

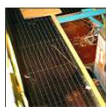
**FPST 2023 Industrial and Occupational Safety
Fall Protection – Part 1**



Source: Homan/Holter, used with permission.



Source: OSHA



Source: OSHA

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“While on a ladder, never step back to admire your work.”



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General Information

- Fatal falls
 - 2015 – 800
 - 2016 – 849
 - 2017 – 887
 - 2.43 per day



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Any elevated unprotected surface has a risk for workers to fall



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Any elevated unprotected surface has a risk for workers to fall

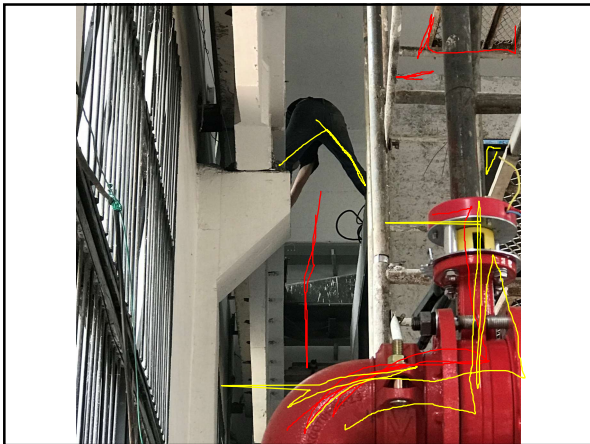


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Any elevated unprotected surface has a risk for workers to fall



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Even this can cause a fatality

- A maintenance worker stood on a folding chair to change a light bulb.
- The chair collapsed and he fell, striking his head on the tile floor.
- He died from head trauma



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Greatest Risk of Falling:

- Tower construction
- Scaffold ladders and platforms
- Holes
- Skylights
- Edges
- Roofing
- Elevator shafts
- Ladder side rails
- Decking and plywood



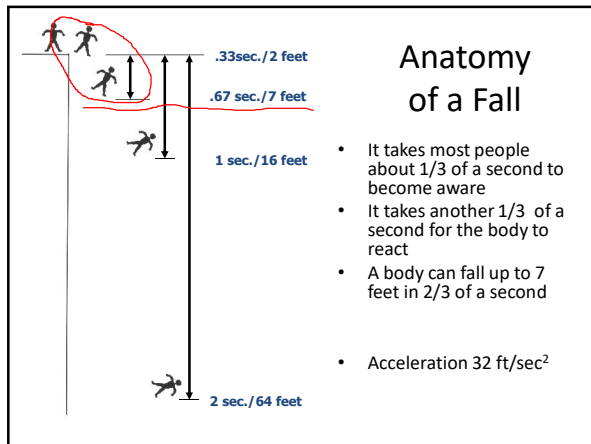
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Standards on Fall Protection

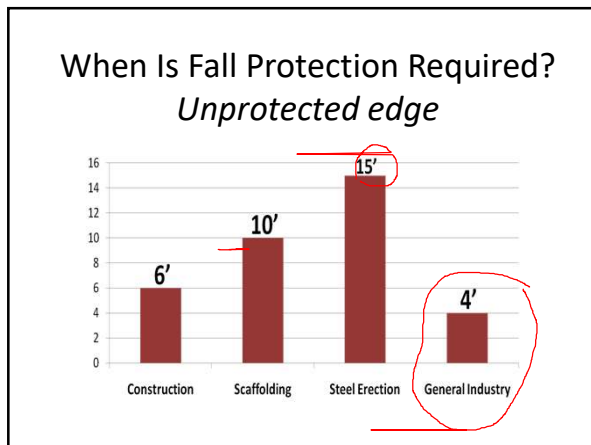
- 29 CFR 1910
 - ~~1910.66-70~~, Walking & Working Surfaces
 - 1910.66, Powered platforms for building maintenance
 - 1910.67, Vehicle-mounted elevating and rotating work platforms [Aerial lifts]
 - 1910.68, Man-lifts
 - 1910.132, Personal Protective Equipment
 - ~~1910.268~~, Telecommunications
 - 1910.269, Electric power generation, transmission, and distribution
- 29CFR 1926 Construction
 - 1926.451 – 454 Scaffolding
 - ~~1926.501~~ – 503 Fall Protection
 - 1926.760, Steel erection (Fall protection)
 - 1926.800, Underground construction
 - 1926.1051-1053 Stairways and ladders
 - 1926.1060, Training requirements (Stairways and ladders)
 - ~~1926.1423~~, Cranes and derricks in construction
- ANSI/ASSE Z359 Fall Protection Code.
 - ANSI Z359.14-2012, Safety Requirements for Self-Retracting Devices for Personal Fall Arrest and Rescue Systems
 - ANSI/ASSE Z359.4-2012, Safety Requirements for Assisted-Rescue and Self-Rescue Systems, Subsystems and Components

The most important law you need to concern yourself with is the law of gravity.

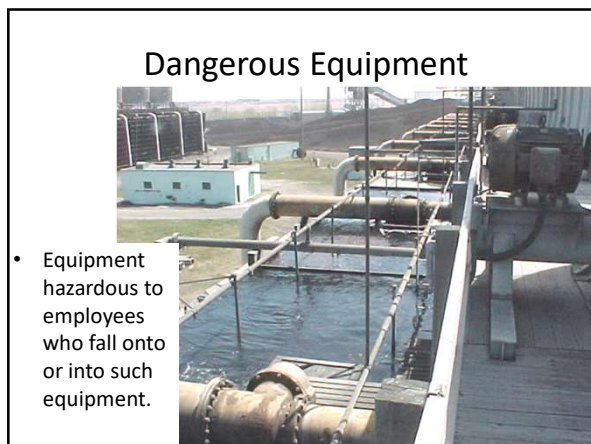
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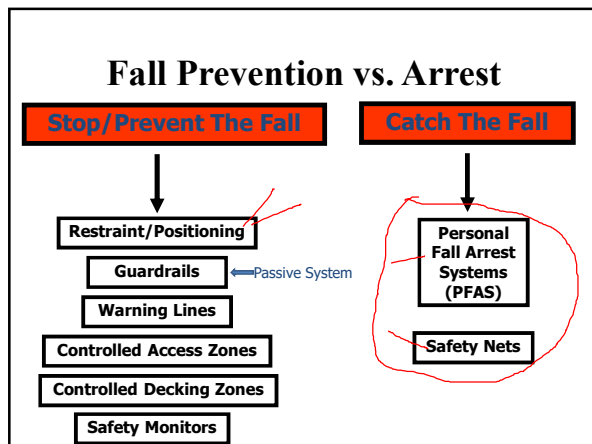
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Fall Protection Priorities

- Prevention
 - Always strive to prevent the fall
- Positioning
 - Including restraint
 - Fall arrest may also be required
- Fall Arrest
 - Employed after the fall, so is one of the least-desirable approaches, assuming, as it does, that an employee will fall and that all systems will function properly to arrest the fall.
- Retrieval
 - Assumes the fall arrest system has already worked,
 - Must be employed as quickly as possible to minimize further injury or damage.

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What Type of Fall Protection Will I Need?

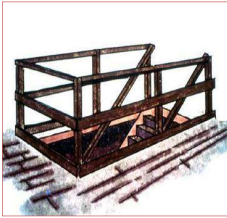
- In most cases, a guardrail system, a safety net system, or a personal fall arrest system must be used
- In some cases fences, barricades, covers, equipment guards or a controlled access zone may be used.
- Employees must be protected not just from falling off a surface, but from falling through holes and from having objects fall on them from above.

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Fall Protection Options



Personal Fall Arrest System (PFAS)



Guardrails

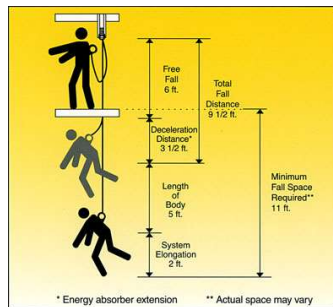


Safety Net

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Free Fall

- Act of falling before a personal fall arrest system begins to apply force to arrest the fall



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Primary Concerns

- Impact Force to the Body Less Than 1800# (with a harness)
- Maximum 6' Free Fall Distance
- May Not Hit Structures Below
- Maximum Weight of Individual w/Tools of 310#

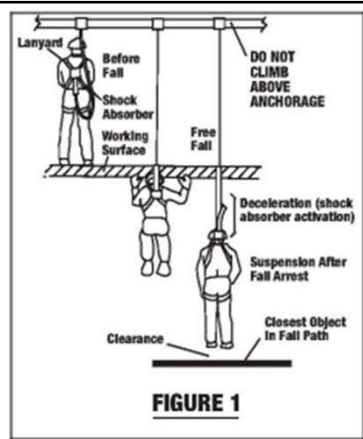
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Impact Force

- Minimize Fall Distance
 - Tie off at or above D-ring height wherever possible
- Use Shock Absorbers
- Choose appropriate harnesses, and ensure a correct fit
- <https://www.youtube.com/watch?v=ZotMi76VbPo>

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Calculating Total Fall Distance



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Free Fall Distance

- How far a worker falls before shock absorbing or deceleration equipment begins to take effect
 - Affects both impact forces and total fall distance
- Anchorage point location in relation to D-ring height
 - Below the D-ring allows excessive falls
 - Above the D-ring minimizes free fall to less than 6'

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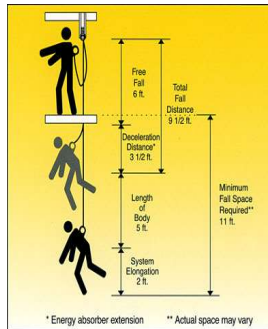
Calculating Total Fall Distance

- $TFD = FFD + DD + HEFF + VEL + SF$
- TFD – Total Fall Distance
- FFD – Free Fall Distance
- DD – Deceleration Distance
- HEFF – Harness Effects (1 ft)
- VEL – Vertical Elongation (OSHA >3.5 ft)
- SF – Safety Factor (at least 1 ft)

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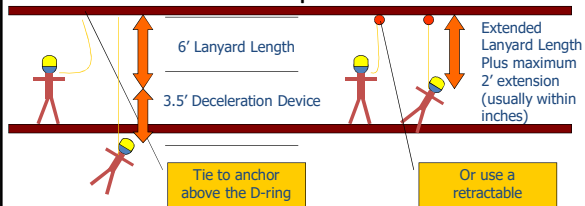
Deceleration Distance

- Distance between the location of an employee's harness attachment point at the moment of activation and the location of that attachment point after the employee comes to a full stop
- Must not be more than 3.5 ft



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Minimizing Free Fall Distance or "Vertical Displacement"



Using an anchorage above the D-ring and a standard lanyard may still allow an employee to fall a distance that may be difficult to rescue from. Using a retractable minimizes forces on the body, and may make rescue easier (and therefore more timely)

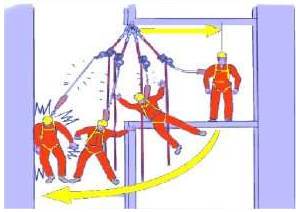
All distances are approximate, and shown for illustration only. This is why it is critical to maintain the safety factor distance!

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The Pendulum Effect

- Swing Fall Hazards

- The farther you move horizontally from the anchor, the greater the chance of swinging when you fall
- The more you swing, the greater force with which you will strike, columns, wall, or other objects in your path



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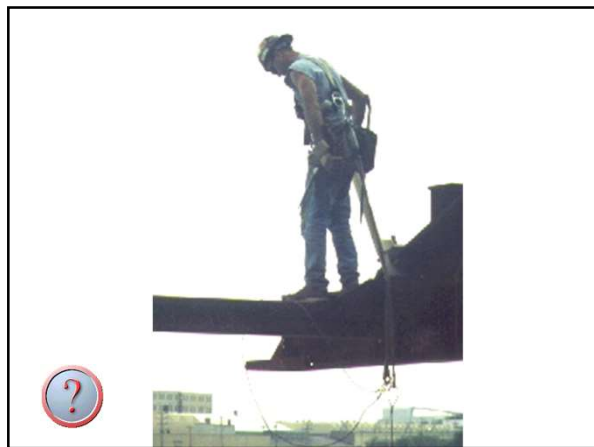
Practical Implications of Total & Free Fall Distance Added Together

Worker tied to the beam he is standing on with choker slings

How far will they fall?



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Watch Swing Falls

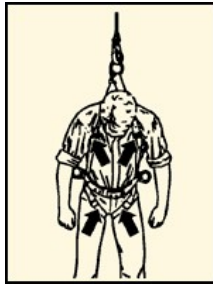
- This worker is tied off using a retractable lifeline.
- There is a major swing fall potential if he fell to either side.



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Personal Fall Arrest Systems

- Once a Personal Fall Arrest System has been used in a fall, it must be removed from service right away.



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Personal Fall Arrest Systems

- Body belts are not acceptable as part of a personal fall arrest system



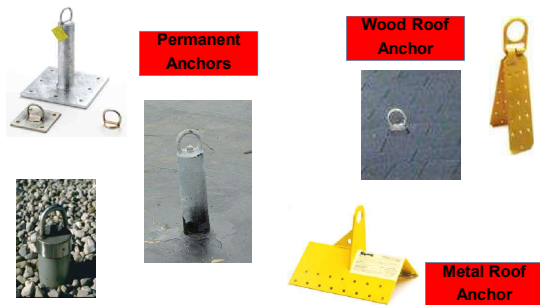
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Anchorage

- Must support 5000# per employee attached,
 - Or as part of a complete personal fall arrest system which maintains a safety factor of at least two
 - Or 3000# when using fall restraint or a Self-Retracting Lifeline (SRL, Retractable, or “yo-yo”) which limits free fall distance to 2 feet
- Should always be at or above D-ring height

34

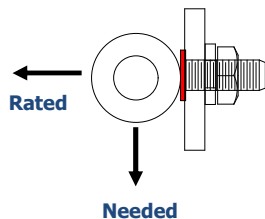
Roof & Deck Anchors



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Use of Lifting Eye Bolts

- Rated for loading parallel to the bolt axis.
- If wall mounted, the rating perpendicular to the axis must be good for 5,000 lbs. per employee



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Girder Grip Anchorage Rings




- These attachments can be mounted through bolt holes on steel members.
- They are rated at 5,000 lbs. in all directions

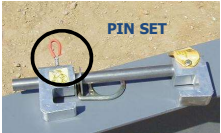
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Beam Clamps


Beam clamps can make an effective anchorage when used properly, and with the correct lanyard



TIGHT



PIN SET




BEAM CLAMP

Be sure pin is inserted full length and clamp is tight.

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- What happens when the employee reaches the next joist?
 - He/she needs a second beam clamp to make the traverse over the joist end, otherwise will not be tied off 100% of the time.
- Also, some prefabricated building rafters/joists may not be suitable for the application of a beam clamp as the flange is too thin to support the potential impact



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Horizontal Life Lines

- Provide maneuverability.
- Must be designed, installed and used under the guidance of a qualified person
 - This could be interpreted as requiring the use of manufactured systems, which is *recommended*

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Line Stanchions

- The connection of the line stanchion to the flange must support the bending moment applied to the base.

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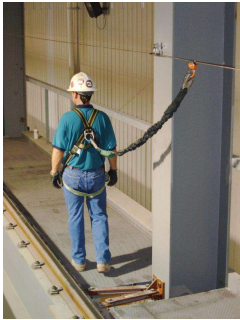
Vertical Lifeline/ Lanyard



- Vertical lifelines/lanyards must have a minimum breaking strength of 5,000 lbs.
- Each worker must be attached to a separate vertical lifeline, except during the construction of an elevator shaft

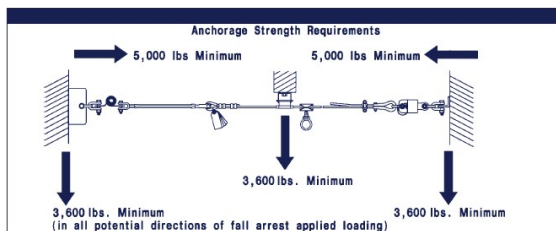
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Horizontal Lifeline




- On work platforms, the devices used to connect to a horizontal lifeline must be able to lock in both directions on the lifeline
- Qualified person should design and install
- Safety factor of at least 2

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Anchorages

- Should be used for PFAS's only
- Capable of supporting at least 5,000 lbs per worker
- Safety factor of at least 2
- Must be supervised by a qualified person

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- There seems to be various theories as to why OSHA settled on 5000 lbs. (from it being twice the forces incurred in the freefall of an average worker to the weight determined in testing on dropped dogs years ago), nevertheless, that's what the regulations have set forth for decades. In fact, when testing systems, you are required to use a weight of 220 lbs. (plus or minus 3 lbs.) at a freefall of 6' [29 CFR 1926 Subpart M Appendix C]. The system would fail the force test if it recorded greater than 2520 lbs. of force during this test. If the system passes, a safety factor of two applied to 2520 lbs. would be approximately 5000 lbs.
- The forces incurred during a fall of a 220 lb. worker who is utilizing a fall arrest system would be approximately 900 lbs.

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Connectors

- Must be made of strong materials and rust free finish
- Make sure it has smooth surfaces and edges!
- Must be made from drop-forged, pressed formed steel, or equivalent materials

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D-Rings

- Minimum tensile strength of 5,000 lbs.
- Proof-tested to a minimum tensile load of 3,600 lbs. without cracking, breaking or becoming permanently deformed



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Snaphooks



- Minimum tensile strength of 5,000 lbs
- Proof-tested to a minimum tensile load of 3,600 lbs without cracking, breaking, or becoming permanently deformed.
- Locking-type, double-locking, designed and used to prevent the disengagement of the snaphook

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Connectors (Lanyards)

- Should be inspected before each use
- Should not be tied back to themselves (unless specifically designed for such use)
- Should be worn with the impact absorber/shock pack at the d-ring
- Should have the appropriate clip for the intended anchorage points
 - Do not use large climbing/rebar/ladder hooks with "beamers"

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Retractable Lifelines

- Very effective for vertical applications.
- Will normally lock up in 1 –2 feet, minimizing total fall distance and impact forces on the worker's body



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Safety Nets



- Must be installed as close as possible under the surface on which you are working
- Nets should never be more than 30 feet below the work surface
- The mesh size must not be bigger than 6 inches by 6 inches

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Safety Nets

- Must be drop-tested at the jobsite:
 - After initial installation and before being used
 - Whenever relocated
 - After major repair
 - At 6-month intervals if left in one place
- A 400 pound (180 kg) bag of sand 30 + or - 2 inches (76 + or - 5 cm) in diameter dropped into the net not from a height not less than 42 inches (1.1 m)

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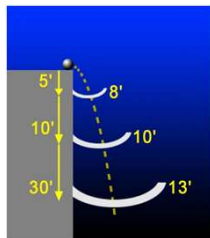


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Safety Nets

Safety nets must extend outward from the outermost projection of the work surface as follows

Vertical distance from working level to horizontal plane of net	Minimum required horizontal distance of outer edge of net from the edge of the working surface
Up to 5 feet	8 feet
5 to 10 feet	10 feet
More than 10 feet	13 feet



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Fatal Fall – North Carolina

- A 57-year-old male electrical mechanic died after falling 45' thru unguarded floor opening
- Opening Measured 54" x 43"
- Subcontractors on a 4 story building – new build
- Rewinding Electrical Cable onto a spool -walking backward
- There had been a guardrail installed, but it had been taken down
- Fall Protection Training two weeks prior
- Safety inspection several weeks prior identified the hazard but no action was taken by the General Contractor



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Fatal Fall – Telecommunications Tower



- 38 yr old Junior Tower Erector – 1 year experience
- Connecting antenna support brackets onto a leg of the tower
- Climbing down from 220' (69m) to 200' (63m)
- Unknown if he disconnected from anchorage point or if connection failed
- Daily Tailgates –Safe Work Plan
- **No 100% tie-off**
- No record of inspection
- Evidence of damaged equipment

Figure 1: 300 Foot Telecommunications Tower



Figure 1a: Enlarged View, Tower Section

