II. Fall Arrest Systems

Fall arrest systems are designed to prevent or reduce injuries when a worker falls from an elevated height.

II.A. Safety Net Systems

Safety net systems (see Figures 12 and 13) are an option when workers are working at elevated heights with hazardous vertical drops (see Table 2). Safety net systems are commonly used during work on bridges and large structures. The nets are available in various sizes and materials, including materials resistant to ultraviolet deterioration.

Table 2. Safety Net System Dimensions

Vertical Distance from Working Level to Horizontal Plane of Net	Minimum Required Horizontal Distance of Outer Edge of Net from Edge of Working Surface
Up to 5 feet	8 feet
More than 5 feet, up to 10 feet	10 feet
More than 10 feet, up to 30 feet	13 feet
More than 30 feet	Safety net not permitted as fall protection
See 29 CFR 1926.502(c)(1), (c)(2)	

Figure 12. Safety net system.

Figure 13. Safety net system.

II.B. Personal Fall Protection Equipment for Personal Fall Arrest Systems

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 (see Figure 14). 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

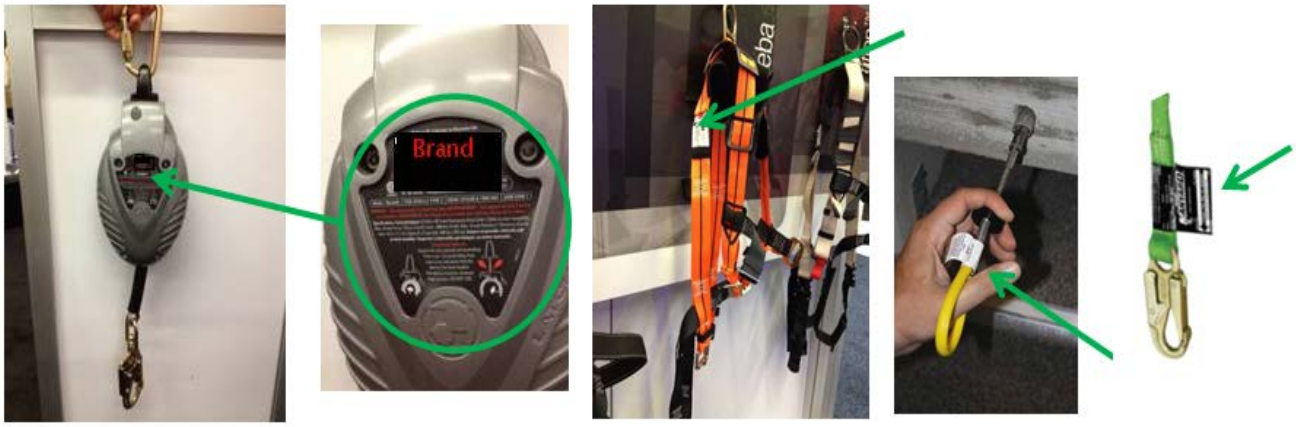


Figure 14. Examples of manufacturers' labels for various types of fall protection equipment.

same manufacturer.

II.B.1. Component Compatibility

Personal fall protection system effectiveness relies on component compatibility. Often, components are supplied together as a set. Using non-compatible fittings can lead to damage and system failure (see 29 CFR 1926.502(d)(5)).

A compatibility assessment should be performed when using fittings from different manufacturers or different product lines from the same manufacturer. This includes assessing the way fittings connect to each other and confirming with the manufacturer(s) that the fittings can be used together safely.

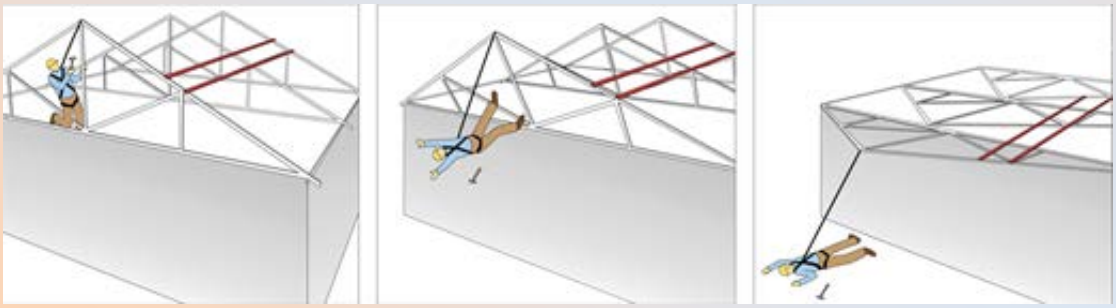
For additional information see:

Many factors can contribute to a workers' risk of falling from an elevated work area. Examples include precarious work positions, excessive leaning or reaching, improper work practices, unstable structures, trip hazards, slippery surfaces, and distractions.

When guardrails are not an option, personal fall protection equipment is helpful in some situations, but only when properly selected, worn, and attached to an adequate anchor point.

A personal fall arrest system was not a good choice in this case. In the illustration below, the trusses were not fully installed, braced and sheathed, so they did not form a sufficiently strong anchor point. The structure collapsed when it received the sudden force of the falling worker.

The fall hazard could have been eliminated by pre-assembling the truss sections (groups of several trusses) on the ground or using special devices that serve as temporary bracing for fall arrest equipment.



Compatibility of Personal Fall Protection System Components, OSHA Safety and Health Information Bulletin, www.osha.gov/dts/shib/shib092203.html.

II.B.2. Anchorage

Anchorage systems normally include, at a minimum, a building structure and an anchorage device to which the worker will tie off (see Appendix C).

Anchors are fixed to a strong structural member. Anchors are not effective if they are attached to weak materials. Certain structural members may not be strong enough to hold the sudden weight imposed by a falling worker. The anchorage manufacturer should provide instructions on anchor installation (see 29 CFR 1926.502(d)(15); 29 CFR 1926.1423(g)).

Many anchors are removed when they are no longer needed. Other anchors are designed to be left in place for future use (e.g., repeated servicing), or are covered over during the job (e.g., with roofing shingles), or are cut flush with the surrounding surface (e.g., concrete bolt-style anchor protruding from a wall). Appendix C provides fall protection anchor examples.

(See 29 CFR 1926 Subpart M, Appendix C(II)(h), Tie-off considerations)

II.B.3. Lanyards

A lanyard is a flexible rope, wire rope, or strap which generally has a connector at each end for connecting the body belt or body harness to a deceleration device, lifeline, or anchorage point (see 29 CFR 1926.500(b)). Some manufacturers offer adjustable length lanyards. Effective lanyards are maintained in a clean, intact condition, and inspected prior to each use for wear, tear, and any obvious distortion or signs that the fall arrest (energy-absorbing) system has been activated (see 29 CFR 1926.502(d)(21)).

Inspecting a lanyard involves beginning at one end and continuing to the opposite end. During an inspection, the lanyard is slowly rotated so that its entire circumference is checked. Spliced ends require particular attention.

Lanyards used for personal fall protection are not to be used for hoisting materials. Equipment used for hoisting is not suitable for use in a fall protection system (see 29 CFR 1926.502(d)(18)).

II.B.3.i. Deceleration Device

A deceleration device is a mechanism (e.g., tearing or deforming lanyards) that serves to dissipate energy during a fall to limit the energy and stress imposed on a worker during a fall. Deceleration occurs over a maximum distance of 3.5 feet (see 29 CFR 1926.502(d)(16)(iv)). Deceleration devices vary widely. Examples include:

- **Self-retracting lanyard.** A self-retracting lanyard/lifeline contains a drum-wound line which can be slowly extracted or retracted. The lanyard extends as necessary to allow the worker to move about the work area, but retracts as necessary to maintain slight tension, preventing the line from becoming slack. The drum is under slight tension during normal worker movement and automatically locks the drum when the line is extracted too rapidly (see 29 CFR 1926.500(b)).

  Self-retracting lanyards and lifelines that limit free fall to two feet or less need to sustain, at a minimum, 3,000 pounds applied to the device with the lanyard in the fully extended position (see 29 CFR 1926.502(d)(12)).

  Self-retracting lanyards that do not limit free fall to two feet or less need to sustain, at a minimum, 5,000 pounds applied to the device with the lanyard in the fully extended position (see 29 CFR 1926.502(d)(13)).

  Some retractable lifelines provide a deceleration (energy-absorbing) function. These lifelines can include a feature that slows the fall over a distance of up to 3.5 feet (see 29 CFR 1926.502(d)(16)(iv)).

- **Rip-stitch lanyards.** A rip-stitch lanyard has extra webbing incorporated into the lanyard. The extra webbing is stitched into place and folded

lengthwise along the lanyard. During a fall, the weaker stitching allows the folded webbing to pull away at a controlled speed, slowing the fall.

- **Shock-absorbing lanyards.** The webbing in a shock-absorbing lanyard is designed to stretch as it receives the worker's falling weight. The stretching action breaks the fall in a controlled manner.
- This is not an all-inclusive list of lanyards. OSHA expects that emerging lanyard technology will continue to improve safety in the workplace.

II.B.4. Vertical and Horizontal Lifelines

A lifeline is a component consisting of a flexible line for connection to an anchorage at one end to hang vertically (vertical lifeline) or for connection to anchorages at both ends to stretch horizontally (horizontal lifeline), and which serves as a means for connecting other components of a PFAS to the anchorage (see 29 CFR 1926.500(b)).

Vertical lifelines remain connected to a set anchorage point while the lanyard moves with the worker. If the worker falls, the clip locks (cable grab) to the lifeline and stops the worker from falling further. When vertical lifelines are used each worker generally needs to be attached to a separate lifeline (see 29 CFR 1926.502(d)(10)).

Vertical and Horizontal Lifelines

Lifelines function as an extension of an anchorage system, allowing an employee to move up and down (vertical lifeline) or back and forth (horizontal lifeline) across a work area. A sliding fitting (rope grab or shuttle) connects to the line and a lanyard connects the worker's harness to that sliding fitting.

Vertical lifelines require active participation by the worker, who must often reposition the rope grab when moving to a new position.

Horizontal lifelines require special attention during design and installation to: (1) limit the distance the worker can fall (a greater sag in the line can mean a farther fall); and (2) minimize the forces on the connectors at the anchorage (a greater sag in the line can mean lower forces on the anchorage connectors at either end). A qualified person must supervise the horizontal lifeline's design, installation, and use (see 29 CFR 1926.502(d)(8)).

Depending on their geometry and sag angle, horizontal lifelines may be subjected to greater loads than the impact load imposed by an attached component. When the horizontal lifeline's sag is less than 30 degrees, the impact force imparted to the lifeline by an attached lanyard is greatly amplified. For reference, a 15-degree sag angle amplifies the force approximately 2:1. A 5 degree sag angle amplifies the force approximately 6:1. See 29 CFR 1926 Subpart M Appendix C for more information.

When a horizontal lifeline is used for multiple tie-offs, if one worker falls, the lifeline's movement may cause other workers to fall.

OSHA is aware of emerging fall protection technology, such as pre-manufactured horizontal lifelines, that will continue to improve workplace safety.

For additional information see OSHA's Fall Protection – It's a Snap: Fall Protection Information.

II.B.5. Full-Body Harnesses

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. For this reason, some harnesses come with D-rings on the front, sides, and lower back.

A safe and effective harness will fit (i.e., be the correct size) and is adjusted so that all straps are snug (see Figure 15). Dangling leg straps or arm straps are signs that the harness is not being worn correctly. The sub-pelvic assembly transfers the forces during a fall or suspension to the worker's sub-pelvic region.

Although adjustable, some models come in different sizes and may be gender specific. See OSHA's Fall Protection – It's a Snap: Fall Protection Information.

Inspect	Position back D-ring between shoulder blades	Buckle up legs	Buckle up front	Adjust so the harness fits snuggly and D-ring remains in the correct position

Figure 15. Simple steps to fitting a full body harness.

II.B.6. Body Belts

A body belt is a wide band that buckles around the hips with means both for securing it about the waist and for attaching it to a lanyard, lifeline, or deceleration device. Body belts serve as positioning devices that position a worker so the person can perform a job safely in a vertical work position. Body belts are designed to hold a worker in place and reduce the possibility of a fall (see 29 CFR 1926.502(e); 29 CFR 1926 Subpart M Appendix D).

II.B.7. Ladder Safety Devices

Ladder safety devices or systems are used to climb fixed ladders. The system includes a body harness, carabiner, carrier rail, and safety sleeve. Ladder safety devices are available as a cable (i.e., vertical lifeline) or fixed rail system (see Figure 16 and 29 CFR 1926.1053(a)(18), (a)(22), (a)(23)).

The worker wears a body harness attached to the system by a carabiner. The system uses a cable/safety sleeve, shuttle, or cable grab specifically designed to attach the climber to the vertical line or rail. The cable grab or shuttle freely travels up or down the lifeline/rail as the worker ascends or descends the ladder, allowing the worker to maintain full contact with the ladder. If the worker falls, a locking cam or friction brake in the cable grab or shuttle locks onto the cable or rail and arrests the fall.

Typically, cable and fixed rail systems are permanently attached to the ladder or supporting structure. The cable (flexible carrier) or rail (rigid carrier) is attached by mountings at the top and bottom of the fixed ladder, with intermediate mountings or cable guides for added strength. Existing ladders may be retrofitted with commercially available ladder climbing systems.

A ladder climbing system should not be confused with a “climb assist” system, which consists of motorized equipment that ascends the ladder and partially bears the worker’s weight. Some, but not all, climb assist systems incorporate fall protection features.

Figure 16. Ladder safety device.

II.C. Fallen Worker Rescue

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 (see Figure 17). 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. (See OSHA SHIB - Suspension Trauma/Orthostatic Intolerance www.osha.gov/dts/shib/shib032404.html)

Figure 17. Worker suspended in harness prior to rescue.

See Washington Industrial Safety & Health Division's Fall Protection Responding to Emergencies.

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 (see 29 CFR 1926.502(d)(20)).

II.C.1. Aided Rescue

A worker who is suspended from a lifeline and cannot perform a self-rescue will need help from trained rescuers using appropriate equipment, including appropriate fall

protection. Off-site emergency response personnel may rescue suspended workers, although most 911 responders are not trained in how to do so.

II.C.2. Self-Rescue

With proper personal fall protection equipment, training and practice, a fallen worker can take steps to minimize suspension trauma. Self-rescue methods allow a fallen worker to temporarily relieve pressure on the legs or in some cases to even lower himself or herself to the lower level. Self-rescue methods are discussed in detail in Washington Industrial Safety & Health Division's Fall Protection Responding to Emergencies.