include a lanyard, deceleration device, lifeline, or suitable combinations of these
- Safety belts (waist belts) are no longer permitted for use as personal fall arrest equipment

MODULE 2 NOW YOU KNOW (continued)...

- Anchorage points should be able to support 5000 pounds
- Always follow the anchor manufacturer's instructions, consult a qualified person when installing and using anchors
- Never shorten lanyard by tying knots or looping over object and tying back to itself
- Free fall distance cannot exceed 6 feet
- Self-retracting lanyards limit free fall distance (up to 2 feet)
- Visually inspect equipment before each use and have routine inspection by a competent person

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58

Review Key Points on slide:

- * Anchorage points should be able to support 5000 pounds.
- * Always follow the anchor manufacturer's instructions or consult a qualified person when installing anchors to ensure they are strong enough to hold the sudden weight of a falling worker.
- * Never shorten lanyard by tying knots or looping over object and tying back to itself.
- * Total fall clearance free fall distance cannot exceed 6 ft.
- * Self-retracting lanyards limit free fall distance, within 2 feet.
- * Visual inspection before each use is required as is a routine inspection by a competent person.

Additional reminders:

- * Never anchor a fall arrest system to sink pipes, scupper drain covers, handrails, roof hatches, fixed ladders or stairs, vent pipes, formwork, shoring jacks, old masonry, or light structural parapets.
- * Install a continuous pass through horizontal lifeline. It allows workers to move through multiple spans with 100% tie-off at all times.
- * When using a self-retracting lifeline be sure to check the manufacturer guidelines.
- * Make sure the lines do not run over an unpadding, sharp edge.
- * Be sure to evaluate the potential for a swing fall.
- * When inspecting snap hooks, the keeper or latch should be double locking to prevent rollout.

FALL PROTECTION/ FALL PREVENTION

TAKE A BREAK

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59