Fall Protection for safety at heights

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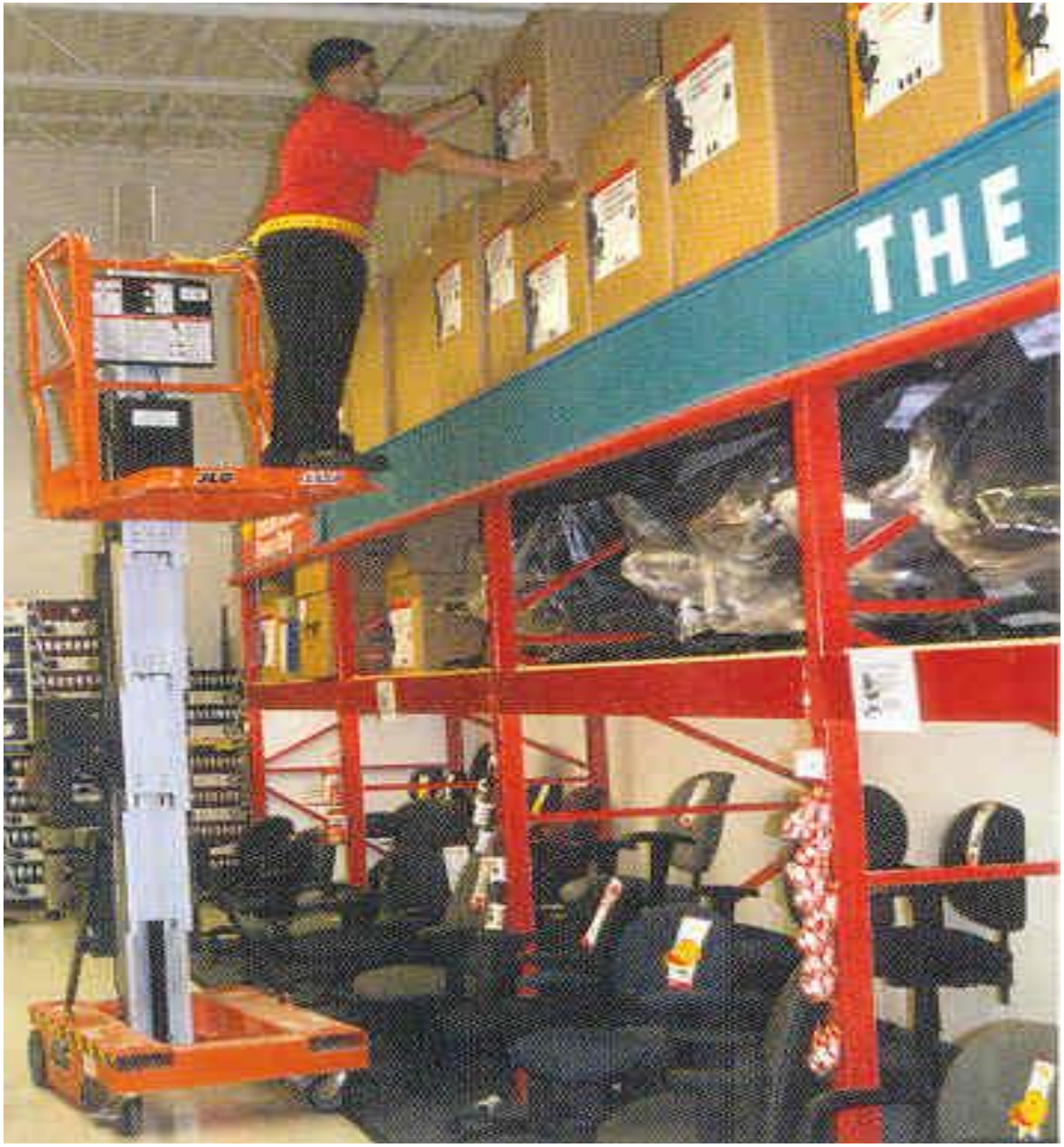

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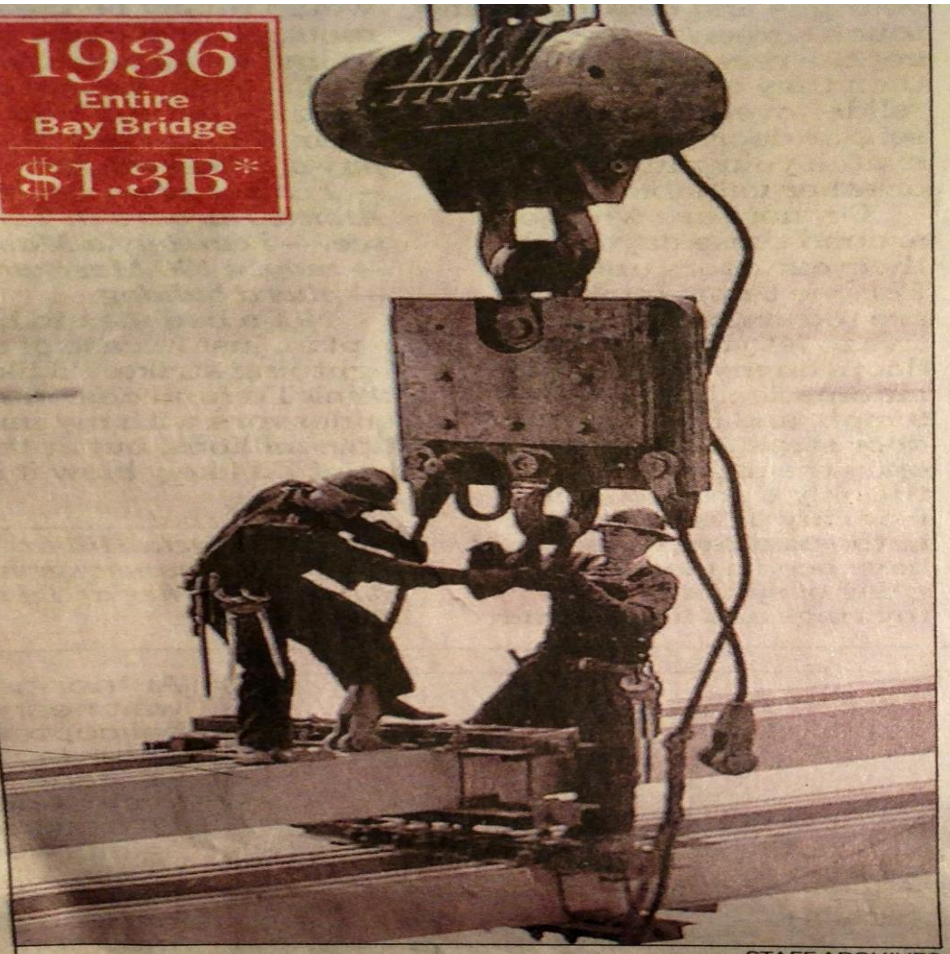
1936
Entire Bay Bridge
$1.3B*



STAFF ARCHIVES

Workers connect a link in a cantilever section during construction in 1936. It took less than six years to design and build the entire bridge.

2: Years to choose, design, award bid

3.6: Years of construction

24: Deaths during construction

148,000: Tons of structural steel

8.2: Miles of bridge

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KARL MONDON/STAFF

Ironworkers on the bridge's new eastern span are dwarfed by a cable saddle. Construction alone, still ongoing, has taken nearly 11 years.

5: Years to choose, design, award bid

11: Years of construction

0: Deaths during construction

250,000: Tons of structural steel

2.2: Miles of bridge

$550,964: Cost per foot to build

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Fall protection safety at heights

- Training Objectives:
  - Physics of fall arrest
  - Fall Protection Hierarchy of controls
  - Fall Protection PPE
    - ANSI Manufacturing Updates
  - Rescue Concerns / Considerations

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Physics of falling & suspension

5 phases of a fall

1. Onset of fall

- Accidental fall starts when you first experience the fall hazard and ends the instant you lose control over your stability.
- Likely to be only a few tenths of a second
- Time period of onset may be affected by your posture at the instant you encounter the fall hazard

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Physics of falling & suspension

2. <u>Free fall.</u>

- Subjected to the forces of gravity
- Body will accelerate until such time you strike an object
- Mass x acceleration
- Body cannot move in a coordinated way

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Physics of falling & suspension

3. <u>Deceleration</u>

- If you are not protected by a PFAS and you strike a concrete floor that has very little “give”, you will undoubtedly be severely or fatally injured
- Energy absorbing lanyard permits the dissipation of built up energy over time and distance

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Physics of falling & suspension

4. Rebound

Some or all of the parts of a personal fall arrest system have a degree of elasticity- *elastic deformation - temporary*.

- Some components will stretch and nearly return to it's original form
- Part of the stretch may be what is called *plastic deformation.-* permanent
- Bounce in the system could cause additional forces & injury

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Physics of falling & suspension

5. <u>Suspension</u>

- You will remain suspended until rescued during the suspension phase.
- You will not be able to perform a self-rescue in all cases.
- During suspension in such a condition, your swift rescue is extremely important

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What Happens in a Fall with a 1.8 m (6 ft) lanyard?

Time	Physical Response	Free-Fall Distance	Velocity
0.1 sec	Unaware	5.1 cm (2 in)	1.0 m/s (3.3 ft/s)
0.2 sec	Aware	20.3 cm (8 in)	2.13 m/s (7 ft/s)
0.5 sec	Start to Move	1.22 m (4 ft)	4.88 m/s (16 ft/s)
0.61 sec	Slight Movement	1.83 m (6 ft)	5.97 m/s (19.6 ft/s)
0.7 sec	Impact	2.41 m (7.9 ft)	7.01 m/s (23 ft/s)
0.9 sec	Rebound	3.96 m (13 ft)	8.84 m/s (29 ft/s)
1.0 sec	Suspend	4.9 m (16 ft)	9.75 m/s (32 ft/s)

How High Can You Go Before You are Afraid of Falling?

Height
1.0 m
2.0 m
2.5 m
3.0 m
3.5 m
4.0 m
> 4.0 m

__% of people who fall from > 3.4 m (11 ft) die .....

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Fall Hazard Assessments/Analysis

- Use Site Fall Hazard Assessments to understand the fall hazards of an identified area.
  - Job Site Assessment
  - Job Hazard Assessment
  - Tool box / tailgate talk

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Hazard Assessment Exercise

Fall Protection Program
Fall Hazard Assessment

Designation:	**Location:**
Date Assessed: 199	**Related Operating Procedures Reviewed:** ☐ Yes ☐ No
Location Marked and Entry Controlled: ☐ Yes ☐ No	

FALL HAZARD ASSESSMENT CHECKLIST

1. Can an employee enter the area without restriction and perform work?	☐ Yes	☐ No
2. Are fall prevention systems such as cages, guardrails, toeboards, manlifts in place?	☐ Yes	☐ No
3. Have slipping and tripping hazards been removed or controlled?	☐ Yes	☐ No
4. Have visual warnings of fall hazards been installed?	☐ Yes	☐ No
5. Can the distance a worker could fall be reduced by installing platforms, nets etc.?	☐ Yes	☐ No
6. Are any permanently installed floor coverings, gratings, hatches, or doors missing?	☐ Yes	☐ No
7. Does the location contain any other recognized safety and or health hazards?	☐ Yes	☐ No
8. Is the space designated as a Permit Required Confined Space?	☐ Yes	☐ No
9. Have anchor points been designated and load tested?	☐ Yes	☐ No

Assessment Information: (indicate specifics with initials)

Initials	Hazard	Remarks/Recommendations
	Total potential fall distance:	
	Number of workers involved:	
	Frequency of task:	
	Obtainable anchor point strength:	
	Required anchor point strength: (not less than 5000 lbs)	

Additional Requirements:

- Potential environmental conditions that could impact safety:

Initials	Condition	Remarks/Recommendations

- Possible required structural alterations:

Initials	Alteration	Remarks/Recommendations

- Possible task modification that may be required:

Initials	Task	Remarks/Recommendations

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Solution Choices

- Use the Hierarchy of Control
  - 1. Elimination or substitution
  - 2 Passive fall protection
  - 3. Fall restraint (travel restraint)
  - 4. Fall arrest
  - 5. Administrative Controls

- Each choice has its place and time

Fall Protection Hierarchy of Controls

1. **Elimination or substitution**

   Removing the hazard or hazardous work practices.

Examples: Elevated work platforms, remote tools, lowering the work or task to the ground. Change a process, sequence or procedure such that a worker does not approach the fall hazard

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Fall Protection Hierarchy of Controls

2. <u>Passive fall protection</u>

Isolating or separating the hazard or hazardous work practice from the worker.

Examples: Installing guard rails, Stairways, netting – vertical and cantilevered

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Fall Protection Hierarchy of Controls

3. Fall restraint (travel restraint)

Securing the worker to an approved anchorage using a lanyard short enough to prevent the person's center of gravity from reaching the fall hazard.

Examples: Restraint Lanyard or energy absorbing Lanyard anchored above the worker over head and behind or on the walking surface.

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Fall Protection Hierarchy of Controls

4. **<u>Fall arrest (PFAS)</u>**

A system designed to stop a worker after the on set of a fall.

Example: An energy absorbing lanyard connected to an approved anchor connector and connected to full body harness

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Fall Protection Hierarchy of Controls

5. <u>Administrative Controls</u>

Work practices or procedures that signal or warn workers to avoid approaching a fall hazard.

Examples: Flat or sloped roof control zones, warning lines, training, lights, sounds and/or a monitor who's sole function it is to watch and warn when anyone is approaching unguarded leading edge or lines.

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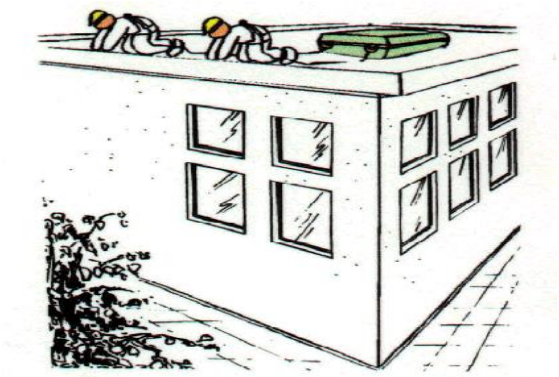
Fall Prevention Options – Fall Restraint

- Fall Restraint System
  - Used with a fully body harness and anchorage
  - 1000 lbs anchor per person attached



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Fall Protection Options – Personal Protective Equipment

- Full Body Harness
- Connectors
- Energy Absorbing Lanyard
- Self-Retracting Lanyard
- Vertical Lifelines
- Ladder climbing systems
- Anchor connectors
- Horizontal Lifeline
- Anchorage point

- These all have specific design and performance requirements – some are established, and some must be engineered.

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Personal Protective Equipment – Full Body Harness

- Materials
  - Nylon, Polyester, Nomex/Kevlar

Buckles
  - Secure-Fit, Qwik-Fit, Tongue buckle

Accessories
  - Shoulder, Back Pads
  - RFID
  - Waist Belts, Saddle

Personal Protective Equipment – Full Body Harness

- D rings
  - Back D-ring for fall arrest
  - Front D-ring for rescue/evacuation
  - Side D-ring for positioning / restraint
  - Shoulder D-ring personnel riding
  - Kevlar for hot work/welding
  - ASTM 887 for Electrical

- What about Body Belts?

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Full body harness

Permanent visual load indicator (Pucker Stitching)

- Fall arrest indicator activates to give a permanent, readily visible warning
- Tears at approximately 2kN or 450 lbs-F

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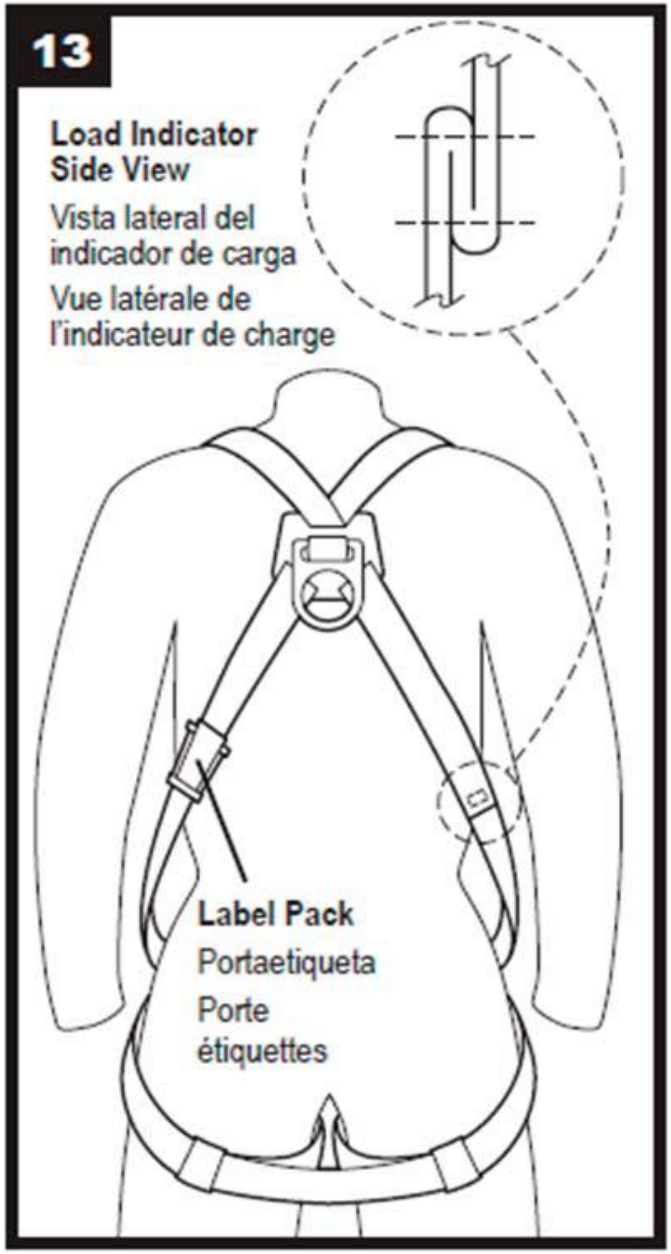
Full Body Harness

<u>Permanent visual load indicator</u> (Pucker Stitching)

- Located below dorsal D-Ring
- 1-2 may be present
- Must be removed from service if deployed



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Personal Protective Equipment – Connectors

- Connectors --
  - Double locking snap hooks
  - Double locking Carabiners
  - Self Closing
  - Self Locking

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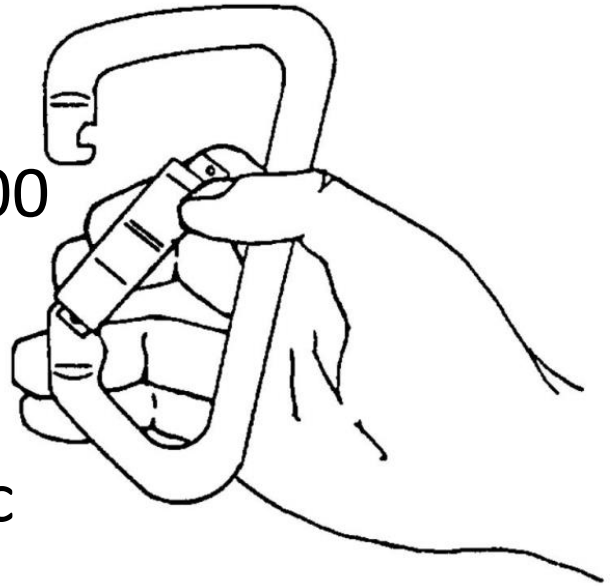
Connectors

- **<u>ANSI Z359.12 - 2009</u>**

- Gate strength must be 16kN /3600 lbs.

- Must be 22.2 kN / 5000 lbs. static load strength



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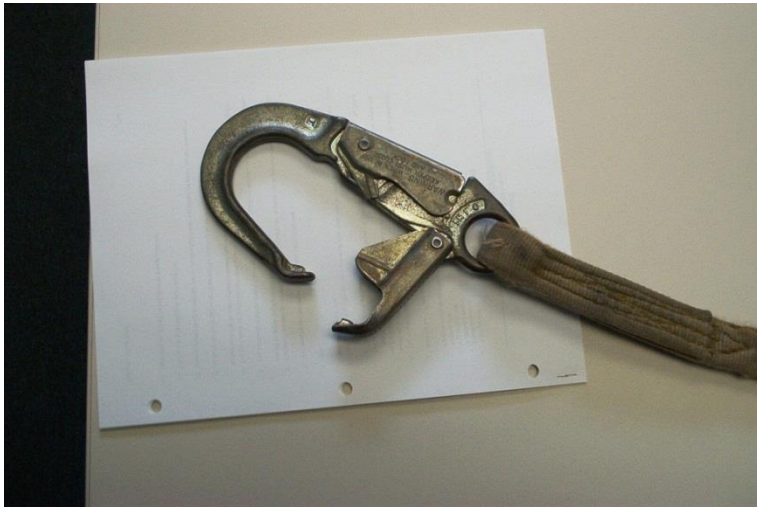
Connectors

Roll Out

- A process by which a snaphook or carabiner “unintentionally” disengages from another connector or object to which it is coupled.



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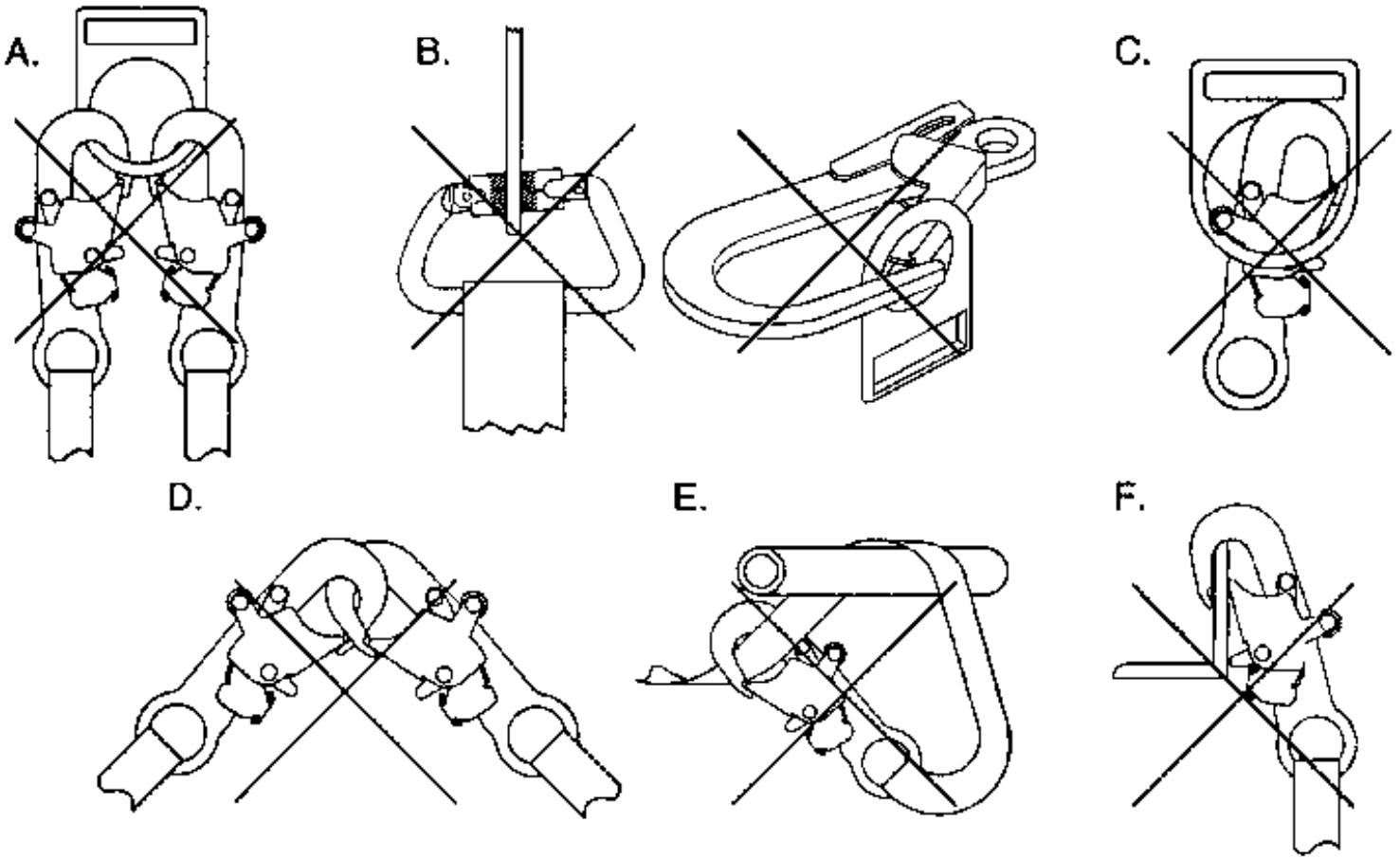
Incorrect Connector Application



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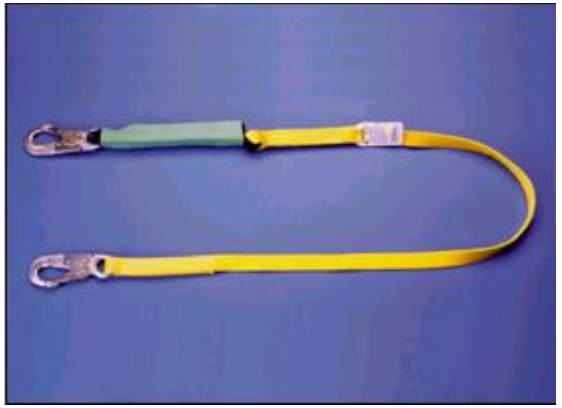
Energy Absorbing Lanyard

- Energy Absorbing Lanyard
  - Energy absorber pack / Internal energy absorber
  - Fixed / Adjustable length
  - Webbing / Cable / Rope
  - Tie back connectors
  - 6’ free fall
  - 12’ free fall



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Energy Absorbing Lanyards

- A system of approved connectors, the lanyard itself & and integral energy absorber
- Can be single leg, twin leg
- Wire rope, webbing or braided rope
- Adjustable in length
- Can be used as travel restraint

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Energy Absorbing Lanyards

- Never connect two lanyards together
- Never tie a knot in the lanyard
- Properly stow an unused leg of a twin leg lanyard
- Twin-leg use has the potential for high fall arrest forces when both lanyard legs are connected simultaneously

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Energy Absorbing Lanyards Allowing 12 ft Free Fall

What does ANSI Z359.13 – 2009 state?

Personal energy absorbers are divided into two distinct classes:

- 6 foot free fall
- 12 foot free fall

- The capacity for both classes of personal energy absorbers remains within the range of 130 to 310 lbs.

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Fall Protection Background – Forces

- Maximum Average Arresting Force
  - Force on the body caused by stopping a fall
  - Maximum peak arresting force is 1,800 lbs by law (OSHA)
  - Force causing serious body damage 2,700+ lbs

- 6 foot free fall lanyards
  - MAAf 900 lbs / 1,125 lbs (tested wet/cold)
  - Max deceleration distance 48”
    (Increased from 42”, older ANSI Z359.1)

- 12 foot free fall lanyards
  - MAAf 1,350 lbs / Max 1,575 lbs (tested wet/cold)
  - Max deceleration distance 60”

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Self-Retracting Lanyard

- Minimizes free fall distance
- Allows vertical mobility
- Contains visual load/Fall indicator
- Wire rope or Nylon webbing
- MAF of 900-1800lbs with integral shock absorber
- SRL's with rescue capabilities

Self-Retracting Lanyard

- <u>ANSI Z359.14 – 2012</u>
- Class A SRL
  - Maximum deceleration 24”
- Class B SRL
  - Maximum deceleration 54”
- Leading Edge (LE-SRL)
  - Inline shock absorber next to user
- Factory Recertification
  - Based on frequency of use from first date of service

Self-Retracting Lifelines
ANSI Z359.14 (2012)

ANSI/ASSE Z359.14-2012 American National Standard — **Safety Requirements for Self-Retracting Devices for Personal Fall Arrest and Rescue Systems**

Appendix A: Inspection Requirements

Type Of Use	Application Examples	Conditions Of Use	Inspection Frequency Competent Person	Factory Authorized Inspection
Infrequent to Light	Rescue and confined space, factory maintenance	Good storage conditions, indoor or infrequent outdoor use, room temperature, clean environments	Annually	At least every 2-5 years, but not longer than intervals required by the manufacturer
Moderate to Heavy	Transportation, residential construction, utilities, warehouse	Fair storage conditions, indoor and extended outdoor use, all temperatures, clean or dusty environments	Semi-annually to annually	At least every 1-2 years, but not longer than intervals required by the manufacturer
Severe to Continuous	Commercial construction, oil and gas, mining	Harsh storage conditions, prolonged or continuous outdoor use, all temperatures, dirty environment	Quarterly to semi-annually	At least annually, but not longer than intervals required by the manufacturer

Personal Protective Equipment – Vertical Lifeline

- Vertical Lifelines
- Rope Grabs / Fall Arrestors

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Vertical Lifeline – Fall Arrester

(Rope grabs)

- Engages a vertical lifeline in vertical or sloped plane
- Can be moved along the lifeline in accordance with the position of the worker; and
- Automatically engages on the lifeline in the event of a fall in order to arrest the fall.

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Vertical Lifeline
- Manual Fall Arrester

- Locked on a synthetic lifeline line
- Requires a manual action by the worker to displace it along the line
- Connected to the dorsal attachment point of a harness
- Remains engaged on the lifeline if released or held beyond its non-engaged position (panic grab feature).

Fixed Ladder Climbing Device

- Ladder climbing devices are the preferred system to protect permanent ladders.
- Rigid Rail and Flexible Cable Systems
- A minimum length connection is attached to the D ring
- Limiting free fall distances to < .6 m (2 ft) reducing your impact forces

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Anchorage Connectors

- Characteristics
  - Temporary
  - Permanent
  - Available for routine work
  - Easy to use

- Mobility Requirements
- Capture/Couple the Anchoring structure

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Anchorage Connector

- Compatible with PFAS 22kN (5000 lbs)
- Eye bolts
- Tripods
- Beam trolleys
- Fixed and travelling beam clamps
- Tie-off adaptors
- Concrete anchorage connectors
- Wedge anchorage connectors

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Anchorage Connector

- Penetrating & non Penetrating
- Friction anchor connectors
- Ballast Anchor Connector

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Anchorage Connectors

- Horizontal Lifelines
  - Requires a Qualified Person for engineering or anchorage certification

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Horizontal Lifelines - Temporary

- Synthetic Rope with Tensioner
- Wire Rope with turn buckle & thimble eye clamp

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Horizontal Lifelines

Purpose

- Improves user horizontal mobility
- Use for fall arrest, positioning or restraint
- 100% continuous fall protection
- Provides additional vertical mobility
- Generally have an inline energy absorber
  - Use with energy absorbing lanyard
  - Use with Self Retracting Lifeline (SRL)

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Horizontal Lifelines

Applied Forces

- Forces generated in HLL sub system tend to be large
- They are generated on the vertical and horizontal axis
- Generate maximum deflection at the point of Maximum Arresting Force (MAF) generation
- In line energy absorbers reduce anchorage requirements to below 22 kNs (5000 lb)

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Horizontal Lifelines

-Tension

- Follow instructions regarding lifeline tension
- Most systems require hand tensioning and adjustment by turnbuckle
- Over tightening results in:
  - Energy absorber deployment
  - Higher end anchor loads
  - Higher MAF
  - Greater rebound after fall

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Anchorage

A fixed structural member such as a post, stanchion, beam, girder, column, floor or wall required for the stability and other purposes of the structure itself.

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Fall Protection Background – Anchorage Points

- Who specifies the anchorage point?
  - Competent person
    - Non-certified anchorage point
    - 22 kN (5000 lbs), per person attached
  - Qualified person
    - Certified anchorage point
    - Designed with a safety factor of at least two (MAF), per person attached

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Fall Protection Background – Personal Protective Equipment

- What all do we consider before using PPE?
  - Free-Fall Distance
  - Maximum Arresting Force
  - Anchorage Point Strength and Location
  - Total fall distance / Clearance calculation

Strength and Location

Type of PPE Desired

Best combination for the Work at Heights task

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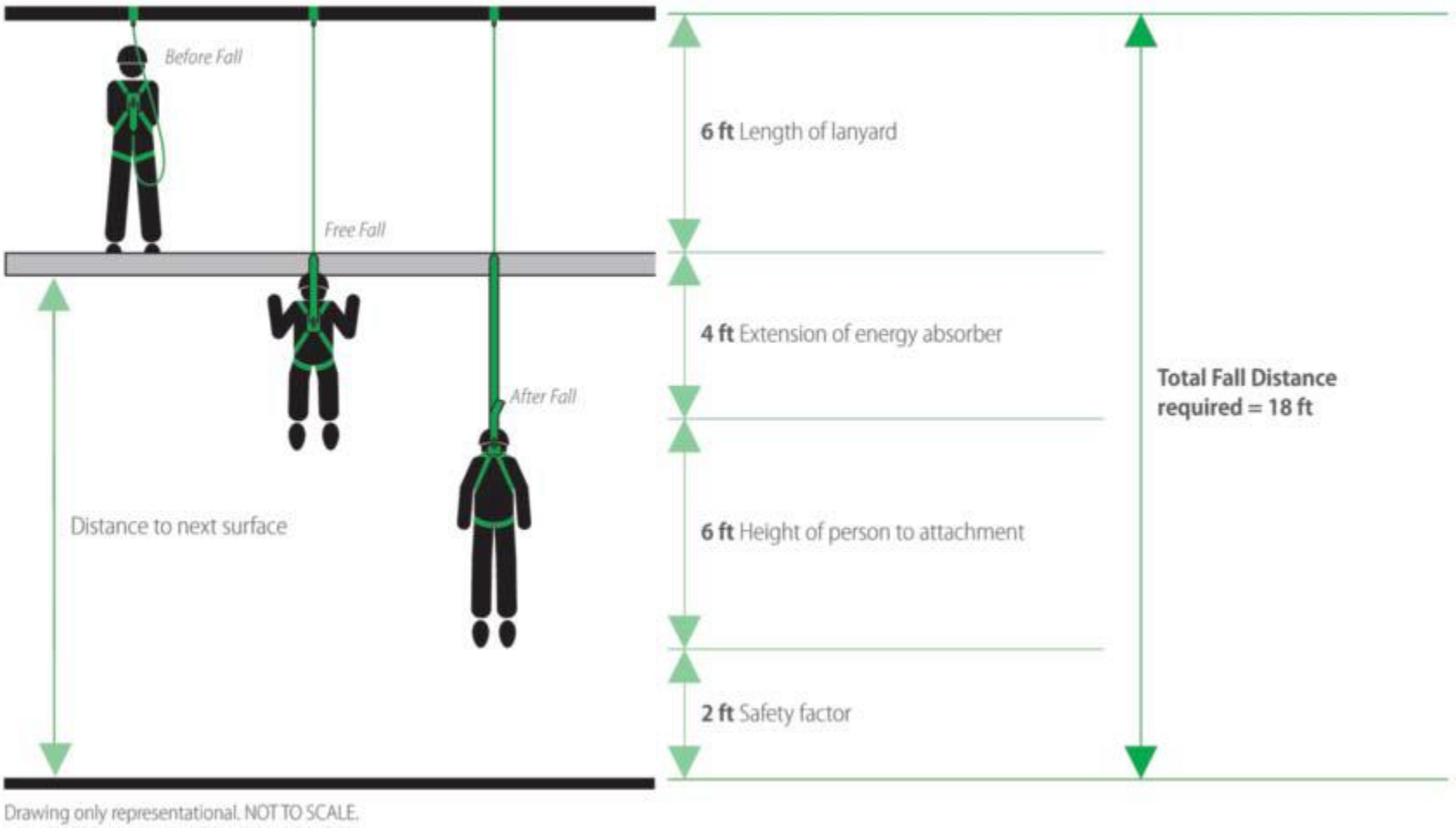
Total Fall Distance Calculation

How to calculate Total Fall Distance



Drawing only representational. NOT TO SCALE.

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Fall Protection -- Rescue Plan

- Each time PPE is used, there must be a rescue plan!
  - You must be able to rescue someone in a minimum amount of time.
  - Define the plan during the Hazard and Risk Prediction.

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Suspension Trauma

Orthostatic incompetence (intolerance)

John Doe on parade

- Blood pools in the legs
- Venus pooling
- Brain detects low O2
- Cardiac output increases
- Brain O2 still falls
- Emergency response:
  - Pulse drops
  - Loss of consciousness
  - John falls over
  - Blood flows back to brain
- John wakes up.

John Doe in suspension

- Blood pools in the legs
- Venus pooling
- Brain detects low O2
- Cardiac output increases
- Brain O2 still falls
- Emergency response:
  - Pulse drops
  - Loss of consciousness
  - John CANNOT fall over
  - Brain function decreases
- John never wakes up.

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Fall Protection - Emergency Rescue Plan

- How many people who may need rescue or evacuation?
- What is the elevations from which rescue or evacuation will be needed?
- Which direction (up or down) must be used for rescue or evacuation?
- What anchorages for personal fall arrest systems may be used for rescue or evacuation?
- What independent anchorages for a rescue or evacuation may be used?

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Rescue Equipment

- Full Body Harness
  - Designed for Rescue
  - Allows longer suspension

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Rescue Equipment

- SRL's
  - Emergency Retrieval capabilities
  - Reset from Retrieval to Fall Arrest
- Hoists
  - Lifting, Lowering, Positioning of personnel and equipment

Pre-Rigged haul System

- Use the rescue utility kit
- Telescopic remote pole
- 4:1 mechanical advantage pulley system
- Remote Connector

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Rescue Equipment - Escape

- MSA Anthron
  - Self-Rescue
  - Great in a panic
  - Manual device
  - Non integrated rope
  - Operator control descent speed with friction

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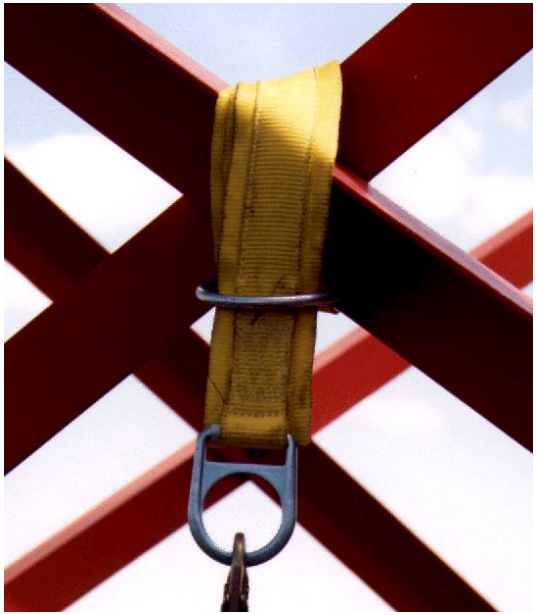
Rescue Anchorage



- Anchorage should be a rigid structure, such as a beam, column or large truss above the casualty
- Anchorage for rescue and decent control needs to be rated for at least 3,000 lbs. (16kN)(1406 kg)
- Select an anchorage other than what may have been used to arrest the fall of the casualty
- A separate (independent) anchor system should be set up for each fall arrest system and each lowering or raising system required.

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Review

- Fall Hazard scenarios have options
- Use the Hierarchy of controls
- Must choose which solution works best for your work situation
- Fall Protection
  - ANSI Product updates
  - Additional training requirements
  - Rescue concerns and considerations

End

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