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The Basics of Fall Protection (Updated Feb. 2012)



“Each employee on a walking/working surface (horizontal and vertical surface) with an unprotected side or edge which is 6 feet (1.8 m) or more above a lower level shall be protected from falling by the use of guardrail systems, safety net systems, or personal fall arrest systems..”

OSHA 1926.501(b)(1)

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Fall protection and confined space, perhaps more than any other area of safety, tends to seem overwhelming. There is no room for error and miscalculations are most often fatal. The pull of gravity cannot be underestimated.

Fall protection, however, doesn't need to be so frightening if some basic principles are applied and some basic rules followed. The purpose of this paper is to try to make fall protection as simple as hand protection or head protection.

The Basics

First of all, we need to know what is required and why.

According to subpart M of the OSHA 1926.502 Code of Federal Regulations:

“Each employee on a walking/working surface (horizontal and vertical surface) with an unprotected side or edge which is 6 feet (1.8 m) or more above a lower level shall be protected from falling by the use of guardrail systems, safety net systems, or personal fall arrest systems.”

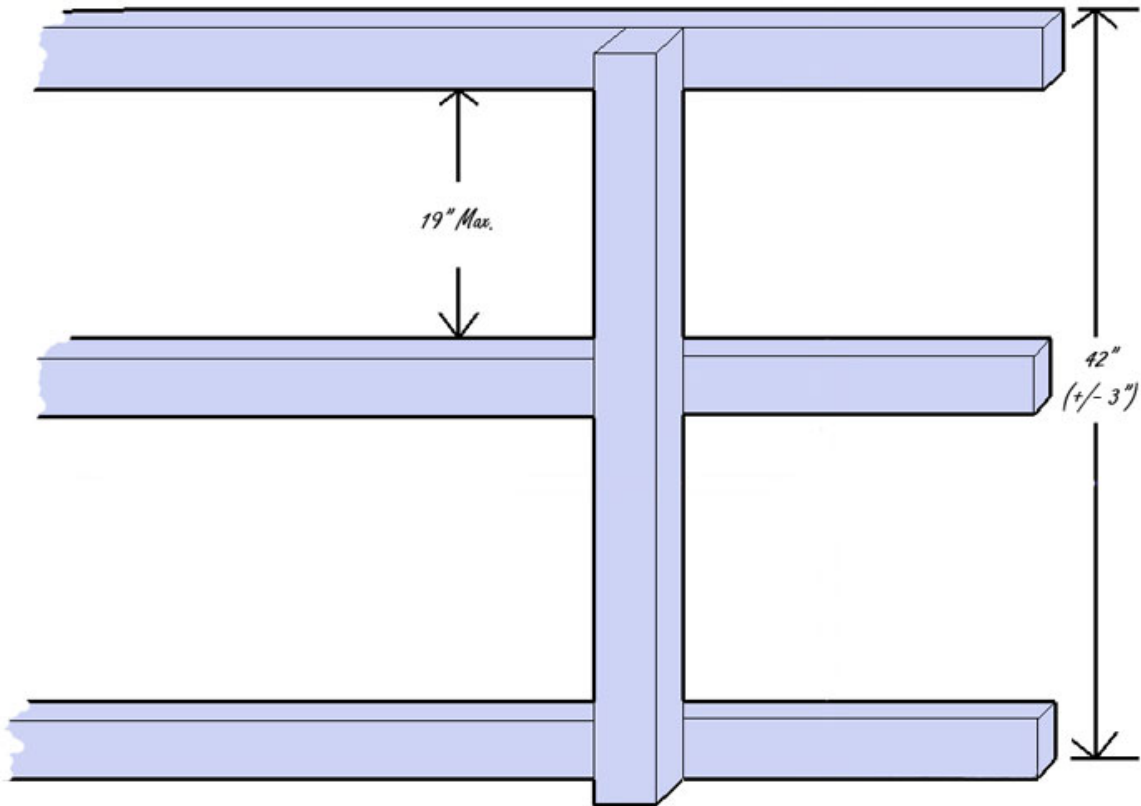
The standard additionally addresses issues with falls from:

- unprotected sides and edges 1926.501(b)(1)
- leading edges 1926.501(b)(2)
- walking and working surfaces where leading edges are under construction 1926.501(b)(2)(ii)
- hoist areas 1926.501(b)(3)
- holes in walking and working surfaces 1926.501(b)(4)
- formwork and reinforcing steel 1926.501(b)(5)
- ramps, runaways, and other walkways 1926.501(b)(6)
- excavations 1926.501(b)(7)
- dangerous equipment 1926.501(b)(8)
- overhand bricklaying and related work 1926.501(b)(9)
- low-slope and steep roofs 1926.501(b)(10)
- Steep roofs 1926.501(b)(11)
- precast concrete erection; 1926.501(b)(12)
- Residential Construction 1926.501(b)(13)
- Wall Openings 1926.501(b)(14)
- Walking/Working surfaces not otherwise addressed 1926.501(b)(15)

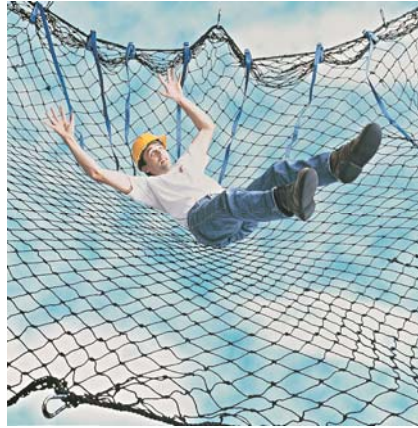
Fall arrest Systems fall into one of two categories, Passive or Active.

1. Guardrail Systems (Passive System)

Guardrail systems rails made up of vertical rails, top rails and mid rails. They are designed to keep workers from getting too close to the leading edge. They must be 42" (+ or - 3") above the walking/working level and must be able to withstand a force of at least 200 lbs as applied 2" from its top edge. Additionally, it must be able to withstand a force of 150 lbs downward or in any direction . Intermediate vertical members, between posts, must be no more than 19 inches apart.



2. Safety Net Systems (Passive System)



Unlike railing, [netting](#) is designed to catch the worker who has fallen off the leading edge. The netting is connected to the side of the building and stretched out, being supported by panels and wires. The mesh of the netting can be no more than 6” wide. The netting should be installed as near the working surface as possible but no farther than 30 feet below. It must withstand the force of a 400 lbs bag of sand 30” in diameter being dropped from the working surface.

The distance from the edge of the working surface to the outer edge of the netting is shown in the table below:

Horizontal and vertical safety net distances form a working surface	
Net distance below the working surface	Minimum horizontal distance of net from the edge of the working surface
Up to 5 feet	8 feet
More than 5 up to 10 feet	10 feet
More than 10 feet	13 feet

The net needs to be inspected and damaged sections replaced at least once a week. Any debris that has fallen into the netting must be removed before the next work shift.

3. Personal Fall Arrest Systems (Active System)

Personal Fall Arrest Systems refer to any number of anchor-connector-harness combinations. This is perhaps the most common type of fall protection on the market and we will spend the rest of this paper addressing all the components of this system.

Understanding the ABCs of Fall Protection

While “ABC” is usually used to refer to the basics, in the case of fall protection it also stands for the three basic components of fall protection.

Additionally we add D.

A = Anchorage or Anchor point

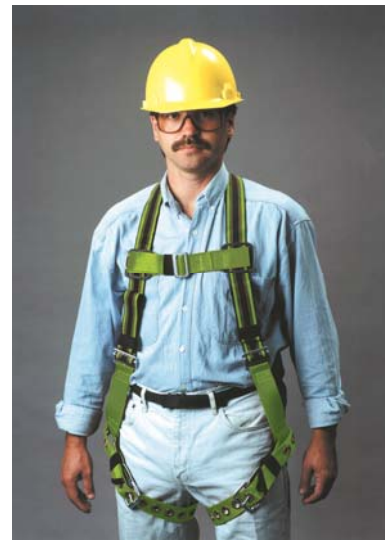
Also known as the tie-off point, this is the point of attachment for the lanyard, the lifeline or the deceleration device. The anchor must support 5,000 lbs of pressure or twice the expected load when in fall arrest mode (requirements are different for **work positioning** anchor points which must support 3,000 lbs of static strength and **restraint and travel restriction** anchor points must support 1,000 lbs of static strength). That’s a lot of pressure! 2 x 4s, pipes or chimneys will not do. There are a number of good [anchor points](#) designed by various manufacturers some are permanent (and can be used again if and when needed), others are removed once the work is finished.



Anchor points can be fixed point anchors (FPAs) or Mobile Anchorage Points. Systems such as [Horizontal Lifelines](#) (HLLs) and [trolleys](#) are examples of mobile anchor points.

B = Body Harness

The [body harness](#) is the combination of straps that distribute the fall arrest force over the chest, thighs, waist, pelvis and shoulders. Body harnesses come in a variety of styles and configurations with a corresponding range in pricing. Harnesses have buckles and adjustable straps for proper fitting. Some are sized (small, medium, large, XL, etc...) while others are universal. Whichever harness you choose, make sure that it is properly tightened and fitted to your body. While a harness that is too tight is restricting and



uncomfortable to work in, a loose fitting harness can be extremely dangerous, particularly in the pelvic region (a fall in a loose harness can result in serious and even permanent damage to genital area).

The connecting D-Ring in a properly fitted harness should be located right between the shoulder blades. Make sure that the harness you are using is approved for industrial work. Recreational harness (rock climbing harnesses) are not approved.

Belts can only be used for positioning or restraint, **NEVER** for fall arrest.

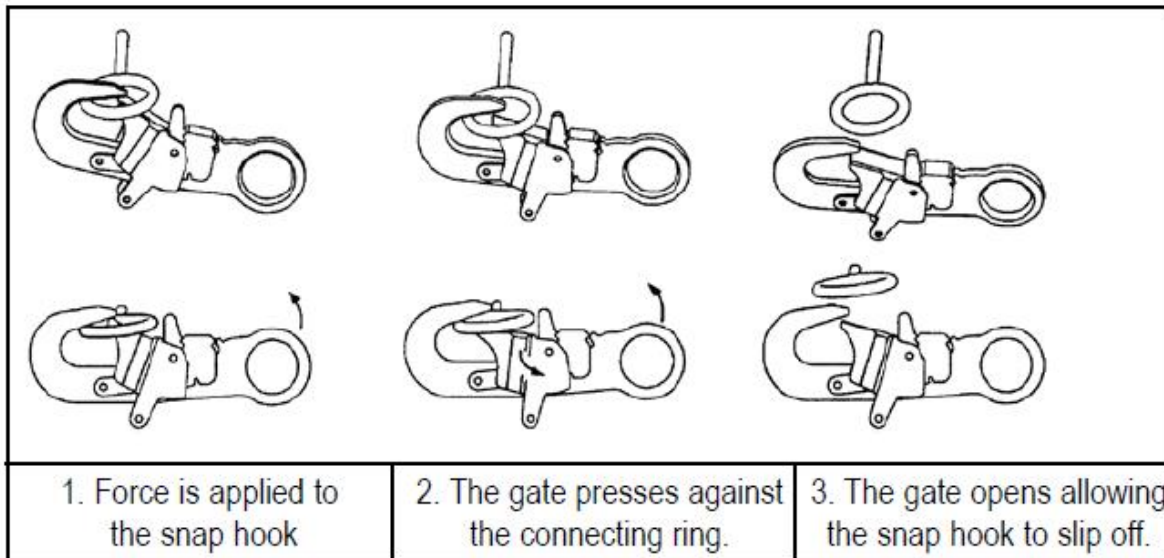
C = Connectivity

The connector refers to the device used to link the body harness to the anchor point. Lanyards, Self-Retracting Lifelines (SRLs) and Shock-Absorbing Lifelines are all different types of connectors.

The gate strength requirements for snaphooks and carabiners was revised as of 2009 to 3,600 lbs in all directions.

Note: It is essential that the user understand the nature of the “compatibility of connectors”. Compatibility is defined such that connecting elements work together so that their size and shape does not cause the gate or snaphook to inadvertently open or roll out, no matter how they get turned while in use (see example graphic below).





(Source: Capital Safety's "[Thinking about fall protection](#)")

In order to ensure connector compatibility, the connector should fit through the anchor point (e.g. the gate on the shock absorbing lanyard should fit through the steel ring of the cross arm strap it will be connected to).

A deceleration device is a type of connector (see above) that is designed to limit the amount of force exerted on the body. The amount of force exerted cannot exceed 1800 lbs according to OSHA (900 lbs according to the ANSI standard). [Self-Retracting Lifelines](#) work like a seatbelt in the car, by locking up as soon as the cable or webbing is rapidly pulled through as would be the case with a fall. [Shock-Absorbing Lanyards](#) work by "tearing out" in order to reduce the amount of force.

D

= **Descent and Rescue**

D is often the neglected part of fall protection but one that is, nonetheless, just as important. Suspension trauma, or "orthostatic intolerance," results when blood circulating in the body is reduced or trapped in the legs. This can be extremely harmful to the brain, the heart and to other organs that might not get enough blood. Additionally, the heart is often unable to cope effectively with the sudden rush of "dirty" blood that occurs once the suspended person is rescued. Serious injury and fatality can occur after a relatively short time of being suspended. It

is therefore crucial to have an effective rescue plan outlined to get a suspended person down immediately. Again there are a number of [SRL's](#), [trauma suspension straps](#) and other fall protection products that are specifically designed to aid in this step.

Calculating the Fall Distance

Many people simply don't realize how far a person will actually fall when he or she takes a fall. The proper fall clearance is reached when all the measurements are added up.

6 ft (length of lanyard) + **3 ½ ft** (deceleration or free fall distance) + **1 ft** (harness stretch) + **5 ft** (average distance from back D-ring to the sole of the foot on 6 ft worker) + **3 ft** (safety factor) = **18 ½ feet**

How to Put on a Harness

(taken from www.millerfallprotection.com)

6 Easy Steps that Could Save Your Life



Step 1
Hold harness by back D-ring.
Shake harness to allow all
straps to fall in place.



Step 2
If chest, leg and/or waist
straps are buckled, release
straps and unbuckle at this
time.



Step 3
Slip straps over shoulders so
D-ring is located in middle of
back between shoulder
blades.



Step 4
Pull leg strap between legs
and connect to opposite end.
Repeat with second leg strap.
If belted harness, connect
waist strap after leg straps.



Step 5

Connect chest strap and position in midchest area. Tighten to keep shoulder straps taut.



Step 6

After all straps have been buckled, tighten all buckles so that harness fits snug but allows full range of movement. Pass excess strap through loop keepers.

A Complete Fall Protection Program

In order to put together a complete fall protection program there are several steps that you need to implement.

1. Make sure you understand all the rules and regulations. This paper is just a guide to try to make fall protection a little easier to understand. For a complete fall protection program it is important to read and understand the standard (www.osha.gov) as well as the recommendations put out by ANSI (www.asse.org).
2. Assess all potential fall hazards. A proper assessment involves identifying the nature of the work that will be done in order to properly understand where the risks are greatest. The assessment should also include other potential hazards (respiratory, heat, impact, etc...)
3. Devise effective solutions to address the hazards. Make use of manufacturer reps, safety suppliers or other professionals to help you find effective solutions. They might be able to recommend something that you wouldn't have thought about or didn't know existed. If there is no other solution available they can also help you design a custom fall arrest system specifically for your own unique challenges.
4. Purchase the products.
5. Training
6. Maintain and inspect all systems and fall protection products on a regular basis for wear, tear and deterioration. Though there is no "expiration date" on a harness, many manufacturers recommend retiring it after 5 years of normal use. Additionally all equipment should be inspected to make sure that there is no visual damage, exposure to chemicals, excessive heat or ultraviolet light.
7. Rescue Plan. As mentioned above under the ABCD & Es of fall protection, any fall protection program that does not have an emergency rescue plan designed to retrieve the suspended worker in a timely manner is incomplete. Capital Safety's website has a

downloadable fall protection Program Rescue Plan that can serve as a example or template for your own rescue plan. It is available [here](#).

8. Put it all down in writing. An effective fall protection program is a written program.

Definitions.

(most of these were taken from the OSHA CFR 1926. The ones that I have added are marked with a *)

Anchorage means a secure point of attachment for lifelines, lanyards or deceleration devices.

* **Barricade** is another term that is sometimes used to refer to a guardrail.

Body belt (safety belt) means a strap with means both for securing it about the waist and for attaching it to a lanyard, lifeline, or deceleration device.

Body harness means straps which may be secured about the employee in a manner that will distribute the fall arrest forces over at least the thighs, pelvis, waist, chest and shoulders with means for attaching it to other components of a personal fall arrest system.

Buckle means any device for holding the body belt or body harness closed around the employee's body.¹

* **Competent Person** is a person who is trained and able to identify hazards in the workplace. A competent person is usually empowered to make the appropriate changes to ensure a safer environment.

Connector means a device which is used to couple (connect) parts of the personal fall arrest system and positioning device systems together. It may be an independent component of the system, such as a carabiner, or it may be an integral component of part of the system (such as a buckle or dee-ring sewn into a body belt or body harness, or a snap-hook spliced or sewn to a lanyard or self-retracting lanyard).

Controlled access zone (CAZ) means an area in which certain work (e.g., overhand bricklaying) may take place without the use of guardrail systems, personal fall arrest systems, or safety net systems and access to the zone is controlled.

¹ * There are several different types of Buckle connections.

1. Friction Buckles
2. Mating Buckles
3. Quick Connect Buckles
4. Tongue Buckles
5. Cam Buckles

Dangerous equipment means equipment (such as pickling or galvanizing tanks, degreasing units, machinery, electrical equipment, and other units) which, as a result of form or function, may be hazardous to employees who fall onto or into such equipment.

Deceleration device means any mechanism, such as a rope grab, rip-stitch lanyard, specially-woven lanyard, tearing or deforming lanyards, automatic self-retracting lifelines/lanyards, etc., which serves to dissipate a substantial amount of energy during a fall arrest, or otherwise limit the energy imposed on an employee during fall arrest.

Deceleration distance means the additional vertical distance a falling employee travels, excluding lifeline elongation and free fall distance, before stopping, from the point at which the deceleration device begins to operate. It is measured as the distance between the location of an employee's body belt or body harness attachment point at the moment of activation (at the onset of fall arrest forces) of the deceleration device during a fall, and the location of that attachment point after the employee comes to a full stop.

Equivalent means alternative designs, materials, or methods to protect against a hazard which the employer can demonstrate will provide an equal or greater degree of safety for employees than the methods, materials or designs specified in the standard.

Failure means load refusal, breakage, or separation of component parts. Load refusal is the point where the ultimate strength is exceeded.

Free fall means the act of falling before a personal fall arrest system begins to apply force to arrest the fall.

Free fall distance means the vertical displacement of the fall arrest attachment point on the employee's body belt or body harness between onset of the fall and just before the system begins to apply force to arrest the fall. This distance excludes deceleration distance, and lifeline/lanyard elongation, but includes any deceleration device slide distance or self-retracting lifeline/lanyard extension before they operate and fall arrest forces occur.

Guardrail system means a barrier erected to prevent employees from falling to lower levels.

Hole means a gap or void 2 inches (5.1 cm) or more in its least dimension, in a floor, roof, or other walking/working surface.

* ***Horizontal Lifeline*** is a cable or rope that is stretched taut between two secure anchor points and that is used for the worker to tie off to. A HLL allow a worker to travel between the two anchor point while still remaining tied off.

Infeasible means that it is impossible to perform the construction work using a conventional fall protection system (i.e., guardrail system, safety net system, or personal fall arrest system) or that it is technologically impossible to use any one of these systems to provide fall protection.

Lanyard means a flexible line of 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.

Leading edge means the edge of a floor, roof, or formwork for a floor or other walking/working surface (such as the deck) which changes location as additional floor, roof, decking, or formwork sections are placed, formed, or constructed. A leading edge is considered to be an "unprotected side and edge" during periods when it is not actively and continuously under construction.

Lifeline means 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 personal fall arrest system to the anchorage.

Low-slope roof means a roof having a slope less than or equal to 4 in 12 (vertical to horizontal).

Lower levels means those areas or surfaces to which an employee can fall. Such areas or surfaces include, but are not limited to, ground levels, floors, platforms, ramps, runways, excavations, pits, tanks, material, water, equipment, structures, or portions thereof.

Mechanical equipment means all motor or human propelled wheeled equipment used for roofing work, except wheelbarrows and mopcars.

* ***Midrails*** are rails that are attached to the vertical beams of a guardrail between the top rail and the platform.

Opening means a gap or void 30 inches (76 cm) or more high and 18 inches (48 cm) or more wide, in a wall or partition, through which employees can fall to a lower level.

Overhand bricklaying and related work means the process of laying bricks and masonry units such that the surface of the wall to be jointed is on the opposite side of the wall from the mason, requiring the mason to lean over the wall to complete the work. Related work includes mason tending and electrical installation incorporated into the brick wall during the overhand bricklaying process.

Personal fall arrest system means a system used to arrest an employee in a fall from a working level. It consists of an anchorage, connectors, a body belt or body harness and may include a lanyard, deceleration device, lifeline, or suitable combinations of these. As of January 1, 1998, the use of a body belt for fall arrest is prohibited.

Positioning device system means a body belt or body harness system rigged to allow an employee to be supported on an elevated vertical surface, such as a wall, and work with both hands free while leaning.

Rope grab means a deceleration device which travels on a lifeline and automatically, by friction, engages the lifeline and locks so as to arrest the fall of an employee. A rope grab usually employs the principle of inertial locking, cam/level locking, or both.

Roof means the exterior surface on the top of a building. This does not include floors or formwork which, because a building has not been completed, temporarily become the top surface of a building.

Roofing work means the hoisting, storage, application, and removal of roofing materials and equipment, including related insulation, sheet metal, and vapor barrier work, but not including the construction of the roof deck.

Safety-monitoring system means a safety system in which a competent person is responsible for recognizing and warning employees of fall hazards.

* **Sag** is used to refer to the amount of extra distance that is added to a horizontal lifeline after a fall.

Self-retracting lifeline/lanyard means a deceleration device containing a drum-wound line which can be slowly extracted from, or retracted onto, the drum under slight tension during normal employee movement, and which, after onset of a fall, automatically locks the drum and arrests the fall.

Snaphook means a connector comprised of a hook-shaped member with a normally closed keeper, or similar arrangement, which may be opened to permit the hook to receive an object and, when released, automatically closes to retain the object. Snaphooks are generally one of two types:

1926.500(b) (1)

The locking type with a self-closing, self-locking keeper which remains closed and locked until unlocked and pressed open for connection or disconnection; or

1926.500(b) (2)

The non-locking type with a self-closing keeper which remains closed until pressed open for connection or disconnection. As of January 1, 1998, the use of a non-locking snaphook as part of personal fall arrest systems and positioning device systems is prohibited.

Steep roof means a roof having a slope greater than 4 in 12 (vertical to horizontal).

* **Swing Fall** is the pendulum motion that results when a worker takes a fall when he or she isn't directly above the anchor point. Swing needs to be properly understood and accounted for when designing and implementing a fall program.

Toeboard means a low protective barrier that will prevent the fall of materials and equipment to lower levels and provide protection from falls for personnel.

Unprotected sides and edges means any side or edge (except at entrances to points of access) of a walking/working surface, e.g., floor, roof, ramp, or runway where there is no wall or guardrail system at least 39 inches (1.0 m) high.

* **Vertical Lifeline** is a rope or cable that is secured to a proper anchor point above the worker. The worker then uses a rope grab and a lanyard, attached to his or her harness to move up and down parallel to the lifeline. A vertical lifeline must be able to withstand at least 5,000 lbs of force.

Walking/working surface means any surface, whether horizontal or vertical on which an employee walks or works, including, but not limited to, floors, roofs, ramps, bridges, runways, formwork and concrete reinforcing steel but not including ladders, vehicles, or trailers, on which employees must be located in order to perform their job duties.

Warning line system means a barrier erected on a roof to warn employees that they are approaching an unprotected roof side or edge, and which designates an area in which roofing work may take place without the use of guardrail, body belt, or safety net systems to protect employees in the area.

Work area means that portion of a walking/working surface where job duties are being performed.