Calculating Total Fall Distance

Knowing how to calculate Total Fall Distance is just as important as selecting the proper harness, lanyard, anchorage connector, and anchorage point for the specific task to be performed. Total Fall Distance (TFD) is defined as the sum of Freefall Distance (FFD), Deceleration Distance (DD), Harness Effects (HEFF), and Vertical Elongation (VEL). It is also wise to include a Safety Factor (SF) of at least one foot in the formula. Total Fall Distance can be calculated using the following formula:

TFD = FFD + DD + HEFF + VEL + SF

Before we can begin to calculate Total Fall Distance, we first need to define the variables in the formula above.

Freefall Distance (FFD): The vertical distance a worker travels between the onset of a fall until just prior to the point where the Fall Arrest System begins to arrest the fall. Federal OSHA limits this distance to 6' or less. To keep FFD to a minimum, always try to keep your anchor point as far above the back D-ring of the harness as possible.

Deceleration Distance (DD): The vertical distance a worker travels between the activation of the Fall Arrest System and final fall arrest. Federal OSHA limits this distance to 3.5' or less. The DD that each energy-absorbing fall arrest device will permit is typically stated on the product label.

Harness Effects (HEFF): The stretch of a harness during fall ar rest. This is typically one foot or less for a properly-fitted harness. However, some harnesses use elastic-type webbing that can increase the harness effects to two feet or more.

Vertical Elongation (VEL): The stretch in the lifeline of the Personal Fall Arrest System. Vertical Elongation is measured on the part of the lifeline that is under tension during deceleration and final fall arrest. This variable will change drastically depending upon the type of Fall Arrest System you are using. For example, most energy-absorbing lanyards are designed to have a maximum deceleration distance of 3.5' which includes the vertical elongation of the lanyard. However, if you are using a rope grab system or a horizontal lifeline, vertical elongation must be calculated based on the stretch of the vertical or horizontal lifelines in those systems. You will need to check the specific manufacturers' product for exact stretch percentages.

Safety Factor (SF): An additional factor of safety to ensure that you have the required clearance below your working surface. This variable should be at least one foot, but can reflect any number with which you feel comfortable.

For illustration purposes, we will use the following equipment:
• Full Body Harness (non-elastic)
• 6' Energy-Absorbing Lanyard
• Fixed, Rigid Anchorage Connector (such as a D-Plate bolted to a structural I-beam)
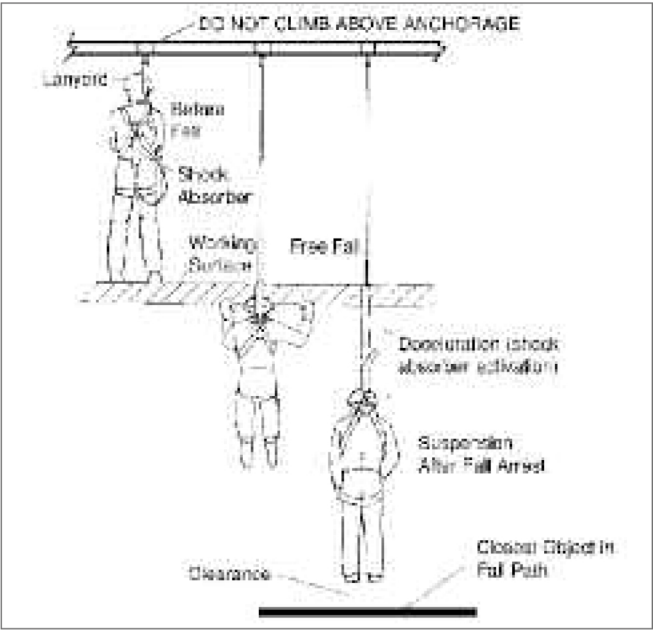

Figure 1

In *Figure 1*, we see a worker with a 6' Energy-Absorbing Lanyard on an elevated platform. In this example, let's assume that his attachment point is 2' above the back D-ring of the harness. For every 1' the lanyard attachment point is above the harness back D-ring, 1' is deducted from the Freefall Distance. For every 1' that the lanyard attachment point is below the harness back D-ring, 1' is added to the Freefall Distance (see *Table 1*). In this scenario, if the worker falls, the Freefall Distance (FFD) will equal 4' since the lanyard attachment point is 2' above the back D-ring of the harness.

So, our formula so far looks like this: **TFD = 4' + DD + HEFF + VEL + SF**

The next variable to consider is Deceleration Distance (DD). Federal OSHA requires that this distance not exceed 3.5'. Since all manufacturers' product is slightly different, you should read the label on the product you intend to use to determine the maximum deceleration distance of that product. When calculating Total Fall Distance, the maximum deceleration distance that a product will permit should always be used. In our example, the maximum deceleration distance would be 3.5'.

TFD = 4' + 3.5' + HEFF + VEL + SF

The Harness Effects variable is relatively constant at less than one foot. This will vary slightly due to the adjustment of the harness, so we generally use one foot to account for those slight differences. However, elastic-type harnesses can have more than one foot of stretch, possibly two feet or more, and that additional distance must be accounted for in your calculation. In our example, we are using a non-elastic harness to keep our Total Fall Distance to a minimum.

TFD = 4' + 3.5' + 1' + VEL + SF

Calculating Total Fall Distance

FreeFall Distance for various Energy-Absorbing Lanyard Lengths and Elevations of Anchorage Connection Point.	Length of Energy-Absorbing Lanyard			
Distance of Anchorage Connection Point Above (+) or Below (-) Harness Fall Arrest D-Ring	6'	5'	4'	3'
+3	3	2	1	0
+2	4	3	2	1
+1	5	4	3	2
0	6	5	4	3
-1	7	6	5	4
-2	8	7	6	5
-3	9	8	7	6
-4	10	9	8	
-5	11	10		
-6	12			
	FreeFall Distance			

Table 1

Most manufacturers design their Energy-Absorbing Lanyards so that the vertical elongation of the lanyard is included in the OSHA mandated 3.5' maximum deceleration distance. However, if we were using a rope grab or horizontal lifeline, or if you were attaching to a non-rigid anchorage connector, VEL would need to be calculated based on the specifications of those components in your Fall Arrest System. Since we are using a 6' Energy-Absorbing Lanyard in our example and the VEL is already considered in the lanyard design, we will enter a "0" for the VEL variable.

TFD = 4' + 3.5' + 1' + 0' + SF

The final variable of the formula is the Safety Factor. It is always a good idea to include at least a 1' safety factor; however, the safety factor could reflect any number that makes you comfortable with your calculation.

Now we can solve our Total Fall Distance Formula:

TFD = 4' + 3.5' + 1' + 0' + 1'

TFD = 9.5'

Now we know that if the worker in *Figure 1* would happen to fall, his Total Fall Distance will be 9.5'.

But what does this number really mean?

It means that the clearance between the working surface and the next closest object in the fall path must be at least 9.5'. It is important to remember that Total Fall Distance is not always measured from the working surface to the ground, because sometimes the ground is not the closest object beneath the working platform. If there is any type of obstruction in the fall path of the worker (see *Figure 2*), your available clearance is measured from the working platform to the top of that obstruction. Sometimes these distances can be very short, and a fall protection means other than a 6' energy-absorbing lanyard is necessary. Total Fall Distance calculations can become more complex than those demonstrated here. The numbers and variables will change depending upon the type of Personal Fall Arrest System used. For example, when calculating Total Fall Distances for Horizontal Lifeline Systems you have additional variables to consider, such as cable deflection and the number of people on the system. The important thing to remember is that calculating Total Fall Distance is just as important as selecting the right product for the job. Forgetting to calculate Total Fall Distance is just as dangerous as forgetting to put on your harness before you begin to perform any work at heights.
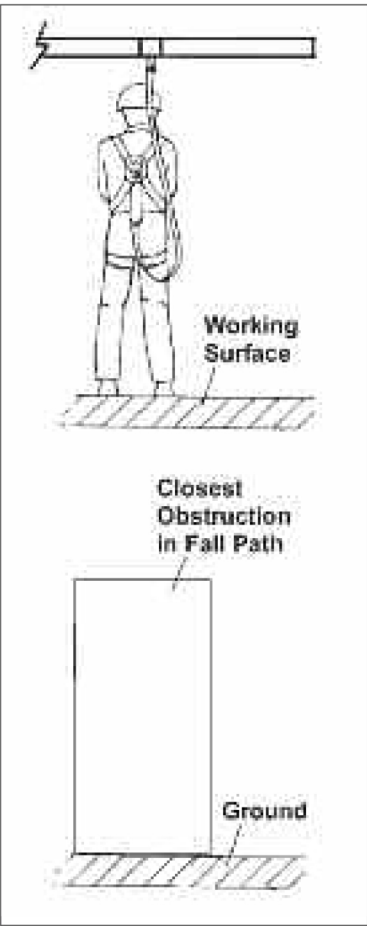

Figure 2