## Measurements for Assessing Fall Hazards and Controls

A few basic measurements and equations can aid in evaluating if a PFAS will be sufficient to prevent workers from contacting a lower level. This section provides information on evaluating:

- The necessary total fall clearance distance for PFASs;
- Swing fall hazards for PFASs.

## I.A. Total Fall Clearance Distance for PFAS

The total fall clearance distance is the minimum vertical distance between the worker and the lower level that is necessary to ensure the worker does not contact a lower level during a fall. The total fall clearance distance is calculated *before* a decision is made to use a PFAS. 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. Total fall clearance distance calculations are 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.

The following variables are necessary to calculate the total fall clearance distance:

- ***Free fall distance:*** This is the distance the worker falls before the PFAS begins to slow the fall. When using a PFAS, this distance must be 6 feet or less and also prevent the worker from contacting a lower level (see Div 3/M, 1926.502(d)(16)(iii)).
    - Free fall distance varies depending on the lanyard's length and where the anchor is set relative to the back D-ring on the harness.
- ***Deceleration distance:*** This is the distance the lanyard stretches in order to arrest the fall. Deceleration distance must be no greater than 3.5 feet (see Div 3/M, 1926.502(d)(16)(iv)).
- ***D-ring shift:*** This is the distance the D-ring moves and the harness shifts when they support the worker's full weight. As the line tugs upwards, the harness can shift so the D-ring location is higher on the worker than it was before the fall. This shift is often assumed to be one foot, but it can vary, depending on the equipment design and the manufacturer. (See International Safety Equipment Association (ISEA), ISEA. 2015. Personal Fall Protection Equipment. Use and Selection Guide).

- ***Back D-ring height:*** The D-ring height is measured as the distance between the D-ring and the worker's shoe sole while the worker is wearing the harness. This height is often standardized as five feet for six-foot-tall workers (shorter workers may also be protected using this default distance). It is necessary to adjust the back D-ring height for workers taller than six feet. (See International Safety Equipment Association (ISEA), ISEA. 2015. [Personal Fall Protection Equipment. Use and Selection Guide]).
- ***Safety factor:*** A safety factor is an additional distance added to the total fall clearance distance to ensure there is enough clearance between the worker and the lower level after a fall. This distance is typically 2 feet.

The total fall clearance distance is calculated by adding these values together.

### I.A.1. Calculating Total Fall Clearance Distance for Fall Arrest Systems with a Shock-absorbing Lanyard

Common assumptions:

- Deceleration distance: 3.5 feet (the maximum per Oregon OSHA requirements (see Div 3/M, 1926.502(d)(16)(iv)).
- D-ring shift: 1 foot.
- D-ring height (shoe sole to point between shoulder blades): 5 feet.
- Safety factor: typically 2 feet.

The equation below shows how to add the various values in order to calculate total fall clearance distance. 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 (measured as the distance between the point at which a worker would be anchored and any lower surface).

| **Clearance Distance** | = | **Free Fall Distance** | + | **Deceleration Distance** (lanyard/lifeline Stretch/elongation) | + | **D-Ring Shift** (harness slip) | + | **Back D-Ring Height** | + | **Safety Factor** |
|---|---|---|---|---|---|---|---|---|---|---|
| *Calculate* | = | *See **III.A.2** chart below* | + | *Assume 3.5 feet** | + | *Assume 1 foot** | + | *Assume 5 feet** | + | *2 feet* |

** If actual workplace values or manufacturer specifications are available, or if circumstances dictate the need to use alternative values, use them instead.*

## I.A.2. Calculating Free Fall Distance

| III.A.2.: 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** |
| *This table applies to a worker using a shock-absorbing lanyard (e.g., ripstitch lanyard). Self-retracting lanyards typically activate, and thus limit free fall distance, within 2 feet. Refer to manufacturer specifications for activation details.* | |

### I.A.3. Examples

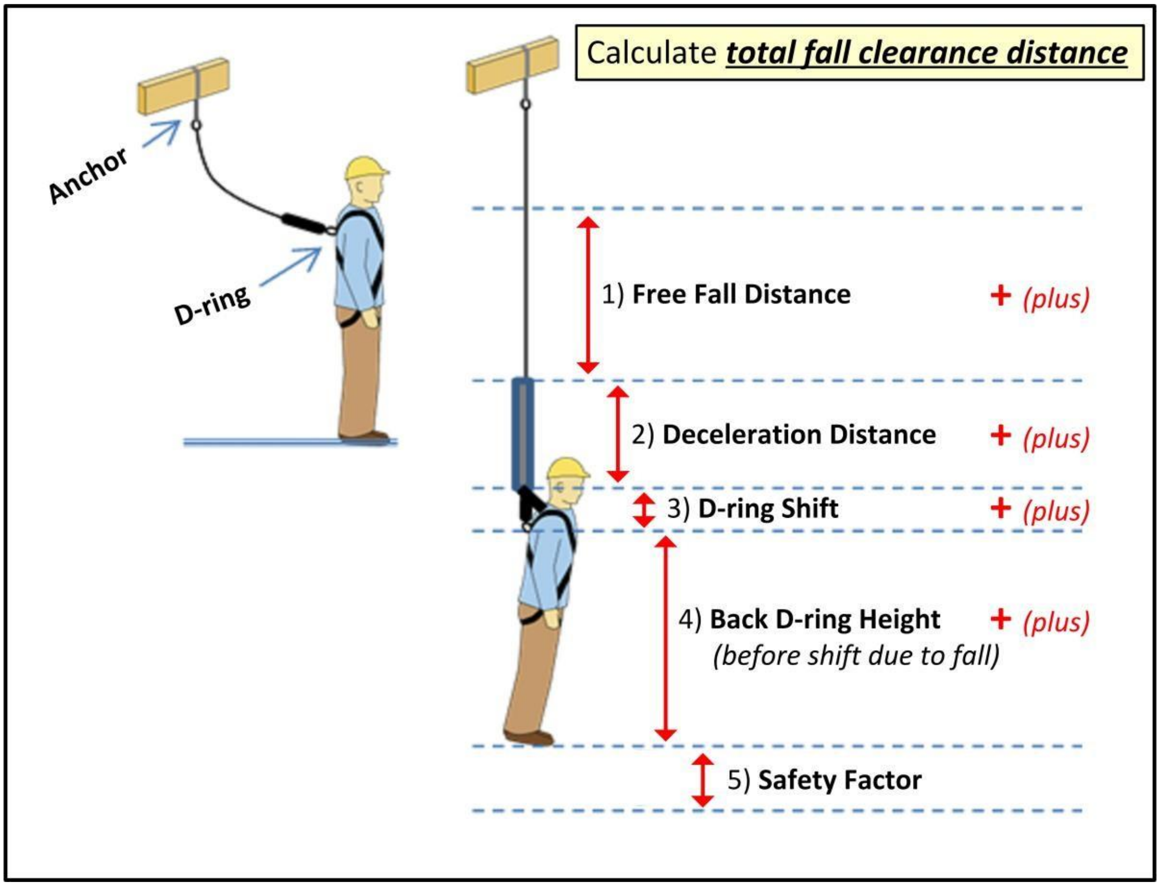


*Figure 18.* ***Total fall clearance distance – Example with D-ring below anchor***

- **Example 1a**

  A worker is framing an attic. The worker will wear a PFAS with a 6-foot rip-stitch lanyard tied off to an anchor attached to a truss' bottom chord. He will also be standing on the same bottom chord (so the anchor will be at foot level). Calculate his total fall clearance distance.

  - Free fall distance = 6-foot lanyard + 5 feet between the anchor and D-ring = 11 feet.

  ***Answer:*** The free fall distance (11 feet) is greater than the 6-foot maximum free fall permitted (see Div 3/M, 1926.502(d)(16)(iii)).

  No further calculations are necessary. 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**

  A competent person sees that the trusses in the adjacent section have been installed, fastened in place, and sheathed, and are stable enough to serve as an anchorage. An anchor is installed 2 feet above the back D-ring on the worker's harness. What is the total fall clearance distance?

  - 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:*** total necessary fall clearance distance = 4 + 3.5 + 1 + 5 + 2 = 15.5 feet. This value can then be compared to the vertical clearance actually available at the work location.

- **Example 2**

  A worker on a concrete wall is wearing a PFAS tied off to a concrete anchor strap, that is 1-foot below his D-ring. His shock-absorbing lanyard is 2 feet long. What is the total fall clearance distance?

  - 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:*** total fall clearance distance = 3 + 3.5 + 1 + 5 + 2 = 14.5 feet. This value can then be compared to the vertical clearance actually available at the work location.

  This example demonstrates that, even with a relatively short lanyard (2 feet), a fall arrest system can require considerable clearance below the elevated work area. 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 (more than the typical space between levels in a building under construction). A falling concrete worker could come in contact with (and be injured by) any object within the space 14.5 feet below the worker's original position.

  If fall protection in this configuration is used, there needs to be at least 14.5 feet of clear space below the worker. The fall protection equipment requires this much vertical distance to stop a fall and prevent the worker from falling on an object and sustaining an injury.

  Where guardrails cannot be used, fall restraint is a better option than fall arrest for a work area with limited clearance below.

- **Example 3**

  A worker welding in a warehouse is using a PFAS. The system includes a 4-foot shock-absorbing lanyard that is anchored to an I-beam clamp, level with the D-ring on her upper back. What is her total fall clearance distance?

  - 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

  ***<u>Answer:</u>*** total fall clearance distance = 4 + 3.5 + 1 + 5 + 2 = 15.5 feet. This value can then be compared to the available vertical clearance actually available at the work location.

- **Example 4**

  A construction worker is wearing a PFAS including a 6-foot rip-stitch lanyard. He uses a strap anchor to tie off around a steel ceiling joist 4 feet above the D-ring on his back. What is the total fall clearance distance?

  - 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

  ***<u>Answer:</u>*** 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.

- **Example 5**

  The same construction worker is now using a self-retracting lanyard that activates (locks) within 2 feet if he falls. This new lanyard is connected to the same steel ceiling joist 4 feet above the D-ring on his back. What is the total fall clearance distance?

  - 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 Div 3/M, 1926.502(d)(12)).
  - Deceleration distance = 3.5 feet
  - D-ring shift = 1 foot
  - Back D-ring height = 5 feet
  - Safety factor = 2 feet

  ***<u>Answer:</u>*** 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.