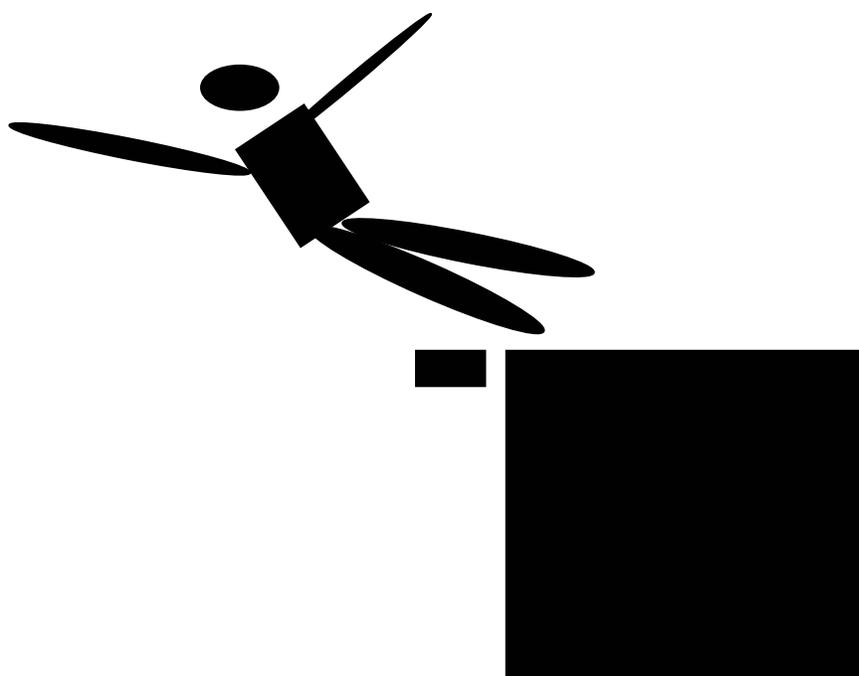


UNIVERSITY OF MARYLAND  

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MARYLAND FIRE AND RESCUE INSTITUTE



Fall Protection Awareness  
Reference Manual

# FALL PROTECTION AWARENESS

## PREFACE

In April 1990, the U.S. Department of Labor, Occupational Safety and Health Administration (OSHA) proposed to amend, for use in general industry, 29 CFR Part 1910- Subpart I *Personal Protective Equipment* by adding criteria for equipment pertaining to fall protection systems, including fall arrest systems; work positioning systems; travel restricting systems; and fall protection systems for climbing. At the same time, OSHA proposed to amend for use in general industry, 29 CFR Part 1910- Subpart D *Walking and Working Surfaces* in order to focus on the hazards that can result from trips, slips, and falls causing serious and fatal injuries. The proposed standard will also eliminate ambiguities and redundancies contained in the existing subpart D; address areas not covered in the existing standards; and consolidate and simplify many of the provisions contained in the existing standard. OSHA re-issued both of the proposals for public comment in the Federal Register, Volume 68, Number 85, pages 23528 through 23568, on May 2, 2003.

On August 9, 1994, OSHA published the Final Rule for 29 CFR Part 1926- Subpart M- *Fall Protection in the Construction Industry*, in the Federal Register. This standard became effective and was implemented on February 6, 1995 with the exception of areas pertaining to steel erection, residential construction, scaffolds and areas which already have specific fall protection requirements applicable to construction workers.

Directive 3.1- *Interim Fall Protection Compliance Guidelines for Residential Construction* was issued on December 8, 1995.

On August 30, 1996, OSHA published the Final Rule for 29 CFR 1926- Subpart L- *Scaffolds*, in the Federal Register. This standard was implemented on November 29, 1996.

The final rule, CFR 1926 Subpart R- *Steel Erection* was published January 18, 2001 in the Federal Register with an effective date of July 18, 2001.

In the sections to follow, highlights of these standards have been reproduced for your convenience.

These systems criteria and practices are not to be considered all inclusive, but reflect only those areas deemed appropriate for illustration in **this** presentation. For complete information on requirements and specifications, please refer to the standards.

The reader should note that requirements are performance based and allow a variety of solutions for fall protection systems provided the criteria and practices are observed. The employer has a responsibility to provide and install all fall protection systems or provide a plan when conventional fall protection is deemed infeasible. The employee shares responsibility to use and maintain the provided equipment and systems in a safe manner.

The Special Programs Section of the Maryland Fire and Rescue Institute (MFRI) has developed fall protection training programs to assist employers in providing safe work practices, through an understanding of fall protection requirements, and the use and maintenance of personal fall protection systems. Please call the Special Programs Section at (301) 226-9940 or 1-800-ASK MFRI (275-6374) for further information regarding this or other training programs.

### **Occupational Fatalities/Disabling Injuries by Event and Industry:**

Total Reported Fatalities: 6,023<sup>1</sup>

Total Percentage of Fall Related Fatalities:

Fatalities from falls-	717-	12.0%
Struck by falling objects-	358-	6.0%

Contributing factors: About half were from ladders

Work related injuries<sup>2</sup> resulting in days away from work:

Total disabling injuries-	5 day median
Falls from elevations-	10 day median- 29.4% out for >31 days
Falls on same level-	7 day median- 22.9% out for >31 days

*Note: The statistics for death and injury from falls and falling objects remain fairly consistent over time; therefore, the statistics presented are for illustration purposes only and do not reflect the most recent figures.*

**For All Industries:** Falls account for the third highest cause of death in the workplace exceeded only by vehicle accidents and violence in the workplace.

**For Construction:** Falls are the leading cause of death for construction workers.

**Additional Lost Time Impact- \$ (dollars lost):**

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<sup>1</sup> Bureau of Labor Statistics Web Site: (BLS-1999)

<sup>2</sup> Bureau of Labor Statistics Web Site: (BLS-1998)

- **Lost wages;**
- **Worker's compensation;**
- **OSHA fines;**
- **Third-party suits.**

**General Duty Clause-** Duties (29 USC 654 Sec. 5.)

(a) *Each employer:*

(1) *Shall furnish to each of his employees employment and a place of employment which are free from recognized hazards that are causing or are likely to cause death or serious physical harm to his employees;*

(2) *Shall comply with occupational safety and health standards promulgated under this Act.*

(b) *Each employee shall comply with occupational safety and health standards and all rules, regulations, and orders issued pursuant to this Act which are applicable to his own action and conduct.*

**Public Law 91-596**

Dec. 29, 1970

**CFR 1926 Subpart M - Safety Standard for Fall Protection in the Construction Industry:**

Effective date February 6, 1995, requires the employer to assess walking/working surfaces in the workplace for:

- Strength and structural integrity;
- Select options for when fall protection is indicated;
- Be responsible for contractors operating at their facilities (jointly with contractors and sub-contractors);
- Required to provide approved fall protection equipment and systems as indicated.

Identifies areas or activities where fall protection is needed.

- Does not apply to those inspecting, investigating, or assessing workplace conditions prior to starting job or after completion of work;
- Sets a uniform threshold height of 6 feet;
- Protects employees from falls when 6 feet above a lower level, and falling objects;
- Protects workers exposed to hazards of falling into dangerous equipment.

Training and retraining shall be provided that teaches employees **who might be exposed** to fall hazards how to recognize such hazards and how to eliminate or minimize them. Several areas of required training are specified:

- Nature of fall hazards in the work area;
- Correct procedures for erecting, maintaining, disassembling, and inspecting fall protection systems;
- Use and operation of the controlled access zone, guardrail, personal fall arrest, safety net, warning line, and safety monitoring systems;
- The role of each employee when a safety monitoring system is used;
- Specific criteria for the use of mechanical equipment performing roofing work on low-sloped roofs;
- Correct procedures for equipment and materials handling and storage and the erection of overhead protection;
- The employees' role in fall protection plans;
- Employer must prepare written certification that identifies employees trained and date of training. It must be signed by the employer or the trainer. Retraining must be provided when necessary, such as when an employee changes jobs.

### **Proposed Safety Standards for General Industry, CFR 1910. Subpart D- Walking and Working Surfaces and Subpart I - Personal Fall Protection Systems:**

These final standards are being developed concurrently. Subpart D refers to, or requires use of fall protection systems. Subpart I proposes criteria for personal fall protection systems.

The proposed standard adopts a performance-oriented approach with a more consistent approach to other OSHA standards and requires surfaces to be designed, constructed, and maintained free of recognized hazards that might result in death or serious injury.

When surfaces cannot be maintained free of those hazards employees shall be provided with a means to avoid or minimize exposure to them.

May be as simple as removing ice, snow, or oil from an elevated walkway as an example, or requiring handrails or guardrails and toeboards.

If they are infeasible, one or more of the following:

- Raised floor mats or anti-slip surfaces (sand, cinders);
- Personal fall protection systems consisting of:
  - Anchorage;
  - Body-holding device; and,
  - Connecting means.

- Safety nets.

The proposed standard sets a general threshold height of four feet with some exceptions:

- Vary in specific applications such as fixed ladders (24 feet), stairs (four risers), ramps (20 degrees from horizontal), etc;
- The "qualified climber" rule;
- Special training required for employees who use ladders six feet or greater in height;
- Scaffolds ten feet or higher.

Training and retraining requirements are specific to the section under which they apply. (Refer to specific application for unique training requirements.) Training is an important factor for employee safety on all special work surfaces. As a minimum, the employer should institute a training program for employees to recognize and avoid the special hazards involved with a particular surface. Training should be conducted to give the employee a better understanding of the working conditions, use of fall protection systems, and special hazards. Retraining may be necessary if an employee has been away from one of these activities for a prolonged period of time.

The OSHA proposal requires that before equipment is used, employees are to be trained in the:

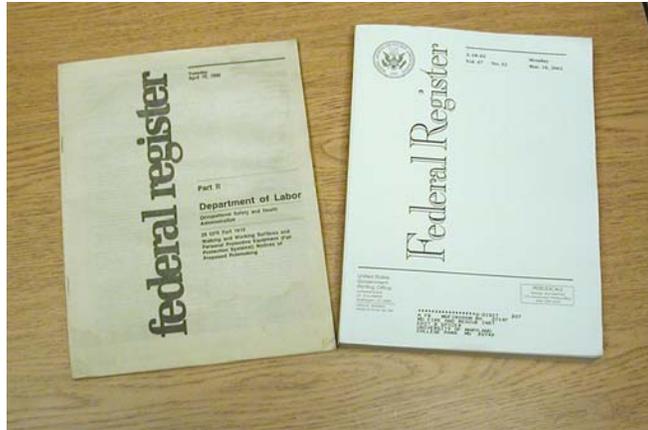
- Application limits;
- Proper anchoring and tie-off techniques, including determination of elongation and deceleration distances;
- Methods of use;
- Inspection and storage.

Manufacturer's instructions for all equipment being used shall be available on site.

## **Information and Resources:**

### **Federal Register - Subscription Service:**

- Government Printing Office (GPO)
- Telephone: 1-888-293-6498 (Toll Free);
- Contains preamble discussion of public comments, proposed date of adoption, final rule.



### **Code of Federal Regulations:**

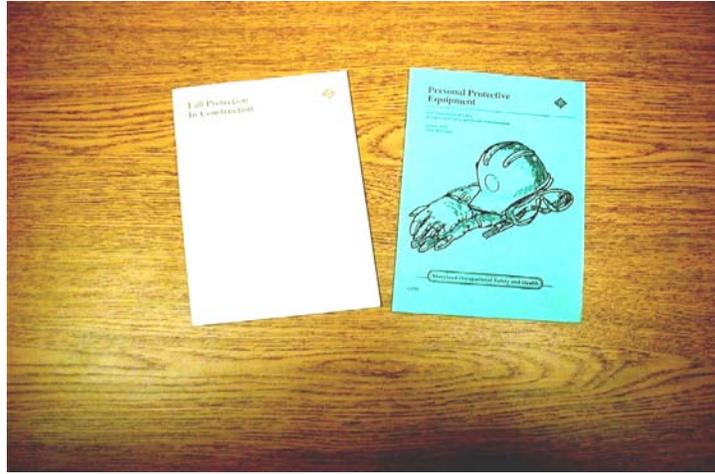
- Government Printing Office (GPO)
- Telephone: 1-888-293-6498 (Toll Free)
- E-Mail: [gpoaccess.gpo.gov](mailto:gpoaccess.gpo.gov)
- Home page: <http://www.acess.gpo.gov>



### **Internet - World Wide Web:**

- <http://www.osha.gov>
- Proposed standards
- Interim amendments
- Topic specific: Example: <http://osha.gov/oshdoc/std31.htm/>

### **Safety Pamphlets:**



**News Release - OSHA- Office of Public Affairs:**

- Telephone: 202-219-8151; after hours: 703-360-7080

**Consultations Available:**

- Voluntary safety audit for small employers;
- On-line telephone to contact persons

**State Plan States vs. Non-State Plan States:**

Some states have chosen to write, enforce, and regulate their own regulations under OSHA guidance. These states must at least meet OSHA standards, but can exceed the OSHA requirements. If you live in a State Plan State, you must be familiar with, and adhere to the State Standards.

**State Plan States:**

All Paid Employees Covered.

- Federal
- State
- Public Sector Employees

Volunteers are not considered employees, but are subject if joint response with paid employees or when they have employees that are covered by worker's compensation.

### **Non-State Plan States:**

Private sector and federal covered by OSHA.

State and local employees are covered by EPA Worker Protection Regulations or by State Agencies within the state.

### **STATE PLAN STATES**

All paid employees - private sector, and federal and local public sector employees - in the following states/territories are covered by their state's worker plans:

Alaska	Maryland	Puerto Rico
Arizona	Michigan	South Carolina
California	Minnesota	Tennessee
Connecticut *	Nevada	Utah
Hawaii	New Mexico	Vermont
Indiana	New York *	Virginia
Iowa	North Carolina	Virgin Islands
Kentucky	Oregon	Washington
		Wyoming

\* For state and local government employees including volunteers only. No private sector coverage under state plan.

### **NON-STATE PLAN STATES**

State Agency Regulations or Executive Order covers by the Environmental Protection Agency (EPA), or Worker Protection Regulation, and/or state and local government employees of the states listed below. Private sector and federal employees including fire fighters in the following states/territories are covered by federal OSHA worker protection regulations:

Alabama	Missouri
Arkansas	Montana
Colorado	Nebraska
Delaware	New Hampshire
District of Columbia	New Jersey
Florida	North Dakota
Georgia	Ohio
Guam	Oklahoma
Idaho	Pennsylvania
Illinois	Rhode Island
Kansas	South Dakota
Louisiana	Texas

Maine  
Massachusetts  
Mississippi

West Virginia  
Wisconsin

## **SLIPS, TRIPS, AND FALLS:**

Are based on laws of science involving friction, momentum, and gravity.

**Friction:** Accidents occur when the resistance between surfaces lose traction or grip. An example would be like walking on ice.

**Momentum:** Accidents involve relationship to speed and size. An example would include the inertia from moving bodies coming to sudden stops. The larger the mass, the more impact involved.

**Gravity:** Accidents involve forces that pull you towards the ground. Example includes disturbance in the center of balance by forces (gravity) which result in shifts beyond one's ability to recover.

### **SLIPS:**

- Involve the loss of traction;
- Leading cause of workplace body motion accidents;
- Best controlled by design and housekeeping;
  - Non-slip surfaces for areas prone to spills;
  - Immediate clean-up of spills;
  - Shoe soles compatible with work and walking surface areas and materials to which exposed;
  - Isolating wet floor areas during routine maintenance, among others.

### **TRIPS:**

- Involve uncontrolled momentum leading to loss of balance;
- Trip prevention tips include:
  - Not carrying objects that obstruct one's vision;
  - Watching where one is walking;
  - Removal or taping down wire, ropes, cables, boxes, etc. placed in walkways;
  - Not hurrying on stairs, in aisles, or around corners;
  - Grasping handrails when using stairs;
  - Not running up or down stairs or jumping from landings;
  - Keeping walking and working surfaces, etc. in good repair.

### **FALLS:**

- Involve moving off your center of balance (gravity) beyond a point of recovery;
- Falls may include only one surface or from one surface to another. Slips and trips are often contributing factors, as are misuse of equipment such as ladders, scaffolding, overloading, poor anchorages, distraction, etc.
- Fall prevention tips include:
  - Not jumping from vehicles or other elevations;
  - Not using a chair for a ladder;
  - Following ladder safety use guidelines;
  - Using guarding around floor openings, shafts, or excavations;
  - Not overreaching in high places; etc.

Falls from elevations or falls from one level to another cause a significant number of injuries and fatalities, with a higher toll in cost, lost time, and indemnity payments. This is the area that this course is primarily designed to address. The objective, then, is to reduce falls from elevated surfaces to at most slips or minor falls at the worst, and hopefully where no injury occurs.

## **DEVELOPING A FALL PROTECTION PROGRAM**

### **Preparatory Steps for Developing the Fall Protection Training Program:**

In preparing for the development of a fall protection program, there are certain major participants who should be identified and certain necessary steps that form the basis for the planning of the program. These people and elements are defined as:

- **Competent Person:** One who is capable of identifying existing and predictable hazards in the surroundings or working conditions which are unsanitary, hazardous, or dangerous to employees, and who has authorization to take prompt corrective measures to eliminate them.
- **Qualified Person:** One who, by possession of a recognized degree, certificate, or professional standing, or who by extensive knowledge, training, and experience, has successfully demonstrated his/her ability to solve or resolve problems related to subject matter, the work, or the project.
- **Job Hazard Analysis (JHA):** Establishing proper safe job procedures by studying and recording each step of each job; identifying existing or potential hazards; and determining the best way to perform the job to reduce or eliminate these hazards.

These people, or their equivalent, must first identify the fall hazards on the jobsite or workplace and conduct an analysis of those jobs or tasks that have the potential to have fall hazards.

The purpose of this analysis is to:

- Evaluate the various fall hazards found during the survey and the job hazard analysis, and group them into like categories for future control measure applications;
- Eliminate or remove the fall hazard from the jobsite, or eliminate the exposure to the fall hazard;
- Use engineering controls where they are feasible;
- Use non-conventional or administrative type controls where engineering controls are not feasible;
- Use fall arresting systems where engineering controls are not feasible and where administrative controls will not fully meet the needs to protect employees;
- Use a fall protection plan only when none of the other above fall protection systems are found to be feasible.

### **Designing in Fall Protection:**

For new facilities, the first consideration should be to design fall protection into buildings and processes to eliminate fall hazards that have been identified. Start at the planning stage identifying and evaluating anchorages, permanent scaffolding, carrier systems, guard railing, etc. It should not be overlooked that construction of the building or facility requires fall protection features and integrating safety at elevations into the building plan.

For existing facilities, review history of fall incidents, do a hazard survey of the facilities and job work activities with potential fall hazard(s), and design means to prevent free fall incidents.

### **Establishing a Fall Hazard Control Policy:**

The technology exists for 100 percent fall protection, but some owners, construction companies, and businesses aren't willing to pay for it, according to industry experts. Two major challenges are in getting smaller companies to purchase fall protection equipment and initiate policies and programs; and to persuade employees and employee unions to accept and use it.

To accomplish safe practices companies must:

- Analyze their fall protection hazards;
- Select the control measures for these hazards;
- Purchase the right equipment;
- Establish and enforce written policies and regulations that are written and enforced.

### **Developing Fall Protection Training Programs:**

Initiate training programs that emphasize, at a minimum:

- Types of harnesses and lanyards workers use, and which device workers should use in various situations;
- Procedures for assembly, care, maintenance, and inspection of fall protection systems;
- Procedures for handling, storing, and securing tools, equipment, and materials;
- How to rescue injured workers and suspended workers.

Once their training is complete, workers must be monitored closely. Without close supervision, workers tend to forget training. For example, they may wear a harness but forget to hook up their lanyard which makes the equipment useless.

### **Dispelling Myths and "Macho" Feelings:**

Dispelling the myths and “macho” feelings is one of the most difficult challenges to overcome due to misconceptions and other factors such as:

- Peer pressure;
- Workers primarily fall to their deaths only from great heights (a number of deaths occur in falls from 10 to 12 feet);
- “*Fall protection restricts mobility;*”
- Some managers and supervisors say it can't be done practically;
- “*This will only take a second,*” or “*I've done it a thousand times;*”
- “*Falls only happen to the other guy.*”

Firm policies must be stated and enforced to assure compliance. Contractors and sub-contractors must be challenged to comply. In addition to these basics you may wish to establish fall protection requirements into bid packages for contractors.

### **Rescue Team or Rescue Service Evaluation Criteria:**

*The following information has been extracted in part from non-mandatory Appendix F of 1910.146 - Permit-required Confined Spaces, and has been modified to apply to fall protection rescue requirements found in 1926.502(d)(20) - Fall Protection.*

*While similar language is not found specifically in the Fall Protection Standard, the need and content is nonetheless valid.*

### **Rescue Team or Rescue Service Evaluation Criteria:**

This section provides guidance to employers in choosing an appropriate rescue service. It contains criteria that may be used to evaluate the capabilities both of prospective and current rescue teams. Before an on-site rescue team can be trained or some other chosen, however, a satisfactory fall protection plan, including an analysis of all fall protection hazards found on the work site, must be completed. In spite of the precautions taken, experience indicates that circumstances will arise where workers will need to be rescued from heights (rope rescues). It is therefore important for employers to select rescue

services or teams, either on site or off site, that are equipped and capable of minimizing harm to both workers and rescuers if the need for rescue arises.

For all rescue teams or services, the employer's evaluation should consist of two components: an initial evaluation, in which employers decide whether a potential rescue service or team is adequately trained and equipped to perform rope rescues of the kind needed at the facility and whether such rescuers can respond in a timely manner; and a performance evaluation, in which employers measure the performance of the team or service during actual or practice rescues.

For example, based on the initial evaluation, an employer may determine that maintaining an on-site rescue team will be more expensive than obtaining the services of an off-site team without being significantly more effective, and decide to hire a rescue service. During performance evaluation, the employer could decide, after observing the rescue service perform a practice rescue, that the service's training or preparedness was not adequate to effect a timely or effective rescue at his or her facility and decide not to select that rescue service, but to look at another one or to form an internal company rescue team.

### **Initial Evaluation:**

The employer should meet with the prospective rescue service to facilitate the evaluations required. At a minimum, if an off-site rescue service is being considered, the employer must contact the service to plan and coordinate the evaluations. Merely posting the service's number or planning to rely on the 911 emergency phone number to obtain these services at the time of the emergency would not be considered adequate protection for employees.

The capabilities required of a rescue service vary with the type of fall incident from which rescue may be necessary and the hazards likely to be encountered in that incident. Answering the questions below will assist employers in determining whether the rescue service is capable of performing rope rescue at the employer's workplace or off-site.

- What are the needs of the employer with regard to response time (time for the rescue service to receive notification, arrive at the scene, and set up to retrieve the victim)?
- How quickly can the rescue team or service get from its location to the incident where which rescue may be necessary? Relevant factors to consider would include: the location of the rescue team or service relative to the employer's workplace; the quality of roads and highways to be traveled; potential bottlenecks or traffic congestion that might be encountered in transit; the reliability of the rescuer's vehicles; and the training and skill of its drivers; in short, response time.
- What is the availability of the rescue service? Is it available at certain times of the day or in certain situations? What is the likelihood that key personnel of the rescue service might be unavailable at times? If the rescue service becomes unavailable while high work is undertaken, does it have the capacity of notifying the employer so that the employer can instruct the competent person at the worksite?

- Does the rescue service meet all the requirements to perform rope rescue? If not, has it developed a plan that will enable it to meet those requirements in the future? If so, how soon can the plan be implemented?
- For off site services, is the service willing to perform rescues at the employer's workplace? (An employer may not rely on a rescuer who declines, for whatever reason, to provide rescue services.)
- Is an adequate method of communication between the competent person, employer, and protective rescuer available so that a rescue request can be transmitted to the rescuer without delay? How soon after notification can a prospective rescuer dispatch a rescue team to the site?
- If the worksite has a vertical entry over four feet in height, can a prospective rescue service properly perform rope rescues? Does the service have the technical knowledge and equipment to perform rope work or elevated rescue, if needed?
- Does the rescue service have the necessary skills in medical evacuation, patient packaging, and emergency response?
- Does the rescue service have the necessary equipment to perform rescues, or must equipment be provided by the employer or another source?
- If the answer to any of these questions is NO, the employer should consider training the worker in self rescue or the employees (teams) should be trained in simple rescue techniques. Appropriate rescue equipment must be provided and the teams trained and drilled in their use.

### **Performance Evaluations:**

Rescue services should perform practice rescues at least once every 12 months, provided that the team or service has not successfully performed a rope rescue within that time. As part of each practice session, the service or team should perform a critique of the practice rescue, or have another qualified party perform the critique, so that deficiencies in procedures, equipment, training, or number of personnel can be identified and corrected. The results of the critique, and the corrections made to respond to the deficiencies identified, should be given to the employer to enable it to determine whether the rescue service can quickly be upgraded to meet the employer's rescue needs or whether another service must be selected. The following questions will assist the employers and rescue teams and services evaluate their performance:

- Have all members of the service been trained in rope rescue, at a minimum, including training in the potential hazards of working in all elevated surfaces, or of representative spaces, from which rescues may be needed?
- Is every team member provided with, and properly trained in, the use and need for PPE, including fall arrest equipment, which may be required to perform rescues at the facility or work site? Is every team member properly trained to perform his or her functions and make rescues, and to use any rescue equipment, such as ropes and backboards, that may be needed in a rescue attempt?
- Are team members trained in first aid and medical skills needed to treat victims of falls?

- Do all team members perform their functions safely and efficiently? Do rescue service personnel focus on their own safety before considering the safety of the victim?
- Has the rescue service been informed of any hazards to personnel that may arise from outside the rescue area, such as those that may be caused by falling objects near or over the rescue area?
- If necessary, can the rescue service properly package and retrieve victims from an area that has limited access?
- If necessary, can the rescue service safely perform an elevated (high angle) rescue?
- Does the rescue service have a plan for each of the kinds of rope rescue operations at the facility? Is the plan adequate for all types of rescue operations that may be needed at the facility? Teams may practice in representative spaces, or in spaces that are “worse-case.”

### **Self-Rescue Techniques:**

The standard also allows for self rescue as an option. While many manufacturers offer self-rescue equipment, the techniques used must be considered in an organized training program and practiced for proficiency. In addition to learning basic techniques for self rescue, other factors which play heavily on the success of these rescue techniques are the physical conditioning of the employee and the injury factor which may result from the fall. The employee working alone or in an isolated area should have a means of communicating with fellow employees or a base station.

### **Review and Correction:** [Ref. 1926.502(k)(10)]

In the event an employee falls, or some other related serious incident occurs, (e.g., a near miss) the employer shall investigate the circumstances of the fall or other incident to determine if the fall protection plan needs to be changed (e.g., new practices, procedures, or training) and shall implement those changes to prevent similar types of falls or incidents.

### **Training Duties of the Competent Person:**

The employer is to instruct each employee in the recognition of fall hazards and how such hazards are to be avoided or controlled. The employee is to be trained in the procedures that the employer has established for the use of the fall protection control measures. The training is to be conducted by a competent person designated by the employer.

### **The competent person must be qualified in these areas:**

- Knowledgeable of the nature of fall hazards in the work area or site;
- Knows the correct procedures for erecting or assembling the fall protection systems that will be used on site. Knows the procedures for the maintenance of these systems

and the procedures for disassembling the fall protection systems;

- Knows the proper procedures and methods to fully inspect the fall protection systems used on the work site;
- Knows the proper applications for the conventional fall protection systems and the non-conventional fall protection systems;
- Knows the role of each employee in using fall protection systems including the safety monitor non-conventional system if this system is used on site;
- Knowledgeable of the limitations of mechanical equipment that may be used on the roof job within the protected areas of fall protection non-conventional system;
- Knowledgeable of the correct procedures for handling and storing of fall protection equipment;
- Knowledgeable of the proper procedures for the storage of materials and equipment to prevent them from becoming a hazard to those working below, and where the erection of overhead protection is needed;
- Knows the role of employees and the fall protection precautions that need to be taken in any fall protection plan that may be developed for a site;
- Knowledgeable of the OSHA 1926 construction fall protection standards in Subpart M;
- Knows the training certification procedures that the employer is using for documenting the training that has been given to employees related to fall protection;
- Knowledgeable of the employer's policy on the recognition of other training sources, training that could be accepted as a substitute for the fall protection training given by the employer;
- Knowledgeable of when retraining is needed for employees that have been previously trained;
- Knowledgeable of the rescue capabilities of the employer and nearby emergency rescue services in rescuing a person that is hanging by their personal fall arrest system.

## **Summary:**

When considering a 100% fall protection program the following flow steps should be employed:

- Analyze each work fall hazard and the type of work to be done.
- Break down horizontal and vertical work situations to analyze mobility.
- Note anchoring methods and types to determine the force pounds of application.
- Sketch out methods to see if they fit your intended application.
- Select equipment for the job remembering the compatibility/cost ratio.
- Establish an on-going training and equipment maintenance program.
- See that instructions are provided with equipment and that the required equipment is provided at job sites.
- Consider what happens after the fall in advance of it. Are automatic lowering devices indicated, or is suspension until rescue systems arrive required?

- Evaluate rescue possibilities and determine your course of action.

## **FALL PROTECTION SYSTEMS**

### **Identification of Fall Hazards on the Job Site:**

The General Duty Clause requires that the employer provide a safe work environment for the worker, and that the employee understand and utilize the safety plan and safety equipment provided. To accomplish this requirement the employer must implement procedures for identifying fall hazards in the workplace and/or at the worksite, to determine which methods of fall protection are appropriate for the task to be accomplished.

There are three methods suggested for accomplishing the identification process:

- Conduct job hazard analysis of the jobs or tasks that may have fall hazards;
- Conduct a walk-around over the job site looking for those areas where fall hazards exist or potentially may exist;
- Document the findings of the walk-around and job hazard analysis by noting the locations, types of fall hazards (same level, to a lower level, and overhead), and whether personal fall protection equipment is needed.

The preferred method of providing fall protection is the installation of engineered or built-in controls. These include the use of guardrails, stair rails, handrails, and toeboards. In addition, the erection of barricades, ladder cages, overhead canopies, and covers over holes and skylights are other forms of engineered fall protection systems.

The use and installation of safety nets also accomplish the task of providing fall protection. This fall protection system may be required in certain safety applications.

When engineered methods of providing fall protection cannot be accomplished, the use of personal fall arrest systems and positioning device systems may be indicated.

Personal fall arrest systems consist of a body holding device (full body harness), connecting means (lanyard), and an anchoring device. Examples of fall arrest systems include:

- Horizontal lifeline systems;
- Vertical lifeline systems;
- Ladder safety devices.

Positioning device systems consist of a body holding device (full body harness or lifebelt) and an anchorage. Examples of jobs utilizing positioning devices include:

- Window washing;

- Line men;
- Rebar installation;
- Leading edge restraint;
- Other positioning jobs that have zero fall arrest possibility.

There are other fall protection systems that may be used under specialized working conditions. These include:

- Warning lines (for low-sloped roof work only);
- Controlled access zones (for overhand brick laying, leading edge work; pre-cast concrete erection work; and residential construction work only);
- Safety monitoring systems (used with the warning line system or the controlled access zone system);
- Fall protection plan (required when conventional fall protection systems are not feasible in leading edge work, pre-cast concrete erection work, and residential construction work only.)

The final consideration in the hazards identification process is to determine where rescue problems exist if a person was to fall, and how rescue might be accomplished.

### **Fall Protection Systems Criteria and Practice:**

Construction employers are responsible for providing and installing all fall protection systems for fall heights of six feet or more and in doing so, shall comply with the appropriate subparts before employees begin work.

General industry employees exposed to unprotected sides or edges of surfaces that present a falling hazard of four feet or more to a lower level or floor holes shall be protected by a fall protection system. If the fall hazard is less than four feet but is above or adjacent to dangerous equipment, materials, or operations, it shall also be protected.

### **Guardrail Systems:**

Guardrail systems are vertical barriers, normally consisting of, but not limited to, an assembly of top-rails, mid-rails, and posts, erected to prevent employees from falling to lower levels.

Guardrails shall consist of 42" top rails (+/- 3") above walking/working surface. These systems shall have mid-rails or screens and mesh if there is no wall or parapet wall of at least 21 inches. Posts or ballasts shall not be more than 19 inches apart nor shall there be an opening in excess of 19 inches wide in the guardrail system.

The guardrail system shall support, without failure, any downward or outward force of at least 200 pounds applied within two inches of the top edge. Mid-rail or screen, mesh, intermediate vertical members, solid panels, etc. shall be capable of withstanding 150 pounds applied downward or outward at any point.

Ends of top-rails and mid-rails shall not overhang the terminal post, except where it does not constitute a projection hazard.



If wire rope is used for top-rails, they shall be flagged at least every six feet with high-visibility materials.

When guardrail systems are in hoisting areas, a chain gate or removable guardrail section shall be in place when not being used. Where materials are passed through holes and guardrail systems are used, the hole shall not have more than two removable sides. When not in use, the hole shall be closed over with a cover or a full guardrail system. When holes are used as points of access (such as for ladder ways), a gate or offset is provided so that a person cannot walk directly into the hole.

When using manila, plastic, or synthetic rope for top-rails or mid-rails they shall be inspected as frequently as necessary to ensure that they continue to meet the strength requirements stated above.

Guardrail systems are the primary fall protection system for walking and working surfaces unless guardrail systems are not feasible, in which case one or a combination of the listed systems shall be used:

- Handrail and stair rail systems;
- Toeboards, canopies, or barricades;
- Hole covers in floors and roofs and other surfaces;
- Safety net systems;
- Personal fall protection systems (see Subpart I);
- Warning lines (see Subpart I);

- Designated areas where employers demonstrate that employees are not exposed to fall hazards;
- Fall protection plan.

## **Stairs:**

In addition to design specifications, general industry stairs with four or more risers shall be provided with at least one handrail. A stair rail system shall be provided on all unprotected sides and edges of stairways and stair landings, unless otherwise enclosed, with a fall hazard of four feet or more. Unprotected sides and edges are any side or edge of a surface, except at entrances to points of access, where there is no wall or guardrail or stair rail system.

Stairways having four or more risers or rising more than 30 inches (76 cm), whichever is less, shall be equipped with at least one handrail, and one stair rail system along each unprotected side or edge.

Winding and spiral stairways shall be equipped with a handrail offset sufficiently to prevent walking on those portions of the stairways where the tread width is less than six inches (15 cm).

The height of stair rails shall be as follows:

- Stair rails installed after March 15, 1991 shall be not less than 36 inches (91.5 cm) from the upper surface of the stair rail system to the surface of the tread, in line with the face of the riser at the forward edge of the tread.
- Stair rails installed before March 15, 1991 shall be not less than 30 inches (76 cm) nor more than 34 inches (86 cm) from the upper surface of the stair rail system to the surface of the tread, in line with the face of the riser at the forward edge of the tread.

Mid-rails, screens, mesh, intermediate vertical members, or equivalent intermediate structural members shall be provided between the top rail of the stair rail system and the stairway steps.

When intermediate vertical members, such as balusters, are used between posts, they shall be not more than 19 inches (48 cm) apart.

Handrails and the top-rails of stair rail systems shall be capable of withstanding, without failure, a force of at least 200 pounds in any downward or outward direction, at any point along the top edge.

The height of handrails shall be not more than 37 inches (94 cm) nor less than 30 inches (76 cm) from the upper surface of the handrail to the surface of the tread.

Handrails shall provide an adequate handhold for employees grasping them to avoid falling.

The ends of stair rail systems and handrails shall be constructed so as not to constitute a projection hazard.

Unprotected sides and edges of stairway landings shall be provided with guardrail systems.

### **Toeboards, Canopies, or Barricades:**

A toeboard is a low protective barrier placed to prevent the fall of materials to a lower level, or when used without a guardrail, to prevent an employee's feet from slipping over the edge of a surface.

Toeboards, when used as falling object protection, shall be erected along the edge of the overhead walking/working surfaces and are to be designed in accordance with the following specifications:

- Capable of withstanding, without failure, a force of at least 50 pounds applied downward and outward;
- Have a minimum vertical height of 3 1/2 inches above the walking/working surface with not more than 1/4 inch clearance above that surface, and shall be solid or not more than 1 inch in greatest dimension.

Where tools, equipment, or materials are piled higher than the top edge of the toeboard, paneling or screening shall be erected to the top or mid-rail of the guardrail system as needed for protection.

Guardrail systems, when used as falling object protection, shall have all openings small enough to prevent passage of potential falling objects.

Other methods of overhead protection from falling objects include restricting materials from the roof edge area, stacking material in stable piles or groups which are self-supporting, and erecting canopies which are strong enough to prevent collapse or penetration by falling objects.

### **Covers:**

Covers shall be capable of supporting without failure, at least twice the intended load imposed on the cover at any one time and shall be secured to prevent accidental displacement by wind, equipment, or employees. All covers shall be color-coded or marked "Hole" or "Cover" (does not apply to cast iron manhole).

### **Safety Net Systems:**

Safety net systems shall be installed as close to the walking/working surface as possible, but not greater than 30 feet below that level. When safety nets are used on bridges, they shall be unobstructed from the walking/working surface to the net.

Safety nets shall extend outward from the outermost projection in proportion to the height of fall. Falls up to five feet, extend the safety net outward eight feet; from five to ten feet, extend to ten feet; and more than ten feet, extend to thirteen feet.

Sufficient clearance under safety nets shall be maintained to avoid contact when subjected to an impact force equal to 400 pounds.

Safety nets shall be inspected at least once a week for wear, damage, and other deterioration. Defective nets shall not be used. Safety nets shall also be inspected after any occurrence that might affect the integrity of the safety net system.

Any material dropped into the safety net shall be removed as soon as possible and at least before the next work shift.

Border rope for webbing shall have a minimum breaking strength of 5,000 pounds.

### **Personal Fall Arrest Systems:**

Body belts are not acceptable, as part of a personal fall arrest system, and only locking-type snap hooks shall be used.

Unless the snap hook is a locking type and designed for the following connections, they shall not be engaged directly to webbing, rope, or wire rope or:

- To each other;
- To D-ring to which another connector is attached;
- To a horizontal lifeline; or
- To any object which is incompatibly shaped so as to allow roll-over disengagement.

Horizontal lifelines, such as those on scaffolds or similar work platforms which may suddenly become vertical lifelines must be equipped with devices capable of locking in both directions on the lifeline.

Horizontal lifelines shall be designed, installed, and used, under the supervision of a qualified person, as part of a complete personal fall protection system, which maintains a safety factor of at least two.

Lanyards and vertical lifelines shall have a minimum breaking strength of 5,000 pounds.

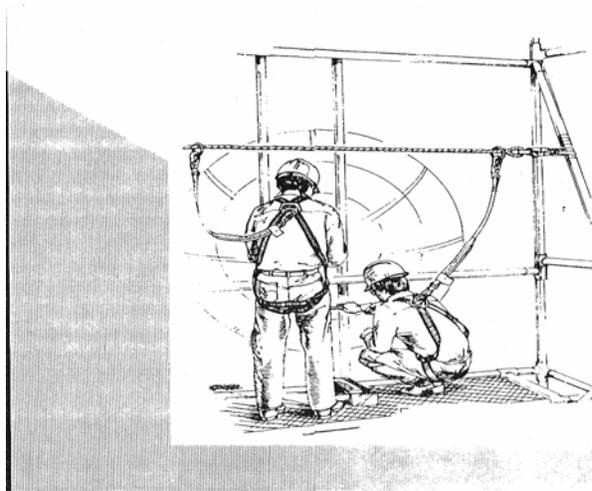
Each employee where required shall be attached to a separate lifeline. There is an exception during the construction of elevator shafts, but only under specified conditions.

Self-retracting lifelines and lanyards that limit free fall distance to two feet or less shall be capable of sustaining a minimum tensile load of 3,000 pounds at a fully extended position. All other self-retracting, rip-stitch lanyards, and tearing and deforming lanyards shall have a minimum tensile load of 5,000 pounds in the fully extended position. Anchorages used to attach fall arrest equipment shall be independent of any other anchorage and shall be capable of supporting at least 5,000 pounds per employee attached, or shall be:

- Designed with at least a factor of two;
- Be under the supervision of a qualified person.

The fall arrest system shall be limited to an arresting force of 1,800 pounds when used with a body harness and:

- It shall be rigged to restrict free fall to a maximum of six feet, avoiding contact with any lower level;
- Bring an employee to a complete stop and limit maximum deceleration distance to three and a half feet; and,
- Have sufficient strength to withstand twice the impact energy of an employee free falling a distance of six feet or a free fall distance permitted by the system, whichever is less.



Personal Fall Arrest System

The attachment point of the body belt shall be located in the center of the wearer's back. The attachment point of the body harness shall be located in the center of the wearer's back near shoulder level, or above the wearer's head. Belts and harnesses shall be used only for their designed uses.

Any fall arrest system or component subjected to impact loading shall be immediately removed from service until inspected and certified by a competent person before reuse.

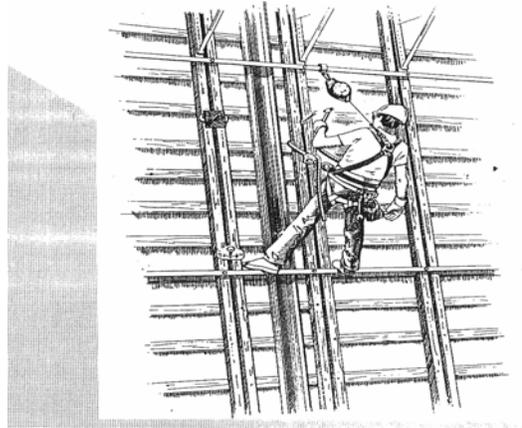
The employer shall provide for prompt rescue of employees in the event of fall or shall ensure that employees are able to rescue themselves.

Personal fall arrest systems shall be inspected prior to each use for wear, damage, or other deterioration.

Personal fall arrest systems shall not be attached to guardrail systems, nor attached to hoists, except in elevator hoist way construction. In that case, it shall be rigged to restrict movement only as far as the edge of the walking/working surface.

### **Positioning Device Systems:**

A positioning device system consists of 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 back.



Positioning Device

Positioning system devices shall be rigged to restrict free fall to a maximum of two feet and shall be secured to an anchorage capable of supporting at least twice the potential impact load or 3,000 pounds, whichever is greater. Connection assemblies shall have a minimum tensile strength of 5,000 pounds.

Snap hooks shall be sized to be compatible with the member to which they are connected so as to eliminate rollout potential.

Unless the snap hook is a locking type and designed for the following connection, they shall not be engaged:

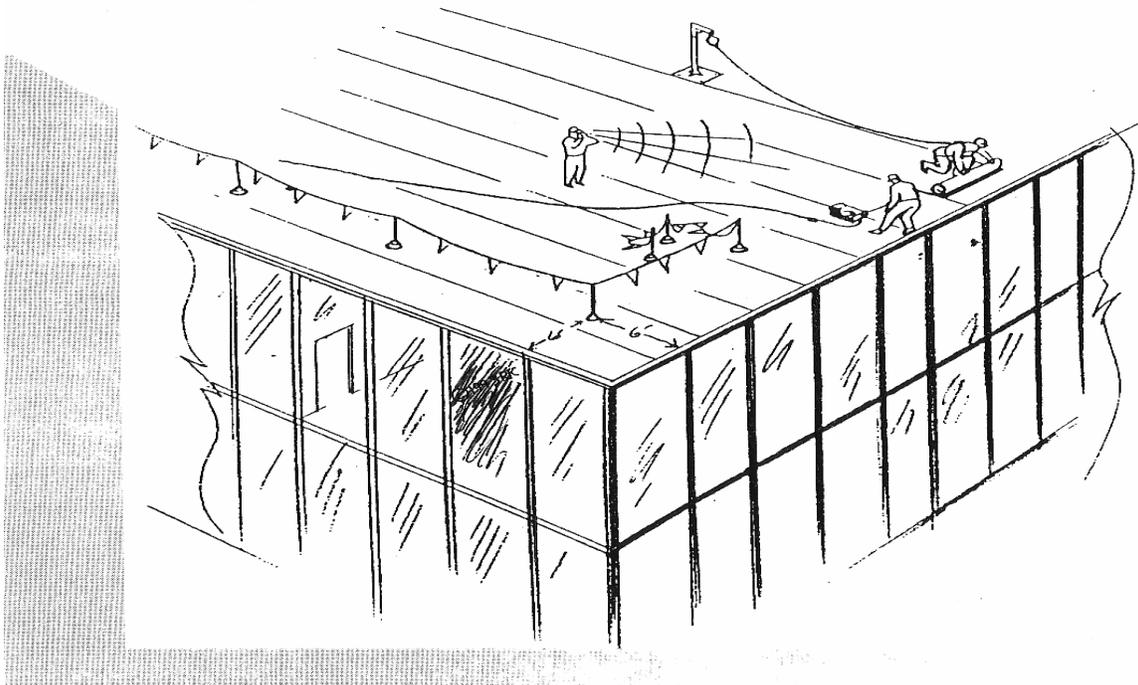
- Directly to webbing, rope, or wire rope;
- To a D-ring to which another snap hook is attached; or,
- To a horizontal lifeline; or to any incompatible shaped or dimensioned fixture where

rollout might occur.

Positioning devices shall be inspected prior to each use for wear, damage, and other deterioration. Defective components shall be removed from service.

### **Warning Line System:**

A warning line system is a barrier erected on a low-slope roof to warn employees that they are approaching the roof side or edge, and which designates the area where work may take place without fall protection devices.



Warning Line and Safety Monitoring System

Warning line systems are permitted for roofing work on low-slope roofs as defined in 1926.501(b)(10) of the Standard.

The warning line shall be erected around all sides of the roof work area. When not using mechanical equipment the warning line shall be erected not less than six feet from the roof edge. When mechanical equipment is being used the warning line parallel to the line of work shall be erected not less than six feet from the edge perpendicular to the direction of mechanical equipment operation.

Warning lines shall be rope, wire, or chain, and supporting stanchions that are:

- Flagged at no less than six-foot intervals with high-visibility material;

- At least 34 inches in height, but not more than 39 inches above walking and working surface;
- Strong enough to resist, without tipping over, a force at least 16 pounds applied horizontal against the stanchion;
- Have a minimum tensile strength of 500 pounds; and,
- Be attached to stanchions in such a way as to prevent slack being taken up in adjacent sections before the stanchion falls over.

No employee shall be allowed in the area between the roof edge and warning line unless performing roofing work in that area.

### **Controlled Access Zones (CAZ):**

A controlled access zone (CAZ) is an area in which certain work (such as overhand brick laying) may take place without use of guardrail systems, personal fall arrest systems, or safety net systems, when access to the zone is controlled by a line erected not less than six feet, nor more than 25 feet from the unprotected or leading edge. An exception is allowed when erecting pre-cast concrete members; the control line may extend up to 60 feet.

The control line shall extend along the entire length of the unprotected or leading edge and shall be approximately parallel to the unprotected or leading edge. The control line shall be connected on each side to a guardrail system or wall.

There are specific rules for erection of control lines in overhand bricklaying and related activities. Please refer to 1910.502 (g)(2) of this section.

Control lines may be rope, tapes, or equivalent materials supported by stanchions as follows:

- Flagged or otherwise marked at not more than six-foot intervals with high-visibility material;
- Not less than 39 inches (including sag) nor more than 45 inches above the walking/working surface (50 inches when doing overhand bricklaying); and,
- The minimum breaking strength of 200 pounds.

### **Safety Monitoring System:**

The safety monitoring system employs a competent person who is responsible for recognizing and warning employees of fall hazards.

The competent person shall be designated by the employer to monitor the safety of other employees and who:

- Is competent to recognize fall hazards;
- Is able to warn other employees of dangers when acting in an unsafe manner;

- Is working on the same walking/working surface within visual sighting distance of the employee being monitored;
- Is close enough to communicate orally; and,
- Has no other responsibilities which might distract the monitor's attention from the monitoring function.

Mechanical equipment shall not be used or stored in areas where safety monitoring systems are being used to monitor employees engaged in roofing operations on low-slope roofs.

Only the employee engaged in roofing work (on low-slope roof) or an employee covered by a fall protection plan shall be allowed in the monitored area.

### **Fall Protection Plan:**

This option is only available to employees engaged in leading edge work, pre-cast concrete erection work, or residential construction work; and only to employees in those areas when it can be demonstrated that it is infeasible or it creates a greater hazard to use conventional fall protection equipment.

The plan shall be site-specific, shall be developed by a qualified person, and shall be kept up to date.

Only those changes approved by a qualified person shall be allowed. The plan shall be maintained at the job site and shall be under the supervision of a competent person.

Components of the plan shall include:

- Reasons why conventional fall protection systems are infeasible or of greater risk;
- A written discussion of other measures taken to reduce or eliminate fall hazards;
- Identity of each location where conventional fall protection methods cannot be used, and classify each as controlled access zones (see reference subpart (g) of this section);
- Where no alternative measures are implemented, a safety monitoring system shall be established by the employer; and,
- Each individual employee who is designated to enter the controlled access zone by name or other methods of identification.

In the event of falls, the employer shall investigate the circumstances to see if the fall protection plan needs to be changed (e.g., new practices, procedures, or training), and shall implement those changes to prevent similar falls or incidents.

Personal fall protection systems consist of positioning devices, climbing devices, or personal fall arrest systems.

### **Selecting a Personal Fall Protection System:**

Before selecting personal fall protection systems examine the work environment for:

- Presence of dirt, chemicals, moisture, oil, grease that could affect the system;
- Job activities such as welding, sandblasting, and chemical cleaning that could damage unprotected components;
- Hot and cold environments that could have a negative effect;
- Parts of the system that may need to be protected from sharp or abrasive edge surfaces;
- Wire rope should not be used where there is a potential electrical shock hazard.

Whatever system you use, regular inspections are necessary to ensure the system is in good working order.

### **Personal Protection Positioning Devices:**

The positioning device system consists of an anchorage and a body holding device which is used to support a worker on an elevated work surface, while allowing the person to work with both hands free. Examples include:

- Lineman's body belt and pole systems;
- Window cleaner's belts and anchorage systems;
- Rebar installation.

### **Personal Fall Protection Systems for Climbing:**

Personal fall protection systems for climbing protect workers from falls while climbing. They are self activating.

Ladder climbing devices or ladder safety devices leave both hands free for climbing. Examples include: fixed or rigid rail systems, cable systems, or rope lock systems. Some additional tips for safely climbing ladders should be noted here which include:

- Always keep three points of contact when climbing a ladder;
- Use two hands and a foot or two feet and a hand;
- Do not carry objects in your hands while climbing a ladder;
- Use a towline or tool belt to bring the objects up to you.

### **Personal Fall Arrest Systems:**

Personal fall arrest systems consist of an anchorage, a connecting device, and a body holding device (harness). When maintained properly and used by a trained person, these systems can protect the employee from serious injury or death when subjected to a fall from one level to another. Improperly used or inadequately maintained equipment adds measurably to the risk of death and injury in the workplace.

Personal fall arrest systems are passive systems that stop a worker's fall. The basic system consists of an anchorage, lanyard, and a full body harness. Other components of the fall arrest system may include:

- Shock-absorbing lanyards;
- Deceleration devices;
- Lifelines;
- Rope grabs;
- Fixed rail systems;
- Emergency escape devices;
- Or a combination of these.

### **How Personal Fall Arrest Systems Work:**

To understand how fall arrest systems work, we must first understand certain terms in relation to their physical action.

**Free Fall-** Act of falling before the personal fall arrest system begins to apply a deceleration force to stop the fall. Free fall distance must not exceed six feet. However, self-retractable lifelines or, for ladder climbing devices the system must begin to stop the fall within two feet or less.

**Deceleration Distance-** Distance it takes after any free fall before the worker comes to a stop after the personal fall arrest system activates. Deceleration distance for a fall arrest system must not exceed 3.5 feet. Examples of deceleration devices include: shock-absorbing lanyards and self-retracting lifelines.

**Arresting Force-** Force needed to stop the worker from falling. The greater the free fall distance, the more force needed to arrest the fall. Deceleration devices absorb and dissipate much of the force needed to stop the fall. A full body harness distributes the force throughout the body.

**Roll-out-** The accidental disengagement of a snap-hook from its connecting point. This condition may occur when the spring shock on a lanyard momentarily causes a twisting action of the snap-hook to move up and around its anchor point. For a fraction of a second the gate part of the snap-hook is in conflict with the anchorage. Snap-hooks attached to body belts or installation points such as eye-bolts, tend to recoil and reverse direction when the lanyard becomes taut during a fall. For this reason only locking-type snap-hooks shall be used.

**Swing Falls-** Occur when a lanyard or lifeline attached to a worker and extended horizontally from an anchor point at the same level allows a pendulum-type vertical arch drop or swing in excess of six feet. A pendulum action occurs during a fall, where the gathering momentum of the swinging person slams the worker against the lower structure.

This condition can be reduced in two ways:

- Decrease the free-fall arch by increasing the height of the anchor point above horizontal thus reducing the angle; or
- Attach a sliding lanyard to a horizontal lifeline fixed above the working area.

In both methods the objective is the same. The vertical distance of the drop arch shall be less than six feet. Also, the anchorage attachment point shall not be lower than waist high on the worker.

## **Using a Personal Fall Arrest System:**

### **Full Body Harnesses:**

The full body harness distributes weight over the thighs, pelvis, waist, chest, and shoulders to lessen the impact to the body when fall is arrested. When using a full body harness the shock arresting force must not exceed 1,800 pounds. A chest harness (which has no leg loops) should not be used where there is a possibility of any free fall.

A lanyard or lifeline is attached at the D-ring in the center of the back near the shoulder level or above the head.

### **Harnesses vs. Body Belts:**

The full body harness distributes impact stresses throughout the body creating less stress on the body mid-section and better circulation is maintained, while keeping the body suspended in an upright position while waiting for rescue.

Body belts concentrate impact in the mid-section area while bending the body. In this bent position more stress is concentrated and imposed on the waist area of the body, which could cut off circulation. In addition, there is a risk of falling out of an improperly worn belt at arrest or while awaiting rescue. For these and other reasons, the body belt may be used as a positioning device only and NOT for fall protection.

### **Lanyards:**

Lanyards connect the harness to a deceleration device, lifeline, or anchorage. These lanyards and vertical lifelines must have a minimum breaking strength of 5,000 pounds. Exception: those lanyards and self-retracting lifelines that begin to stop falls before a two-foot drop; they must have a breaking strength of at least 3,000 pounds.

Do not connect lanyards between a body harness and a self-retracting lifeline device because this will add more free fall distance to the system. (Remember the limit of free fall is a maximum of six feet.)

### **Snap-Hooks:**

Lanyards need to be attached to an anchorage in such a manner as to not reduce its required strength. This is accomplished by use of locking snap-hooks. Locking snap-hooks have a positive locking mechanism and spring-loaded keeper to prevent roll-out. Locking snap-hooks are required by the construction standard. Like all other hardware it must meet at least 5,000 pounds and be proof tested to 3,600 pounds.

Lanyard snap-hooks and D-rings on the body harness must fit together properly. Do not attach two snap-hooks to each other as this can also lead to a roll-out condition.

### **Anchorage:**

The anchorage must be attached to the personal fall arrest system and be independent from the means of supporting or suspending a worker in the normal work location. They must be able to support a weight of at least 5,000 pounds for each worker attached, and be located at a height that reduces free fall to six feet or less.

Points to consider when determining free fall are:

- Deceleration distance;
- Elongation of lanyard or lifeline;
- Minimizing any obstruction between anchor location and work location.

Note: Deceleration distance and elongation factors are available from manufacturers of equipment.

The anchorage should also be located so that if a free fall occurs, the attached worker will not collide with it or contact any lower level hazard.

When connecting directly or indirectly to an anchorage point, the tie-off point to a lifeline or anchorage is usually at or above the D-ring on the back of the worker's harness. This reduces free fall distance.

The tie-off using a knot in the lanyard or lifeline at any location can reduce the strength of the line by 80 percent or more depending on the type of knot used in the system. A tie-off around "H" or "I" beams can reduce strength of the line by 70 percent or more. Use a webbing lanyard, wire core lifeline, or use padding to seat rope over sharp turns. Avoid rough or sharp edges. Use a webbing strap around the beam with a D-ring, then use a locking snap-hook on the lanyard connected to the anchor strap D-ring.

### **Other Fall Arrest Systems Components:**

Shock-absorbing lanyards are designed to absorb up to 80 percent of the arresting force and are recommended to reduce the impact on the body of the person who falls.

Vertical lifelines are flexible vertical lines suspended from a fixed anchorage to which fall arrest system components including the lanyard are connected. Each worker must have a separate lifeline.

A horizontal lifeline is a flexible line between two horizontal fixed anchorages to which a fall arrest system component such as a self-retracting lifeline or lanyard is secured. It must be designed, installed, and used under the supervision of a qualified person. The horizontal lifeline and anchorage strength must be increased for each additional worker tied-off to a specific single horizontal line.

A self-retracting lifeline can hang from an anchorage or horizontal lifeline above the work. Self-retracting lifeline must arrest a free fall within two feet or less.

A rope grab is a deceleration device that travels on a vertical lifeline is attached to an anchorage point. It automatically engages the lifeline and locks to arrest a fall if it is sized properly to the diameter of the vertical lifeline.

### **Inspection and Maintenance:**

#### **Inspection:**

The worker who is expected to use it must inspect fall protection devices before each use. If the worker has any question about any device he or she should contact a *competent person*.

Personal fall protection systems should be checked for the following:

- Mildew;
- Wear and damage;
- Cuts, tears, and abrasions;
- Stretching;
- Loose or damaged mountings;
- Non-functioning parts;
- Cracked, broken, or deformed D-rings and snap-hooks;
- Other damage or deterioration;
- Changes that may affect their strength;
- Contact with fire, acids, or other corrosives;
- Distorted hooks or faulty hook springs;
- Tongues unfitted to the shoulder of buckles;
- Ropes that show wear or internal deterioration.

Personal fall protection systems that have been used to arrest a fall must not be used again unless inspected and approved by a qualified person. Most manufacturers advocate that the full body harness, vertical lifeline, and lanyard be destroyed once it has experienced a free fall shock impact. Self-retracting lifelines are to be sent back to the manufacturer for reconditioning if they had arrested a free fall

#### **Maintenance:**

When needed, wash fall protection devices in warm water using mild detergent. Rinse thoroughly in clean, warm water and allow to dry at room temperature.

Stow in clean, dry area away from strong sunlight and extreme temperature which could degrade materials.

Check the manufacturer's recommendations for cleaning, maintenance, and storage information.

## **Summary:**

Most fall hazards are caused by personal or environmental factors. Once a potential fall hazard is identified, engineering controls are used to engineer out the hazard and/or personal fall protection is needed.

- The type of personal fall protection you use depends on your work environment.
- There are three basic types of personal fall protection systems: personal fall arrest systems, positioning device systems, and personal fall protection systems for ladder climbing activities.
- In a fall, the fall arrest system does not immediately activate. The person is in free fall at this point. When the system activates, it applies force to stop the fall. The distance it takes to come to a stop is the deceleration distance. The force needed is called the arresting force.
- Free fall must be limited to 6 feet or less, and preferably less.

A basic personal fall arrest system has three parts: a full body harness, a lanyard, and an anchorage. Other parts include shock-absorbing lanyards, self-retracting lifelines, rope grabs, and horizontal and vertical lifelines.

Locking snap-hooks prevent roll-out from occurring;

- Chest harnesses should not be used if there is a possibility of free fall;
- Full body harnesses are required for all personal fall arrest systems;
- The person who is going to use it must inspect fall protection devices before each use. A *competent person* is to be available to help make a decision whether a piece can be used or not when any question arises;
- Defective parts must be removed from service if their function or strength is affected;
- A personal fall arrest system that has been used in a fall arrest must be inspected before reuse by a *qualified person*, who will determine if any changes or substitutions need to be made in the fall arrest systems and help if needed to determine if a component is able to be reused.

Fall protection devices can be washed in warm water using a mild detergent, when needed and then should be dried at room temperature.

Store all fall protection software in a clean, dry area away, from sunlight and extreme

temperatures.

## **LEADING EDGES AND RESTRAINING SYSTEMS**

The concept of the leading edge, unique to the construction industry, includes the edge of a floor, roof, or form work for a floor, or other walking/working surface which changes location as work continues; the unprotected sides and edge.

The unprotected sides and edge is defined as any side or edge (except at entrances to points of access) on a walking/working surface, without a wall or guardrail system at least 39 inches high.

If unprotected sides and edges are six feet or more above the lower level, a guardrail system, safety net system, or personal fall arrest system is required.

### **Leading Edge Construction:**

In leading edge construction where the worker is engaged six feet or more above the lower level, a guardrail system, safety net system, or personal fall arrest system is required. Exception: If the employer can demonstrate it is infeasible or creates a greater hazard, the employer shall develop and implement a fall protection plan [ref. 1926.502.(k)].

The employer has the burden of establishing proof that fall protection systems are infeasible or present a greater hazard before developing an alternative plan for a particular workplace situation, in lieu of implementing any of those systems.

It is required that each employee on walking/working surfaces where leading edge work is in progress, but who are not themselves involved in leading edge work, also be protected if at a height of six feet or greater above the lower level. A control line, to control access to the leading edge work area, shall be connected to a guardrail or wall. Any work done on the inside of the control line is considered the Controlled Access Zone.

### **Hoist Areas:**

Hoist areas six feet or more above the lower level shall be protected by guardrail systems or personal fall arrest systems. If guardrail systems (chain, gate, or guardrail section) are removed to facilitate hoisting operations, a fall arrest system is required if the employee must lean through the access opening or out over the edge of the access opening to receive or guide material.

### **Holes:**

Holes having gap or void, two inches or more at its least dimension, in a floor, roof, or other walking/working surface must be protected if six feet or greater above lower level by guardrail systems, personal fall arrest system, or covers. Covers are required at any height when there is a hazard from tripping in or stepping into or through holes (including skylights) or if people are working under the hole.

### **Fall Protection Restraining System:**

The purpose of the restraining system is to stop workers from falling while engaged in leading edge work, by restricting the distance they can move towards the opening or leading edge.

Unlike a positioning device, the restraining system has a connecting means in addition to the anchorage and body holding device, by the connecting means - lanyards, rope, self-retracting lifelines), or mechanical connectors - the restraint system will allow the worker to work at the edge of the opening, but not exceed the leading edge.

The anchorage for the restraining system must be capable of supporting 3,000 pounds minimum.

The connecting means must have a minimum tensile strength of 5,000 pounds and shall consist of:

- Lanyard with double locking snap-hooks;
- Rope with properly tied knots, the length of which must be determined and fixed not to exceed the leading edge;
- Mechanical fall arrest connectors.

The body holding device may be a full body harness or a body belt as long as there is no fall arrest possible.

### **Rigging a Restraining System Using Ropes and Knots:**

A “knot” is the tool used to harness the tremendous strength of rope. It allows you to effectively connect rope to hardware, anchors, personnel protective equipment, or other objects. Good knots help make operations easier, while lesser knots may cause difficulties or even failures.

#### **Knot Characteristics:**

There are many types of knots, but all have the same general characteristics:

- **Ease of Use.** The knot must be relatively easy to tie under adverse conditions. The knot must allow simple visual inspection for correctness. Finally, the knot should be easy to untie after operational use.
- **Knot Strength.** The effective knot must not excessively reduce the strength of the rope system. In doing so, you eliminate the need for “over-engineering” of rope

systems. As such, critical resources (e.g., rope or hardware) can be more effectively used.

- **Safety Knot.** You've probably already heard the phrase, "A knot isn't a knot without a safety." Safety knots control the loose ends of knots, reducing the possibility of untying during operations. Unless both ends are controlled (e.g., tied to something else), safety knots are generally required.

### **Basic Knots:**

The knots discussed here fall into four broad categories, based on their uses:

- **Stopper/Safety Knots.** Stopper knots are used to control the rope ends, but normally bear no load. Examples of this include safety knots at the end of a haul line to prevent rope traveling off the end of a pulley. Stopper knots include the overhand knot and the basic Figure-8 knot.
- **Bends.** Bends are knots, which join two ropes together. This may be for the purpose of extending lifelines where one is too short, or joining the ends of a cord or webbing. Examples of bends include the Figure-8 bend, and the water (or waterman's) knot.
- **Loops.** Loops provide the capacity to attach carabiners and other hardware to the rope. They allow you to attach rope to personal protective equipment or anchors. "Loop" knots include the Figure-8 on a bight, as well as the Figure-8 reweave.
- **Hitches.** Hitches are used to connect a rope to a "standing object," such as a post or bar. Uses of hitches include tying guylines or other objects off.

### **Strength of Knots:**

The bends in a rope, whether caused by a knot, pulley, or other device, are of particular concern to the user. Bends in a rope produce unequal stresses in the rope (tensile stress on the "outside" curve of the bend and compressive stress on the "inside"). These stresses reduce the effective strength of the rope. Tighter bends (e.g., over a carabiner) produce more stress and weakness than wide bends (e.g., over a four inch pulley).

Knots contain bends, which stress the rope as well. However, some knots, such as the Figure-8, utilize less tight bends than others. For that reason, the "Family of 8s" knots are preferred, primarily due to their strength (80% to 85% of rope strength) and simplicity. Most other common knots vary between 60% and 70% of rope strength. Of note is the square knot, which reduces rope strength to less than half.

Over the years, there has been much time, energy, and paper dedicated to the research of knot strength/losses. We must realize, however, that knot strength is a minimal part of the actual rope system. Setnicka said:

*While it is of interest how strong one knot is versus another, it is important to realize that knots do not break, at least not on testing machines in laboratories. Climbers simply are not found at the bottom of crevasses and caves with broken knots*

*protruding from their harnesses.*<sup>3</sup>

Setnicka was right; a good rescue knot won't fail us. Rope will fail when you don't provide edge protection, improperly tied knots may untie during use, and bad knots may not work at all. These failures should be the focus of the user's efforts.

### **Terms Associated with Knots:**

It is necessary to know the nomenclature of the tools you are working with. Rope is a tool and has nomenclatures for its parts as you begin to form it into knots and later into various configurations for rigging.

- The **running part** of the rope is used for work such as hoisting, pulling, and belaying;
- The **working end** of the rope is used to tie the knot;
- The **standing part** of the rope is between the working end and the running part;
- A **bight** is formed by making a U-shaped curve in the rope without crossing the ends of the U;
- A **round turn** is made when the ends of the bight's U are crossed;
- A **bend** is a knot whose purpose is to join two ropes together;
- A **hitch** is a knot used to fasten a rope to an object;
- A **splice** is a method of weaving together two ropes or the strands of two parts of the same rope to form an eye;
- An **anchor** is an immovable object;
- A **safety knot** is a knot, such as an overhand or Fisherman's, used to control the running end of the knot to reduce the chance of accidental untying. The half-hitch is not acceptable for a safety knot;
- A **whip** is a special wrap done on the end of a rope to keep it from unraveling.

With most synthetic ropes, a hot blade is applied to melt the ends together. Usually the same hot blade is used to cut the rope.

There are so many knots that it would take a lifetime to learn them all. All of these knots have a purpose and have served that purpose well in most instances. With the advent of synthetic ropes, however, it rapidly became apparent that a large portion of the basic knots that were previously "safe to use" (because they never failed) were failing. The slipperiness of synthetics caused some of the knots to slip apart. New techniques had to be learned to ensure the safety of the user. These new methods can also be safely applied when using natural fiber ropes.

### **How to Tie Working Knots:**

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<sup>3</sup> Wilderness Search and Rescue, Tim Setnicka, Appalachian Mountain Club, 1980; pg. 195.

This section provides diagrams showing how certain working knots are tied. While studying these diagrams, remember that they are shown loosened for clarity. All knots require “dressing,” or tightening and flattening them. In addition, safety knots need to be set and tightened as close to the original knot as possible.

### The Overhand Knot



### Family of Eights

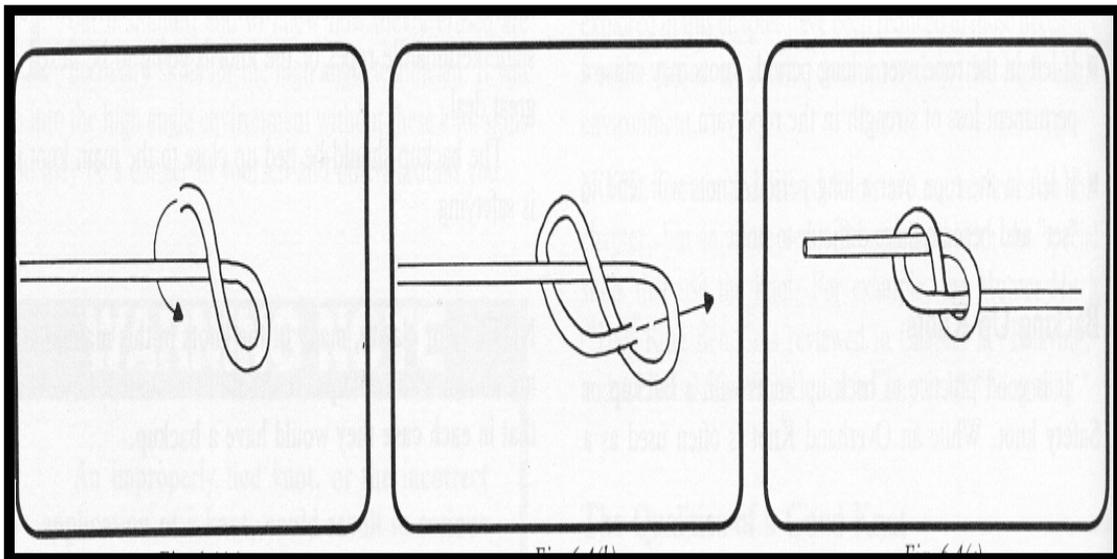
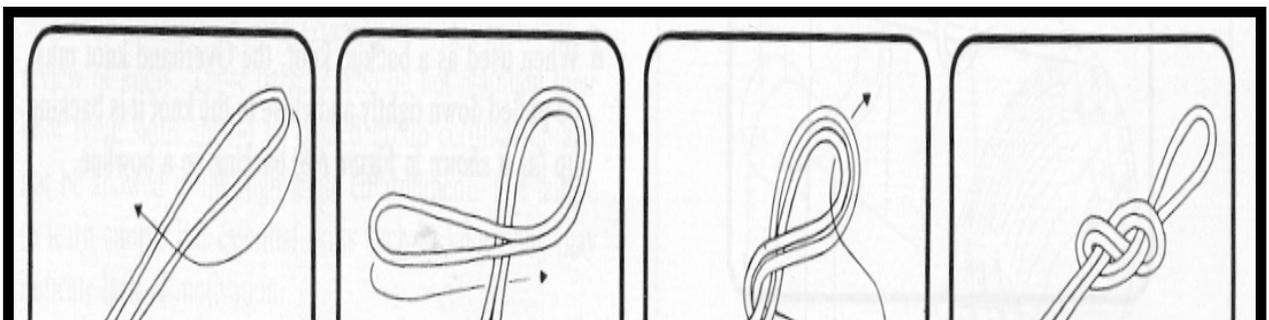
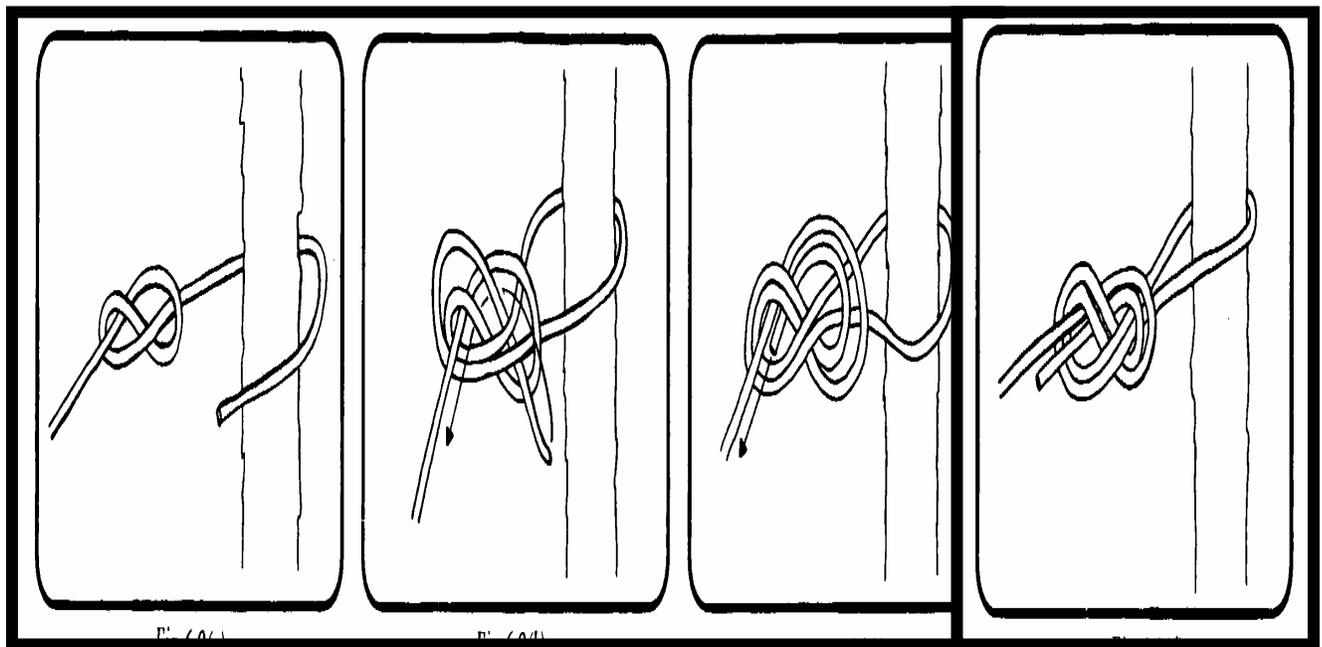


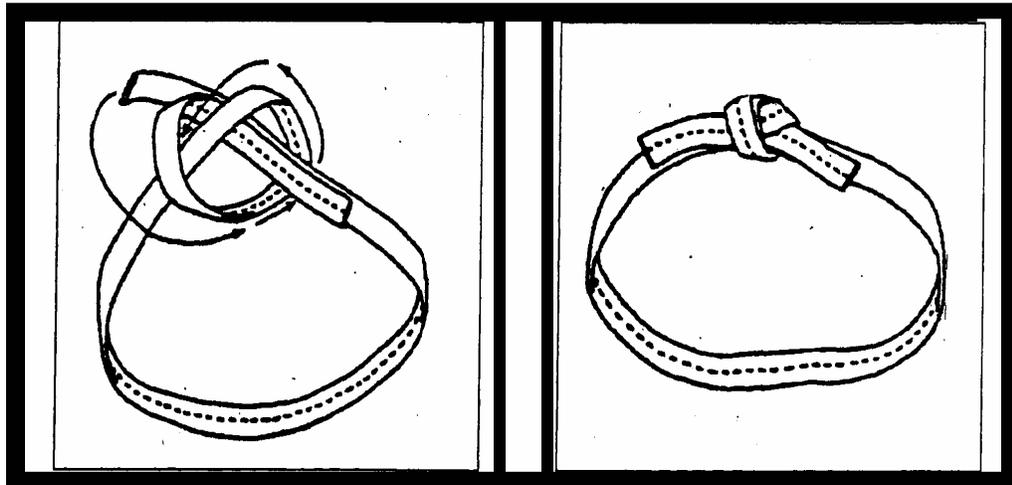
Figure - 8



**Figure-8 on a Bight**



Water Knot



## Summary:

In leading edge construction where the worker is engaged six feet or more above the lower level, a guardrail system, safety net system, or personal fall arrest system is required.

In hoisting areas, where guardrails and safety nets are impractical, restraining systems may be used which prevent the worker from falling. The restraining system is made-up of an anchorage, a body holding device (harness or lifebelt), and connecting means - Lanyard, rope, self-retracting lifeline.

When using a rope restraining system, a “knot” is the tool used to harness the tremendous strength of rope. It allows you to effectively connect rope to hardware, anchors, personnel protective equipment, or other objects.

For a variety of reasons, the knots determined as superior for our training purposes are:

- The overhand knot for tying safeties;
- The family of Figure-8 Knots, including:
  - Figure-8
  - Figure-8 on a bight
  - Figure-8 Re-weave
- Water Knot for tying webbing.

Good knots help make operations easier, while lesser knots may cause difficulties or even failures. Remember, practice makes perfect!