## WORKPLACE HAZARDS

**SAFETY HAZARDS**:
These are the most common and will be present in most **workplaces** at one time or another. They include unsafe conditions that can cause injury, illness and death. Machinery-related **hazards** (lockout/tagout, boiler **safety**, forklifts, etc.)

*Reference:https://www.osha.gov/dte/grant_materials/fy10/sh-20839-10/circle_chart.pdf*

**SAFETY HAZARDS:** These are the most common and will be present in most workplaces at one time or another. They include unsafe conditions that can cause injury, illness and death.

Safety Hazards include:

- Spills on floors or tripping hazards, such as blocked aisles or cords running across the floor
- Working from heights, including ladders, scaffolds, roofs, or any raised work area
- Unguarded machinery and moving machinery parts; guards removed or moving parts that a worker can accidentally touch
- Electrical hazards like frayed cords, missing ground pins, improper wiring
- Confined spaces
- Machinery-related hazards (lockout/tagout, boiler safety, forklifts, etc.)

**BIOLOGICAL HAZARDS:** Associated with working with animals, people, or infectious plant materials. Work in schools, day care facilities, colleges and universities, hospitals, laboratories, emergency response, nursing homes, outdoor occupations, etc. may expose you to biological hazards.

Types of things you may be exposed to include:

- Blood and other body fluids
- Fungi/mold
- Bacteria and viruses
- Plants
- Insect bites
- Animal and bird droppings

**PHYSICAL HAZARDS:** Are factors within the environment that can harm the body without necessarily touching it.

Physical Hazards include:

- Radiation: including ionizing, non-ionizing (EMF's, microwaves, radiowaves, etc.)
- High exposure to sunlight/ultraviolet rays
- Temperature extremes – hot and cold
- Constant loud noise

**ERGONOMIC HAZARDS:** Occur when the type of work, body positions and working conditions put strain on your body. They are the hardest to spot since you don't always immediately notice the strain on your body or the harm that these hazards pose. Short-term exposure may result in "sore muscles" the next day or in the days following exposure, but long-term exposure can result in serious long-term illnesses.

Ergonomic Hazards include:

- Improperly adjusted workstations and chairs
- Frequent lifting
- Poor posture
- Awkward movements, especially if they are repetitive
- Repeating the same movements over and over
- Having to use too much force, especially if you have to do it frequently
- Vibration

**CHEMICAL HAZARDS:** Are present when a worker is exposed to any chemical preparation in the workplace in any form (solid, liquid or gas). Some are safer than others, but to some workers who are more sensitive to chemicals, even common solutions can cause illness, skin irritation, or breathing problems.

Beware of:

- Liquids like cleaning products, paints, acids, solvents – ESPECIALLY if chemicals are in an unlabeled container!
- Vapors and fumes that come from welding or exposure to solvents
- Gases like acetylene, propane, carbon monoxide and helium
- Flammable materials like gasoline, solvents, and explosive chemicals.
- Pesticides

**WORK ORGANIZATION HAZARDS:** Hazards or stressors that cause stress (short-term effects) and strain (long-term effects). These are the hazards associated with workplace issues such as workload, lack of control and/or respect, etc.

Examples of work organization hazards include:

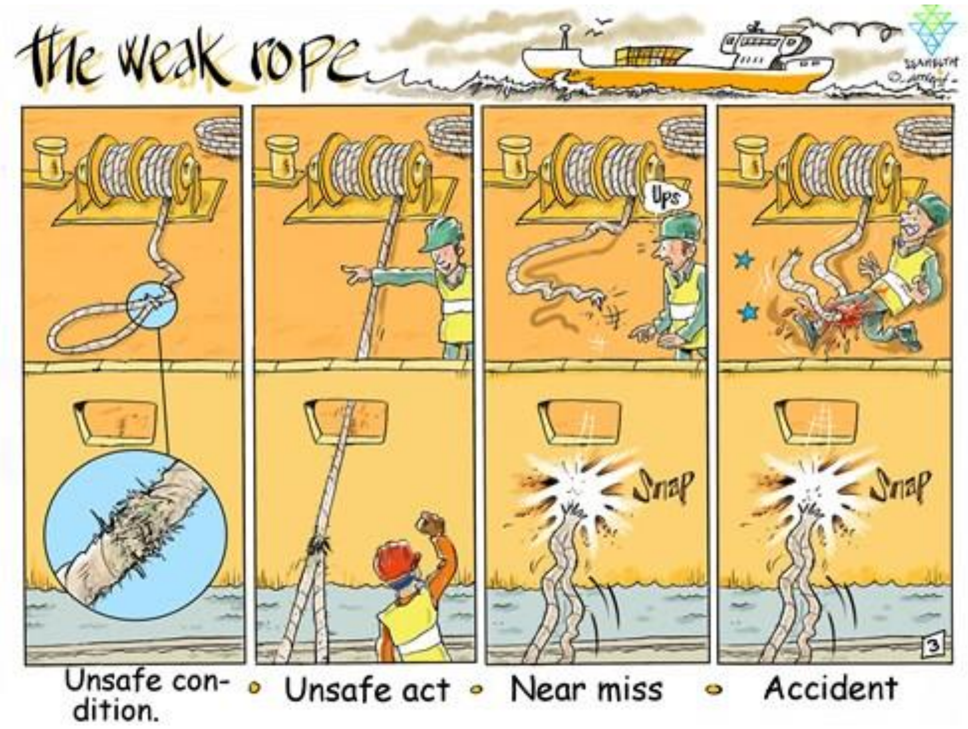
- Workload demands
- Workplace violence
- Intensity and/or pace
- Respect (or lack of)
- Flexibility
- Control or say about things
- Social support/relations
- Sexual harassment

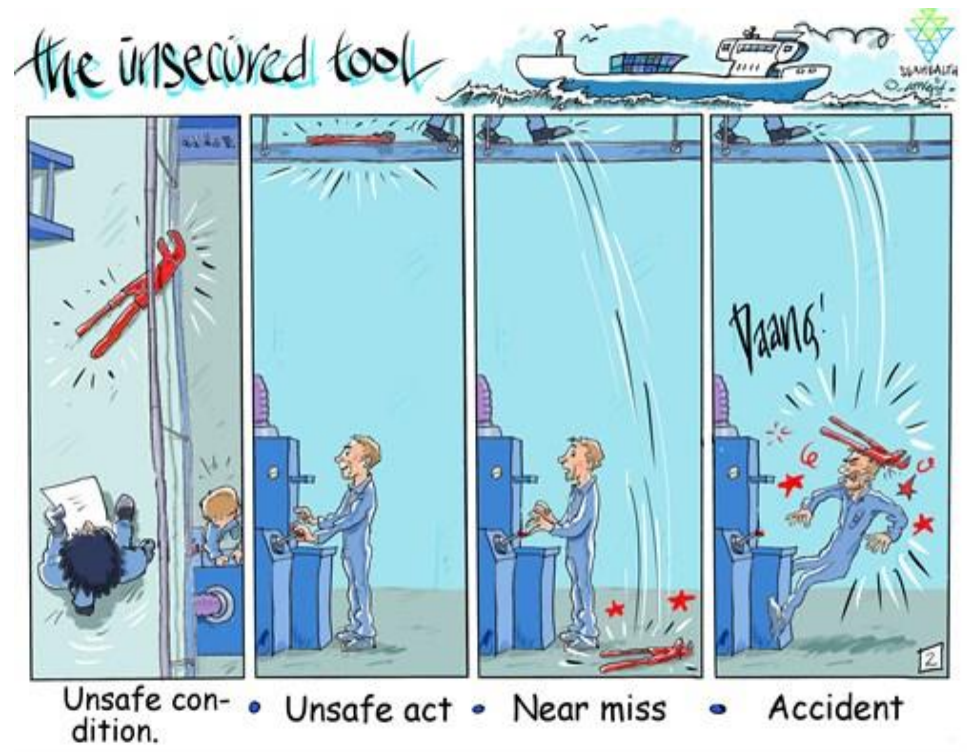
**Near Miss**:
Means any act, action and condition which could have led to an accident or incident, though it did not actually materialize, and includes both "action or condition which has resulted in a narrow escape before its developing into an "actual accident or incident" and "unsafe act / condition (trivial one which frequently occurs)".
*Reference: NYKSM – SMS*

**Unsafe / Unhealthy Act:**
Definition by The American National Standards Institute (ANSI)
"Any human action that violates a commonly accepted safe work procedure or standard operating procedure".
This is an act done by worker that does not conform or departs from an established standard, rules or policy.
These often happen when a worker has improper attitude, physical limitations, or lacks knowledge or skills.
Example: smoking in non-smoking area, using substandard or defective tools, working under the influence of liquor or drugs, improper storage of chemicals and or paints among others.

**Unsafe / Unhealthy Condition;**
ANSI Definition
Physical or chemical property of material, machine or the environment which could possibly cause injury to people, damage to property, disrupt operations in plant or office or other forms of losses.
These could be guarded or prevented.
Example:
Slippery and wet floors, dusty work area, octopus wiring, etc.

*Poster reference: http://uk.nearmiss.dk/knowledge/what-is-what/*



**Poor work practices create hazards – examples of unsafe work practices commonly found in the workplace include:**

using machinery or tools without authority operating at unsafe speeds or in violation of safe work practices

- removing or disabling guards or other safety devices on machinery or equipment
- using defective tools or equipment or using tools or equipment in unsafe ways
- using hands or body instead of tools or push sticks
- overloading, crowding or failing to balance materials or handling materials in other unsafe ways, including improper lifting
- repairing or adjusting equipment that is in motion, under pressure, or electrically charged
- failing to use and/or maintain, or improperly using personal protective equipment or safety devices
- creating unsafe, unsanitary or unhealthy conditions by improper personal hygiene, poor workplace maintenance or by smoking in unauthorized areas. Learn how to **avoid carrying hazardous substances home with you**.
- standing or working under suspended loads, scaffolds, shafts, or open hatches

- *http://www.takeonestep.org/Pages/yoursafety/safenotsorry/workplacehazards.aspx*

================================================================

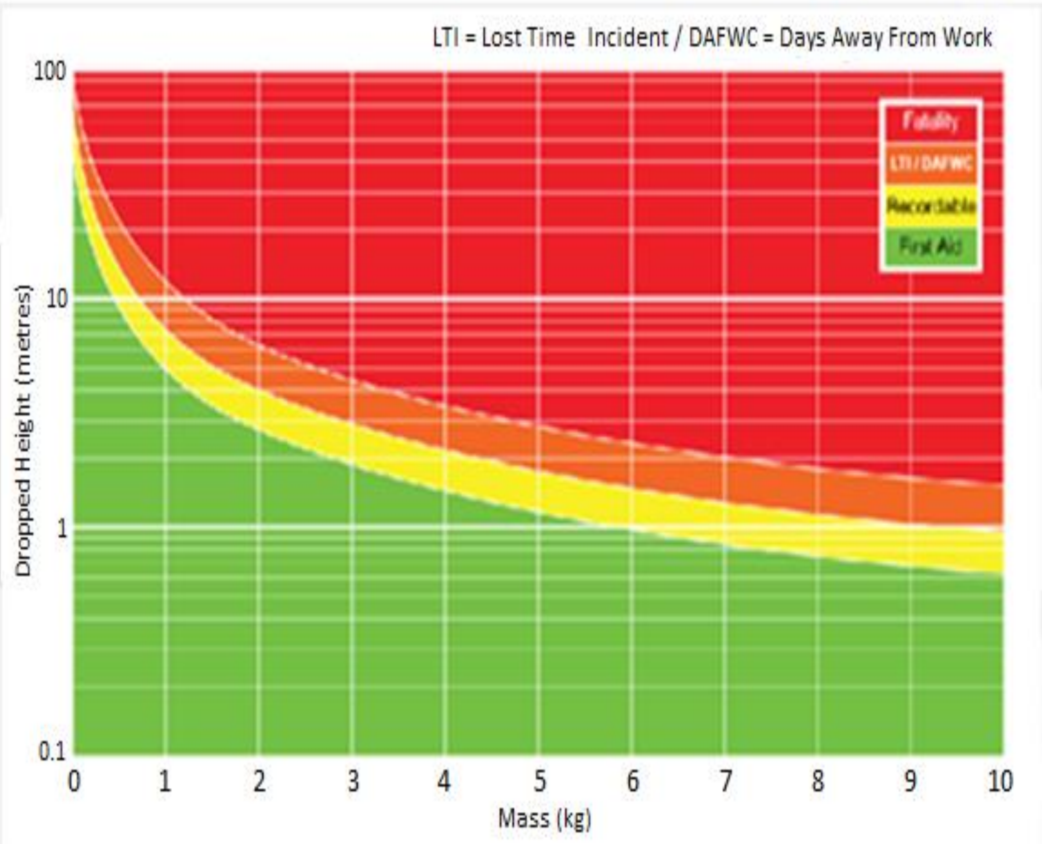
**Dangers associated with falling and falling objects :**

**Falling object hazards**

Falling objects on worksite exposes workers to minor injuries and even death. Anytime work is being performed overhead where others may be working or walking below or any object (big or small) high above if left unsecured puts a worker on that site at risk of falling objects.

**The higher the height of the fall the greater damage an object can create to the workers’ body (head and other parts of the body).**

***EVEN SMALL OBJECT CAN KILL !!!***




*Reference: chart from the presentation of Leong Weng – DROPS Asia Chairman*

## IMPACT FORCE OF A DROPPED OBJECT

MEASURED IN POUNDS PER SQUARE INCH

Weight of Dropped Object (pounds)

| Drop Height (feet) | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| 300 | 434 | 867 | 1,301 | 1,735 | 2,168 | 2,608 | 3,036 | 3,469 | 3,903 | 4,337 |
| 200 | 354 | 708 | 1,062 | 1,416 | 1,771 | 2,125 | 2,479 | 2,833 | 3,187 | 3,541 |
| 150 | 307 | 613 | 920 | 1,227 | 1,533 | 1,840 | 2,147 | 2,453 | 2,760 | 3,067 |
| 100 | 250 | 501 | 751 | 1,002 | 1,252 | 1,502 | 1,753 | 2,003 | 2,253 | 2,504 |
| 50 | 177 | 354 | 531 | 708 | 885 | 1,062 | 1,239 | 1,416 | 1,593 | 1,771 |
| 20 | 112 | 224 | 336 | 448 | 560 | 672 | 784 | 896 | 1,008 | 1,120 |
| 10 | 79 | 158 | 238 | 317 | 396 | 475 | 554 | 633 | 713 | 792 |
| 6 | 61 | 123 | 184 | 245 | 307 | 368 | 429 | 491 | 552 | 613 |

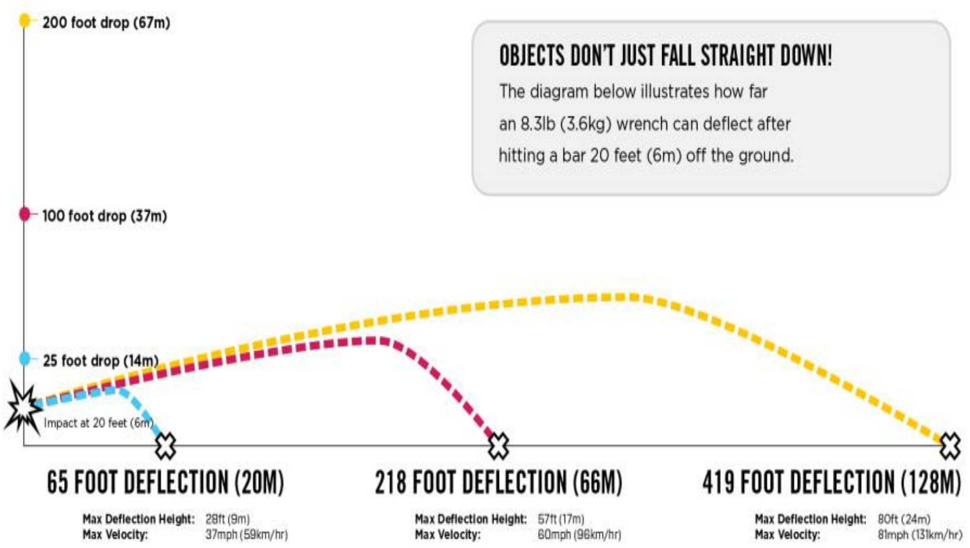
SERIOUS — SEVERE — FATAL

## FALLING OBJECT DEFLECTIONS

“Dropped Object Deflection Study,” Southern Polytechnic State University

DROPPED OBJECTS DON’T ALWAYS FALL STRAIGHT DOWN

# FALLING OBJECT DEFLECTIONS




*Reference: http://blog.gallawayb2b.com/stop-the-drop/*

## Falls

Falls is one of the leading causes of injury and or death in a worksite. But falls are easily preventable.

OSH requires workers to use fall protection system where they could fall at least 3 meters or where a fall from a lower height may result in serious injury. Fall prevention is required on scaffolds three (3) meters or higher.

The risk of falls can be lowered by implementing a fall prevention/protection plan in the company safety program. Good housekeeping also reduces the chance of slips, trips and falls.

The physical characteristics of various falls and associated calculations related to fall dynamics and force of impact (potential severity) illustrate the critical importance of fall prevention and the use of various fall protection control structures, devices, and activities.

**VELOCITY UPON IMPACT (V)**

$$V = (V_0^2 + 2\,gh)^{1/2} \text{ or } V = \sqrt{V_0^2 + 2\,gh} = \sqrt{2gh}$$

where:

**V** = velocity upon impact (ft/s or m/s)

**$V_o$** = initial velocity (ft/s or m/s)

**g** = acceleration due to gravity (32.2 ft/s$^2$ or 9.81/s$^2$ )

**h** = distance of the fall (ft, m)

**KE or Dynamic energy (E)**

**$E = \frac{1}{2} mv^2$** (Joules, ft-lb)

**m=** mass of the object (kg, slugs)

**v=** velocity of the object (m/s, ft/s)

**Impact Force ($E_F$)**

**$E_F = mgh / s$**

**m =** mass (kg, slugs)

**s=** slow down distance ; **$s = 1/2\ m\ v^2 / F$**

**F=slow down force** **$F = 1/2\ m\ v^2 / s$**

*Ref:* NELSON & ASSOCIATES; *PHYSICS CALCULATIONS RELATED TO FALLING OBJECTS*
*By Gary S. Nelson and Timothy D. Snowden // www.engineering toolbox.com*

The severity of injury increases with the height of the fall, but also depends on body and surface features and the manner of body impacts on to the surface. The chance of surviving increases if landing on a surface of high deformity (a surface that bends, moves, or compresses), such as snow or water.
*Reference: wikipedia*

**How long does it take to Fall?**
*Reference: Work Safe BC - worksafebc.com*
*An Introduction to Personal Fall Protection Equipment*

Following table indicates how far a person can fall in just few seconds

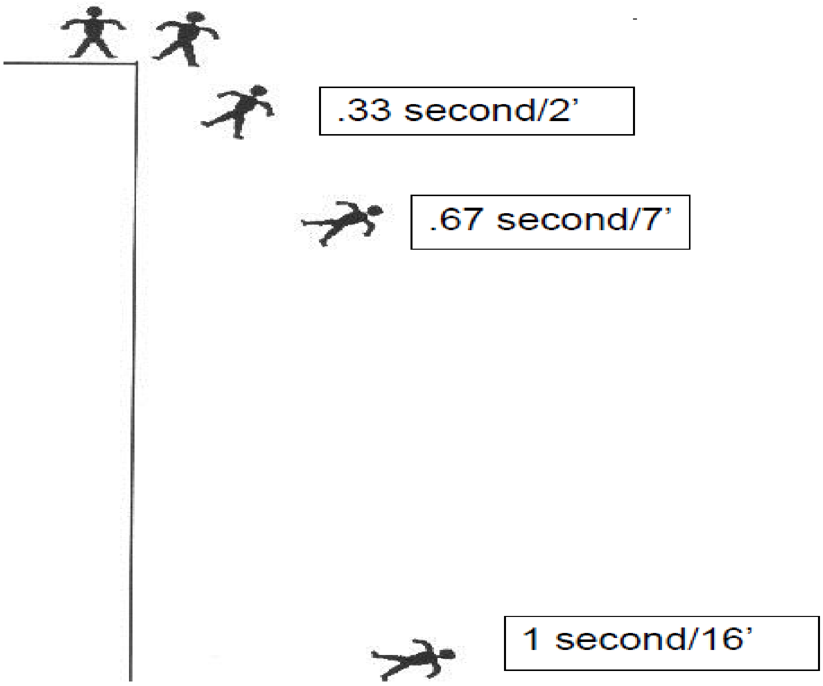
| Time (*seconds*) | Distance (*metres*) | Distance (*feet*) |
|---|---|---|
| 0.5 | 1.2 | 4 |
| 1 | 5 | 16 |
| 1.5 | 11 | 36 |
| 2 | 20 | 64 |
| 2.5 | 31 | 100 |
| 3 | 44 | 144 |
| 4 | 78 | 256 |

Referring to the above table, one may not have the time to grab hold of something safe, but still tragedy can be prevented. Properly maintained and worn, safety belt or full body harness attached to a secure anchor could save life.

'it's not the fall that's hurts but the sudden stop at the end'. Think of a fall as *"…a sudden, unanticipated descent in space driven by gravity".* Although this may not *sound* severe, the consequences are often disabling - or deadly. It takes most people about 1/3 of a second to become aware of a fall. It takes another 1/3 of a second for the body to react. A person can fall up to 7 feet in 2/3 of a second.

*Reference: https://www.osha.gov/dte/grant_materials/fy11/sh-22230-11/FallHazardManual.pdf*

Anatomy of Fall




Referring to the above mentioned formula:
(sample; 65 kilogram man, falling from a height of 5 meters)

Speed at impact: 9.90 m/s
Time until impact: 1.01 sec
Energy at impact: 3185.0 joules

*In deciding to use a fall protection, first consider installing guardrails or barriers (engineering control). However, installing barriers or guardrails at a worksite may not always be practical and that is when a worker needs a personal fall protection equipment.*

**Two types of fall protection:**

a) **Fall arrest:**

Fall arrest system protects the workers body after by stopping the fall before he /she hits the surface below.

Equipment use:

a) Full body harness connected by lanyards or lifelines to secure anchors
b) Safety nets

## Personal Fall Arrest Systems - The Fall

A free fall is defined as the act of falling before a personal fall arrest system begins to apply force to arrest the fall. When a fall is experienced using a PFAS, the fall is referred to as a free fall up until the system starts to arrest the fall to stop the fall.
OSHA regulations allow no more than a **six** foot free fall distance.
When the fall does come to a complete stop, the action is referred to as the fall arrest. Tremendous force is imposed on the body during the fall arrest. This force imposed during the arrest is known as the ***arrest force***. Forces imposed in a fall greatly depend on the type of system you are using and the free fall distance.
For example: A 220 lb. worker:

- Free falling 2 ft. using a wire rope lanyard (without a deceleration device) = approx. 3917 lbs.
- Free falling 4 ft. using a nylon rope lanyard (without a deceleration device) = approx. 2140 lbs.
- Free falling 6 ft. using a synthetic web lanyard (with a deceleration device) = <900 lbs.

OSHA sets limits on the Maximum Arrest Force (MAF). The law prohibits the use of a safety belt for fall arrest and allows a maximum of **1800 lbs.** when using a full body harness.
**ARREST FORCE = the force imposed when the stop occurs.**
*Reference:https://www.osha.gov/dte/grant_materials/fy11/sh-22230-11/FallHazardManual.pdf*

**b) Fall Restraint**

Fall restraint system prevents a worker from falling

a) Work-positioning systems includes using safety belts or full body harness that attach a worker to an anchor and leave both the workers hands free to work.

b) Travel-restriction system of guardrails personal fall protection equipment used to prevent a worker from travelling to an edge from where a worker may fall.

## INSPECTION OF FALL PROTECTION EQUIPMENT

*Reference: ISEA // INTERNATIONAL SAFETY EQUIPMENTASSOCIATION USE AND SELECTION GUIDE Personal Fall Protection Equipment*


**There are three vital components that make up a complete fall protection system.**

These are the ABC's of fall protection:

- **A**nchorage.
- **B**ody support.
- Means of **C**onnection.

Each one must be in place and properly used to provide maximum worker protection.

While each of these components is vital to worker safety, the connecting device is the critical link in assembling a safe fall protection system since it bears the greatest force during a fall. Careful consideration must be given to the selection, materials, construction and inspection/ maintenance of fall Protection equipment before, during and after a connecting device has been selected.

An anchorage, as defined by OSHA, is a secure point of attachment for lifelines, lanyards or deceleration devices. ANSI Z359 defines anchorage as a fixed structural component such as a beam, girder, column or floor that can support the forces exerted in arresting a fall, and introduces the term “anchorage connector” to refer to the component by which the connecting device is coupled to the anchorage. It may be a beam anchor, cross-arm strap, D-bolt, hook anchor, tripod, davit or other secure device that serves as a point of attachment for lifelines, lanyards or deceleration devices.

Anchorages and anchorage connectors must be independent and capable of supporting 5,000 lb per employee attached, or designed, installed and used under the supervision of a qualified person as part of a complete personal fall arrest system which maintains a safety factor of at least two. They must also be located high enough for a worker to avoid contact with a lower level should a fall occur.

A body support, or body wear, is the component that is worn on or around the torso. **Body belts and full body harnesses are the two most common body supports.**

**Body Belt**

A body belt is a belt that circles the waist and is used for worker positioning and fall prevention.

*A body belt may be supplied with D-rings on the hips and/or middle of the back. A body belt must NEVER be used for personal fall arrest.*

**Full Body Harness**

A full body harness is a body support device that distributes fall arrest forces across the shoulders, thighs and pelvis. Full body harnesses have a center back fall arrest attachment for connection to the fall arrest connecting device and may have other Drings for use in worker positioning, fall prevention, suspension or ladder climbing.

**The only form of body wear acceptable for fall arrest is the full-body harness.**

Full body harnesses should be selected based on work to be performed and the work environment.

Side and front D-rings on full body harnesses are for positioning only.

**Means of Connection**

The connecting subsystem is the critical link which joins the body wear to the anchorage/anchorage connector. It can be an energy-absorbing lanyard, fall limiter, self-retracting lanyard, rope grab, or retrieval system. Connecting means will vary depending on whether the worker is equipped for personal fall arrest or work positioning and travel restriction

**Connecting Means for Personal Fall Arrest**

The connecting means for personal fall arrest is often a lanyard equipped with an energy-absorbing element to reduce the energy transmitted to the user's body in the event of a fall. Self-retracting lifelines or fall limiters reduce free-fall distance as well as reducing energy loads from a fall.

**Connecting Means for Positioning and Travel Restriction**

The connecting means for positioning and travel restriction is often a simple lanyard, constructed of rope, web or wire rope.

These may also include specialized positioning assemblies for rebar work, constructed of chain or web. All positioning devices are intended to reduce the potential for free fall to a distance of less than two feet. Restraint lanyards are specified in length to prevent the user from reaching a fall hazard zone.

**FREE FALL DISTANCE, TOTAL FALL DISTANCE, AND SYSTEM ELONGATION**

Personal fall arrest systems must be selected and rigged to ensure that potential free fall distances will never exceed 6 ft (1.8 m) as required by OSHA. See manufacturer's instructions for connecting subsystems to determine the deceleration distance and elongation that must be taken into consideration.

Total fall distance is the sum of free fall distance and deceleration distance. Dynamic elongation of the system (temporary elastic stretch of connecting components and subsystems) and the worker's height must be added to total fall distance and the user must allow for clearance. It is prudent to allow for an additional safety factor of 3 ft (1 m) below the fallen worker's feet.

Potential fall distance must be calculated to determine how to rig the system, and selection of the appropriate type of connecting device.

For example, when using a 6-foot lanyard, the

illustration below shows a typical calculation of total estimated fall distance.

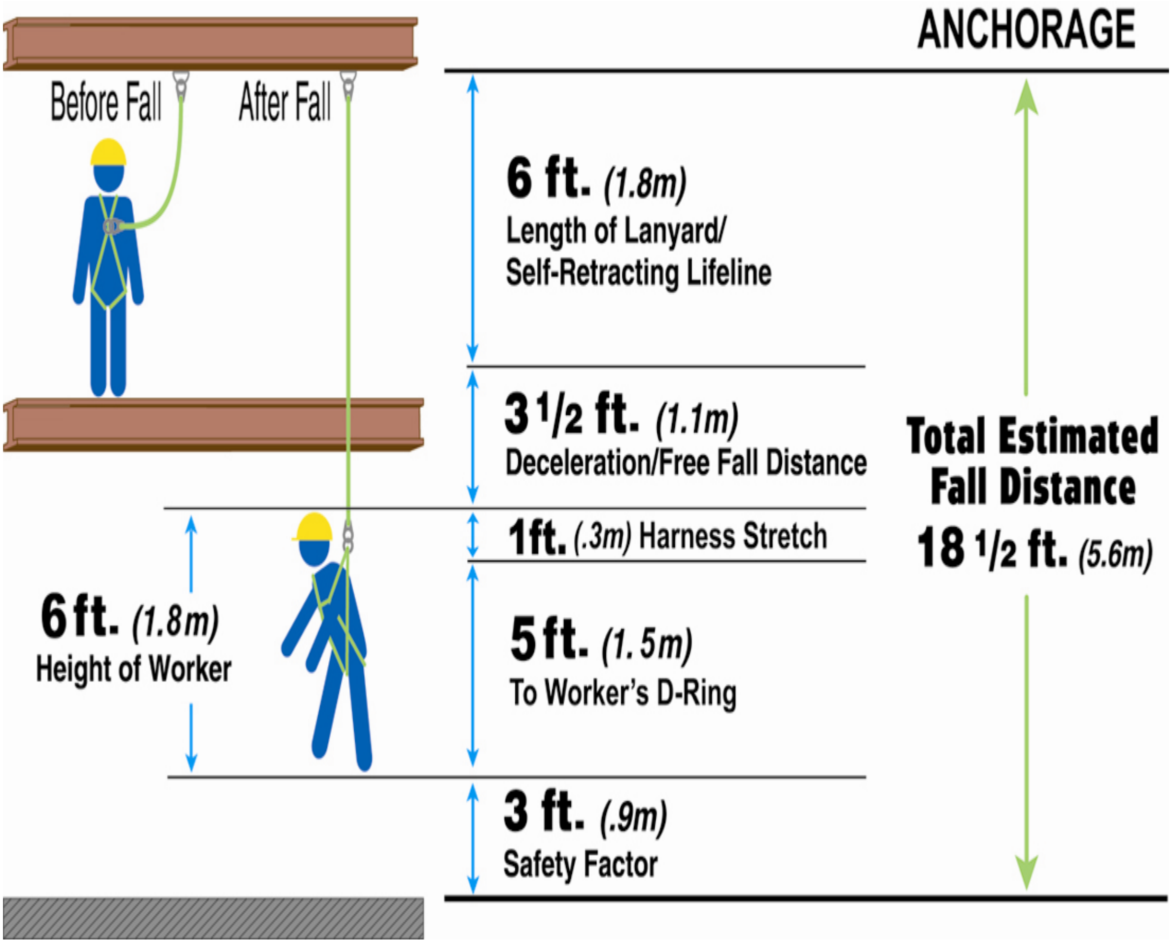
For the example shown:

When fall clearance is under 18.5 ft (5.6m), an alternative solution such as a shorter lanyard length, or a different connecting device such as a self-retracting lanyard or fall limiter, is needed to reduce the total fall distance.

When fall clearance is over 18.5 ft (5.6m) there is sufficient total fall distance available and the 6 ft lanyard is acceptable to use. Note that energy absorbing lanyards can expand up to 3.5 ft (1.1m). Consult manufacturer's instructions.

**Note:**

*Never tie a knot in any lanyard to make it shorter, as it reduces the strength by more than 50%. Instead, purchase an adjustable lanyard and adjust it to proper working length.*

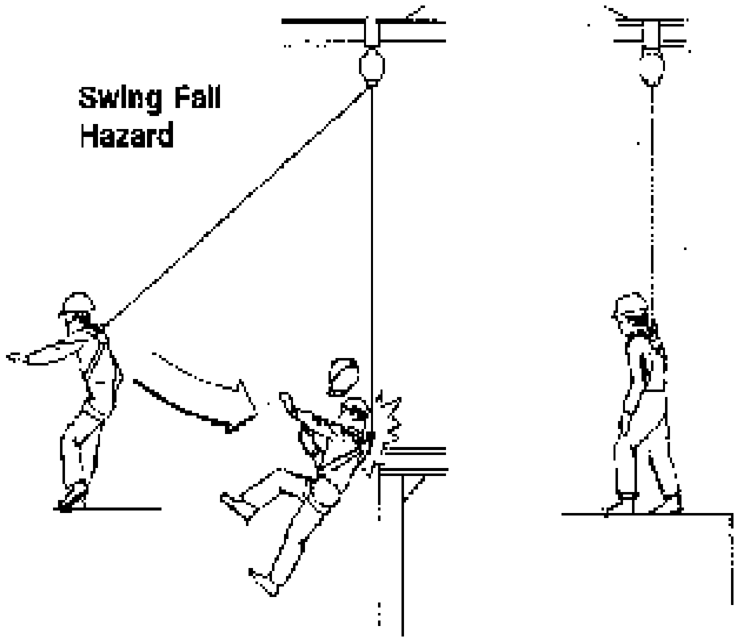


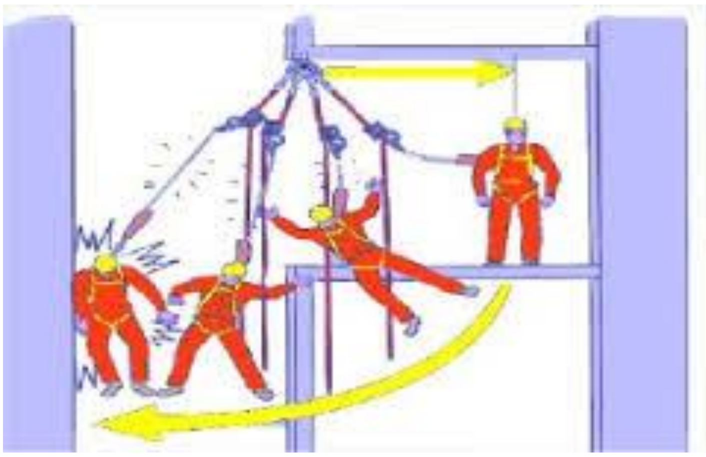

**User movement**

Identify all necessary movements of the user and the materials and equipment needed to perform the planned work. The plan should ensure there is no crossing or tangling of connecting subsystems of two or more workers. Make certain users do not clamp, knot or otherwise prevent the connecting subsystem from functioning properly. Establish controls to prevent these occurrences.

**PENDULUM (SWING) FALLS**

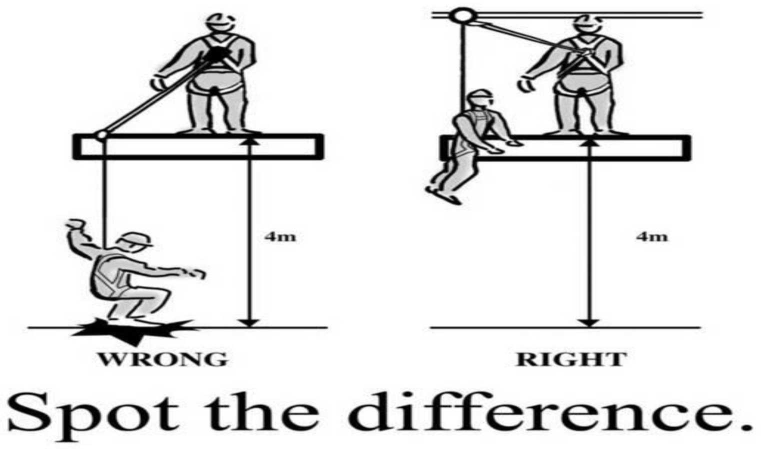
Swing falls can occur when the system is not anchored directly above the user. The force of striking an object in a pendular motion can cause serious injury. Always minimize swing falls by working as directly below the anchorage point as possible.



**Clear Space in Fall Path**

Make certain that enough clearance is available in all potential fall paths to prevent striking an object. The amount of clearance needed depends upon the type of connecting subsystem used, and the location of the anchorage. Consult the manufacturer's instructions for the particular connecting subsystem or component for clearance needed.




**Inspection of Fall Protection Equipment**

Fall protection equipment must be visually inspected before each use. Regular inspection by a competent person for wear on the equipment should be performed at least every 6 months. Severe service or wear will require more frequent inspections.

Inspection procedures should be written and each inspection should be documented. It is also important to follow any specific instructions that are provided with the equipment at the time of purchase. Instructions should be stored in a location where they are readily available to the users.

*Inspect all equipment according to the manufacturer's instructions. If required by the manufacturer, return the equipment to the manufacturer for inspection, repair, or recertification.Remove equipment from service if a stress indicator or warning system has been activated.*
*Follow manufacturer's instructions for disposition of the equipment.*

***If a fall has been arrested, remove all components of the system from service and follow the manufacturer's instructions for disposal.***

To inspect your harness or body belt, perform the following procedures.

**Webbing** – Grasp the webbing with your hands 6 in. (152mm) to 8 in. (203mm) apart. Bend the webbing in an inverted "U" as shown. The surface tension resulting makes damaged fibers or cuts easier to detect. Follow this procedure the entire length of the webbing, inspecting both sides of each strap. Look for frayed edges, broken fibers, pulled stitches, cuts, burns and chemical damage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**D-Rings/Back Pads** –
Check D-rings for distortion, cracks, breaks, and rough or sharp edges. It should pivot freely. D-ring back pads should also be inspected for damage.

**Attachment of Buckles** –
Inspect for any unusual wear, frayed or cut fibers, or broken stitching of the buckle or D-ring attachments.

**Tongue/Grommets** –
The tongue receives heavy wear from repeated buckling and unbuckling. Inspect for loose, distorted or broken grommets. Webbing should not have additional punched holes.

**Tongue Buckles** –
Buckle tongues should be free of distortion in shape and motion.
They should overlap the buckle frame and move freely back and forth in their socket. Roller should turn freely on frame. Check for distortion or sharp edges.

**Friction and Mating Buckles** – Inspect the buckle for distortion. The outer bars and center bars must be straight. Pay special attention to corners and attachment points at the center bar.

**Quick-Connect Buckles** – Inspect the buckle for distortion. The outer bars and center bars must be straight. Make sure dual-tab release mechanism is free of debris and engages properly.

When inspecting lanyards, begin at one end and work to the opposite end, slowly rotating the lanyard so that the entire circumference is checked. Additionally, follow the procedures below.

**Hardware**

**Snaps** - Inspect closely for hook and eye distortions, cracks, corrosion, or pitted surfaces. The keeper (latch) should seat into the nose without binding and should not be distorted or obstructed. The keeper spring should exert sufficient force to firmly close the keeper. Keeper locks must prevent the keeper from opening when the keeper closes.

**Thimbles** - The thimble must be firmly seated in the eye of the splice, and the splice should have no loose or cut strands. The edges of the thimble must be free of sharp edges, distortion, or cracks.

**Lanyards**

**Wire Rope Lanyard** – While rotating the wire rope lanyard, watch for cuts, frayed areas, or unusual wearing patterns on the wire. Broken strands will separate from the body of the lanyard.

**Web Lanyard** – While bending webbing over a pipe or mandrel, observe each side of the webbed lanyard. This will reveal any cuts or breaks. Swelling, discoloration, cracks and charring are obvious signs of chemical or heat damage. Observe closely for any breaks in stitching.

**Energy-Absorbing lanyard -** Examine as a web lanyard (described above). However, also look for the warning flag or signs of deployment. If the flag has been activated, remove this energy--absorbing lanyard from service.

**Rope Lanyard** – Rotate the rope lanyard while inspecting from end-to-end for any fuzzy, worn, broken or cut fibers. Weakened areas from extreme loads will appear as a noticeable change in original diameter. The rope diameter should be uniform throughout, following a short break-in period.

**Energy- Absorber Pack** – The outer portion of the pack should be examined for burn holes and tears. Stitching on areas where the pack is sewn to D-rings, belts or lanyards should be examined for loose strands, rips and deterioration.

An energy-absorbing lanyard or self-retracting lifeline is composed of only one strength member (i.e., webbing, rope, steel cable). Substandard design, poor quality workmanship, excessive exposure to UV light or chemicals, physical damage, improper storage or inadequate inspection can lead to lanyard/lifeline failure.

To inspect your self-retracting lifeline, perform the following procedures.

**Check Housing** –

Before every use, inspect the unit's housing for loose fasteners anbent, cracked, distorted, worn, malfunctioning or damaged parts.

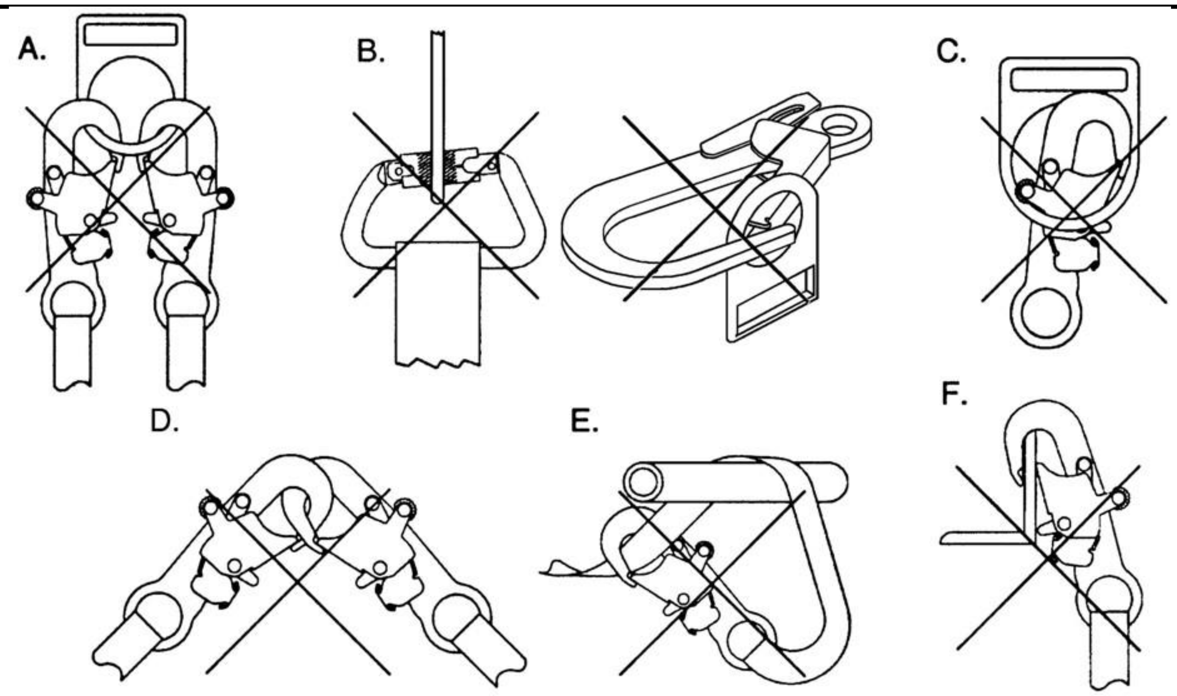
**Retraction and Tension** –

Test the lifeline retraction and tension by pulling out several feet of the lifeline and allow it to retract back into the unit. Always maintain a light tension on the lifeline as it retracts. The lifeline should pull out freely and retract all the way back into the unit. Do not use the unit if the lifeline does not retract.

**Lifeline** –
The lifeline must be checked regularly for signs of damage. Inspect for cuts, burns, corrosion, kinks, frays or worn areas. Inspect any sewing (web lifelines) for loose, broken or damaged stitching.

**Braking Mechanism** –
The braking mechanism must be tested by grasping the lifeline
above the impact indicator and applying a sharp steady pull downward which will engage the brakes. There should be no slippage of the lifeline while the brakes are engaged, once tension is released, the brakes will disengage and the unit will return to the retractable mode. Do not use the unit if the brakes do not engage.
Check the hardware as directed under lanyard inspection (page 18). The snap hook load indicator is located in the swivel of the snap hook. The swivel eye will elongate and expose a red area when subjected to fall arresting forces. Do not use the unit if the load impact indicator has been activated.
Just as a chain is only as strong as its weakest link, the integrity of a fall protection system depends on proper connection of all its components.

**The following are some examples of improper connections:**
A. Do not attach two or more snap hooks or carabiners to a single D-ring.
B. Do not load a carabiner or snap hook at the gate.
C. Ensure that connections are compatible and secure.
D. Do not attach two snap hooks or carabiners together.
E. Do not tie back on a lanyard unless specifically designed to do so by the manufacturer.
F. Ensure that the snap hook is closed and locked.




**Basic Care of Fall Protection Equipment**

Basic care of your fall protection equipment will prolong the durable life of the unit and will contribute toward the performance of its vital safety function. Proper storage and maintenance after use are as important as cleansing the equipment of dirt, corrosives or contaminants.

**Nylon or Polyester** –

Remove all surface dirt with a sponge dampened in plain water. Squeeze the sponge dry. Dip the sponge in a mild solution of water and commercial soap or detergent. Work up a thick lather with a vigorous back and forth motion; then wipe with a clean cloth. Hang freely to dry, but away from excessive heat.

**Housing** –

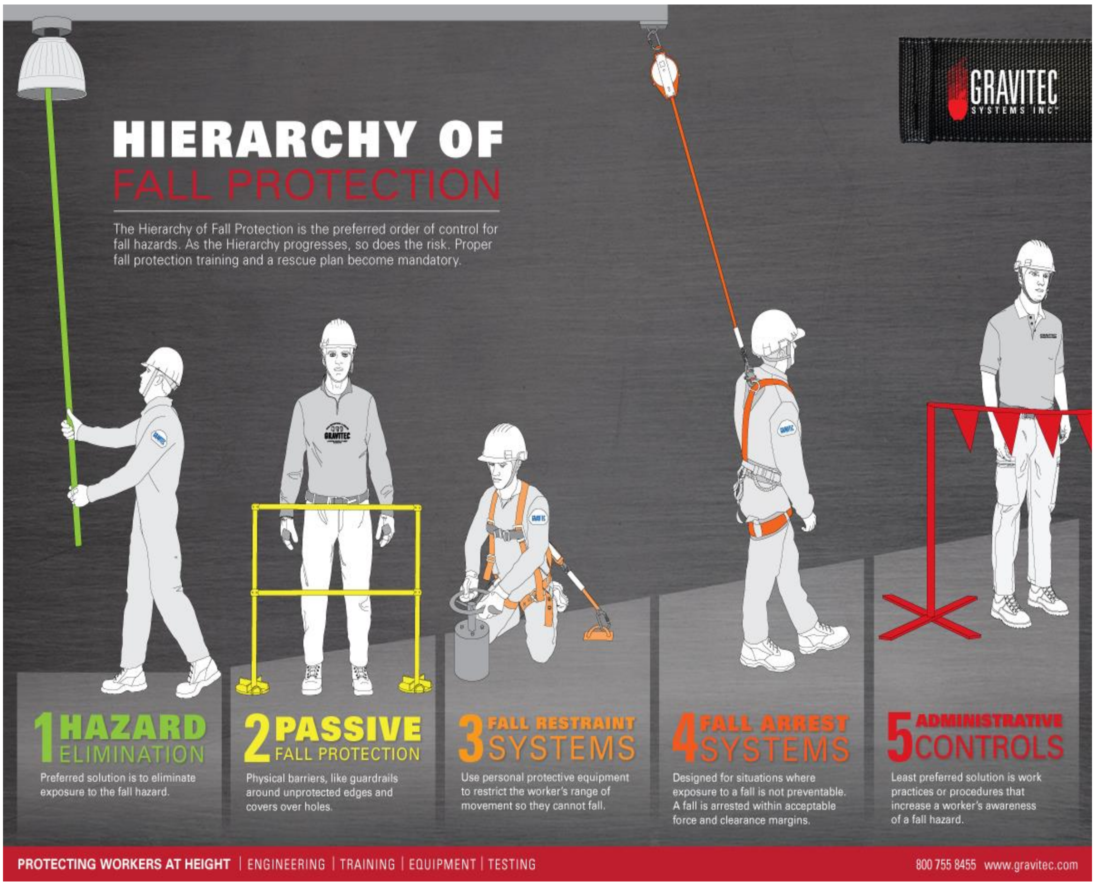
Periodically clean the unit using a damp cloth and mild detergent. Towel dry.

**Drying** – Equipment should dry thoroughly without close exposure to heat, steam or long periods of sunlight.

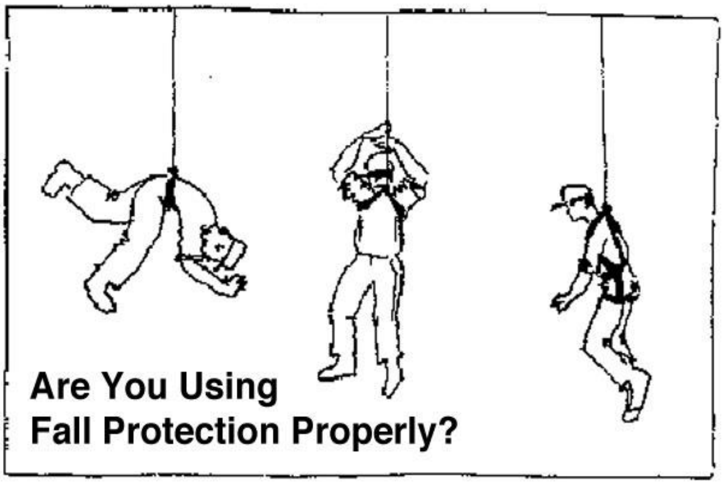
When not in use, fall protection equipment should be stored in a cool, dry and clean place out of direct sunlight. Avoid areas where heat, moisture, light, oil, chemicals (or their vapors) or other degrading elements may be present.

*Equipment that is damaged or in need of maintenance should NOT be stored in the same area as usable equipment. Heavily soiled, wet or otherwise contaminated equipment should be properly cleaned and dried prior to storage.*

*Prior to using equipment which has been stored for long periods of time, a formal inspection by a competent person should be performed.*




*Reference: poster from Gravitec system*




Danger of Suspension: (after falling and suspended in mid-air)

Suspension trauma, also known as orthostatic intolerance or harness hang syndrome, can be a killer.

Suspension trauma is simply fainting in a harness. It will happen to anyone who is held in an upright position and with their legs immobile. One does not need to be ill ,injured or even in a harness to suffer the condition and if you don't stop its progress then you will lose consciousness and eventually die.
*Reference: http://www.healthandsafetyatwork.com/hsw/content/dangers-*

***When using a personal fall protection system, a prompt rescue is must in case of a fall. Proper training of personnel in rescue operation must be provided.***

**Use of Helmet**


**Head protection against injury from Falling Object:**

In many workplace such as in the engine room and on main deck onboard ship, the most serious risks are physical injuries, which can be as a result of the impact of a falling object or collision with fixed objects at the workplace.

Safety helmets are one of the most frequently used forms of PPE. Safety Helmets will protect the user's head against:

*Reference:www.3M.com/occsafety*

The main function and purpose for wearing a protective hard hat is to:
1. Help protect workers from head trauma due to small objects falling from above
2. Help prevent force from transmitting down the spine if an impact from above occurs
3. Help protect from low level electrical shock (Applies only to hard hats that meet ANSI/ISEA Z89.1-2009 Type I, Class G and E.)

| Test | Compliance to the ANSI/ISEA Z89.1 Standard means… |
|---|---|
| Force Transmission | Helmets shall not transmit a force to the test head form that exceeds 4450 N (1000 lbs). Maximum transmitted force of each individual test sample shall be averaged. The averaged values shall not exceed 3780 N (850 lbs). |
| Apex Penetration | The penetrator shall not make contact with the top of the head form. |
| Flammability | No flame shall be visible 5 seconds after removal of the test flame. |
| Class C | Class C helmets are not tested for electrical insulation. |
| Class G (Electrical) | Shall withstand 2200 volts (root mean square), AC, 60 Hertz, for 1 minute. Leakage shall not exceed 3 milliam-peres. |
| Class E (Electrical) | Must first pass the Force Transmission Test. Shall with-stand 20,000 volts (root mean square), AC, 60 Hertz, for 3 minutes. Leakage shall not exceed 9 milliamperes. At 30,000 volts, the test sample shall not burn through. |

**Hard Hat Inspection**

A hard hat shell should be inspected prior to each use. Immediately replace the hard hat if any sign of wear appears or if there is any evi-dence of damage, abuse or plastic degradation as this may be a sign that protection is reduced. Any hard hat that shows signs of worn or damaged parts should be removed from service immediately and re-placed.

Workers in environments with higher levels of exposure to sunlight, heat, cold or chemicals should replace their hard hats more frequently than workers in other environments. If the hard hat shell becomes faded in color, exhibits a chalky appearance, or feels stiff and brittle, degradation of the shell may be occurring. A hard hat should be re-placed immediately at the first sign of any of these conditions. Hard hat suspensions should also be inspected closely for cracks, frayed straps or other signs of wear. Any suspension that is damaged must be removed from service and replaced immediately.

It is recommended to replace the entire suspension system at least every 12 months.

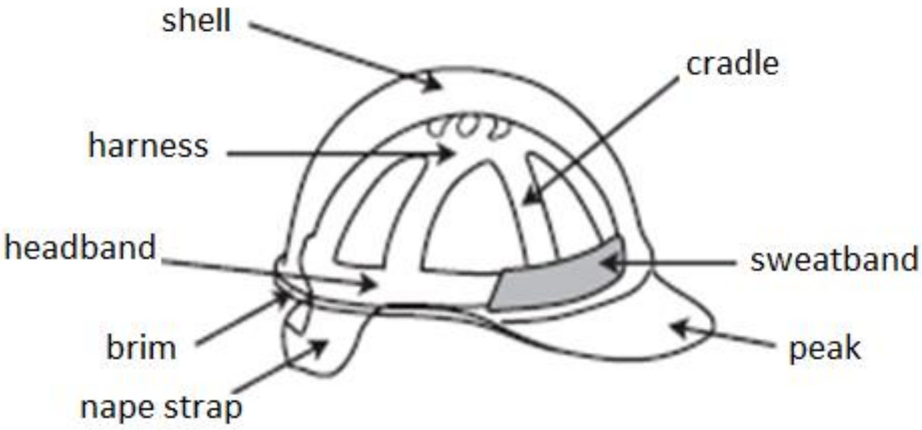
Factors that can damage the hard hat

- Impact to the hard hat

- UV exposure
- Chemical exposure
- Abuse

Under any of the following circumstances, hard hat should not be used and be replaced

- Immediately if a blow to the hard hat occurs.




General design

Parts

The *shell* is a dome-shaped covering for the head and made of hard and durable materials.

The outer surface of the shell should be smoothly finished.
It may include:
a *brim* (a rim surrounding the shell which may include a rain gutter); or/ and a peak (a permanent extension of the shell above the eyes).

The *harness* is the assembly that provides a means of maintaining the helmet in position on the user's head and absorbing kinetic energy within the shell during an impact.

It basically includes:
a *cradle* (the assembly of the parts of the harness in contact with the head to maintain the helmet in correct wearing position and with a suspension system to absorb shock in case of an impact);

a *headband* (the part of the harness surrounding the head of the user above the eyes); and
a *nape strap* (an adjustable strap normally integrated with the headband to fit behind the head).

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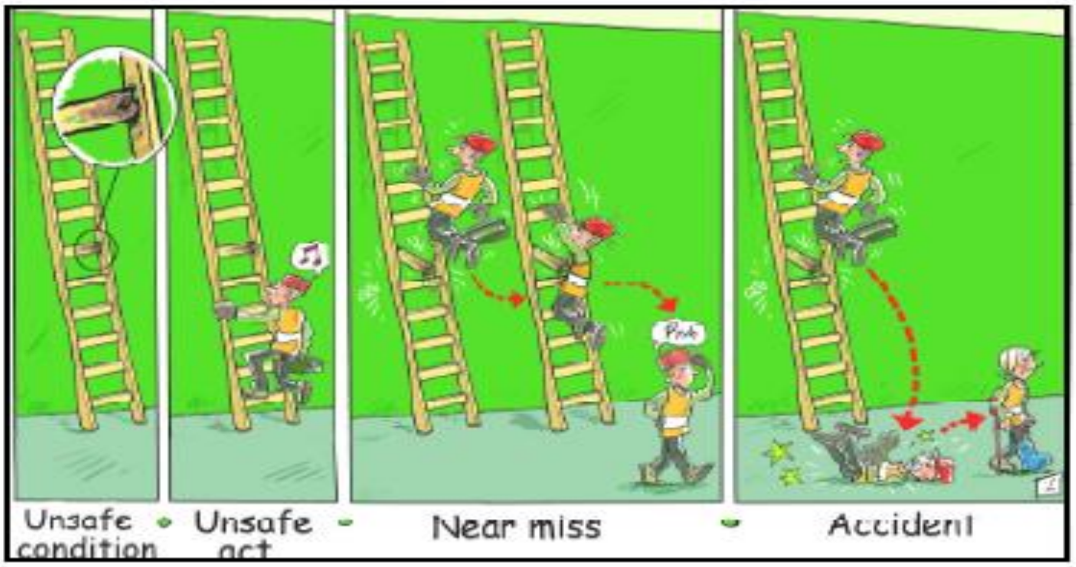
**Dangers associated with using Ladders:**




Causes of Occupationally - Related Deaths: Ladder mishaps result from several unsafe acts and conditions:

- Ladders placed on unstable surfaces.
- Workers on ladders reaching too far beyond the sides of the ladder. (Beyond the center of the body)
- Personnel standing too high on the ladder in order to maintain balance.

- Defective or broken ladders (e.g., broken rails, rungs, missing hardware).
- Ladders that were not secured or braced. (Particularly extrusion ladders.)
- Personnel hand carrying loads while ascending or descending.

- Selecting the wrong ladder for the job.
- Improper positioning of the ladder.
- Strong winds or rain.
- Eighty percent of ladder fall victims fell or slipped and nearly half of these fell at least 8 feet.
- Fifty-seven percent of fall victims were holding object(s) with one or both hands.
- -Sixty-six percent of fall victims were not trained in how to inspect ladders.
- -Seventy-three percent of fall victims were not provided written instructions on the safe use of ladders.
- -Thirty percent of fall victims had wet, greasy or oily shoes.

**HAZARDS:**

Most ladder mishaps result in falls which are sometimes fatal. Electrical shock can occur if the user is working with electrical equipment while standing on a conductive metal ladder. Portable metal ladders must always have warning labels affixed to the ladder.

Some of the various hazards are summarized below.

| HAZARD | HELPFUL HINT |
|---|---|
| Personnel slipping | Remove grease, oil, and mud from shoes. Avoid overreaching. Do not climb past SAFE height. Watch your step. |
| Ladder movement | Secure base and top of ladder. Use nonskid feet. Set the ladder at the proper 4:1 angle. Avoid slippery surfaces. |
| Ladder breakup | Inspect all ladders before using. |
| Electrical shock | Use nonmetal ladders around electricity. |
| Environmental conditions | Use extra caution in climbing on windy days. Avoid climbing during storms. |
| Pinching (Body parts caught between moving parts in closing ladder.) | Use gloves where required. Use caution in closing ladder. |

*Reference:*

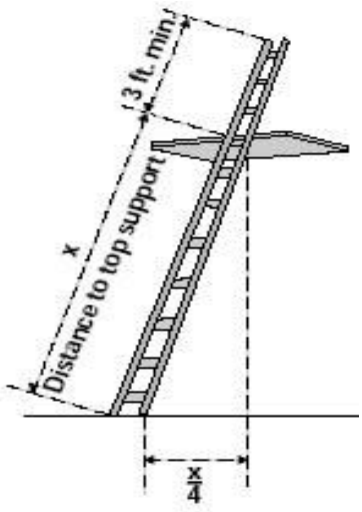
# Portable Ladder Safety

Falls from portable ladders (step, straight, combination and extension) are one of the leading causes of occupational fatalities and injuries.

- Read and follow all labels/markings on the ladder.
- Avoid electrical hazards! – Look for overhead power lines before handling a ladder. Avoid using a metal ladder near power lines or exposed energized electrical equipment.
- Always inspect the ladder prior to using it. If the ladder is damaged, it must be removed from service and tagged until repaired or discarded.
- Always maintain a 3-point (two hands and a foot, or two feet and a hand) contact on the ladder when climbing. Keep your body near the middle of the step and always face the ladder while climbing (see diagram).

- Only use ladders and appropriate accessories (ladder levelers, jacks or hooks) for their designed purposes.
- Ladders must be free of any slippery material on the rungs, steps or feet.
- Do not use a self-supporting ladder (e.g., step ladder) as a single ladder or in a partially closed position.
- Do not use the top step/rung of a ladder as a step/rung unless it was designed for that purpose.
- Use a ladder only on a stable and level surface, unless it has been secured (top or bottom) to prevent displacement.
- Do not place a ladder on boxes, barrels or other unstable bases to obtain additional height

- Do not move or shift a ladder while a person or equipment is on the ladder.
- An extension or straight ladder used to access an elevated surface must extend at least 3 feet above the point of support (see diagram). Do not stand on the three top rungs of a straight, single or extension ladder.
- The proper angle for setting up a ladder is to place its base a quarter of the working length of the ladder from the wall or other vertical surface (see diagram).
- A ladder placed in any location where it can be displaced by other work activities must be secured to prevent displacement or a barricade must be erected to keep traffic away from the ladder.
- Be sure that all locks on an extension ladder are properly engaged.




- Do not exceed the maximum load rating of a ladder. Be aware of the ladder's load rating and of the weight it is supporting, including the weight of any tools or equipment.

*Reference: https://www.osha.gov/Publications/portable_ladder_qc.htm*

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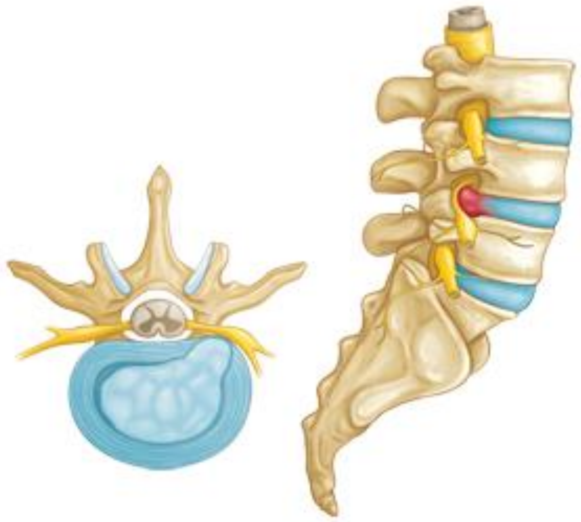
**Dangers Associated with Manual Lifting:**

Improper posture when lifting an object can result to back injury - Herniated disk



A herniated disk (side view and cross-section).

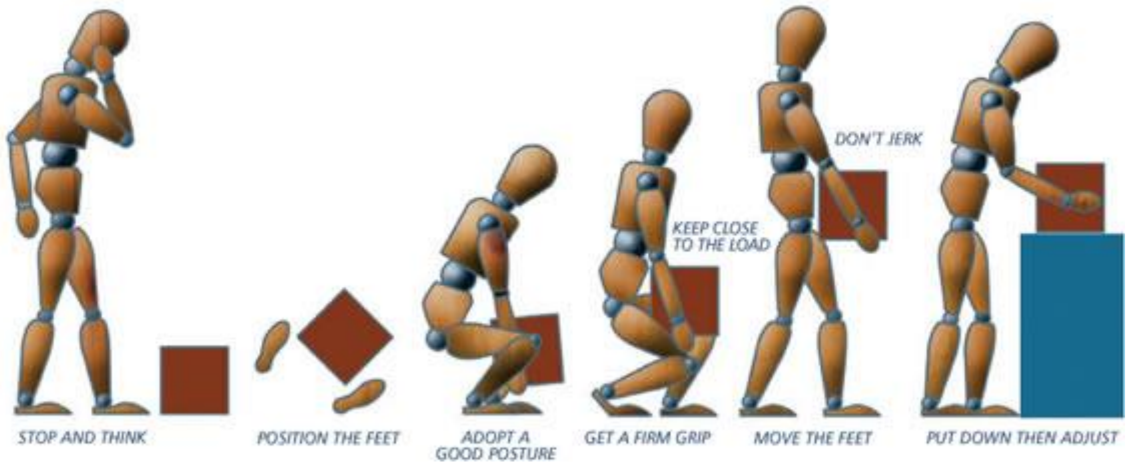
If the disk is very worn or injured, the jelly-like center may squeeze all the way through.

Once the nucleus breaks — or herniates — through the outer ring, pain in the lower back may improve. Sciatic leg pain, however, increases. This is because the jelly-like material inflames the spinal nerves. It may also put pressure on these sensitive spinal nerves, causing pain, numbness, or weakness in one or both legs.

**Improper lifting.** Using your back muscles to lift heavy objects, instead of your legs, can cause a herniated disk. Twisting while you lift can also make your back vulnerable. Lifting with your legs, not your back, may protect your spine.

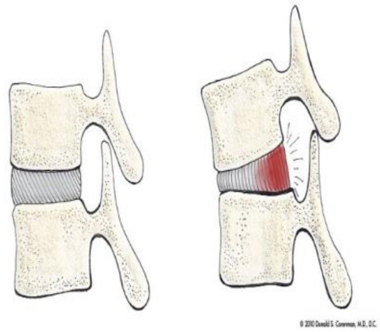
**Good handling technique for lifting**
**HSE Manual Handling – brief guide**
*Reference:http://www.hse.gov.uk/pubns/indg143.pdf*

Lifting Technique



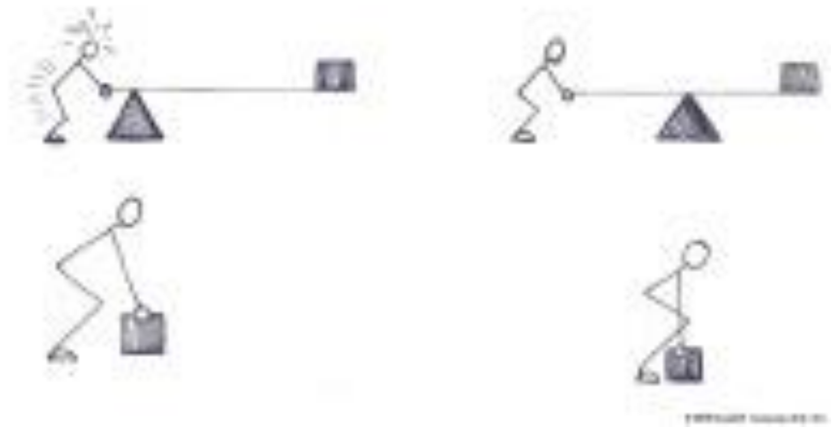

*Reference: www.intersafety.co.ok/blog/wp-content/upload/2014/08/safe-lifting jpg*

This following illustration demonstrates the stresses on the back wall of the disc with standing relaxed and with flexion (bending forward). With forward bending, the back wall of the disc is stretched. With any significant load (lifting), the fibers are tensioned and can tear




*Reference: http:// www.synergy.com/blog/wp-content/upload/2015/07/strain2a-BB.jpg*

The further away the load is from your center of gravity, the greater the stress is on the back wall of the disc (remember high school physics- the laws of levers and fulcrums).



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**Dangers Associated with Electric welding:**

Pneumoconiosis

*a disease of the lungs caused by the habitual inhalation of irritants (as mineral or metallic particles*) – Miriam Webster Dictionary

metallic particles are part of the welding fumes, adequate protection (face mask) as well as providing ventilation  is necessary when doing welding works

**Welding Fume**

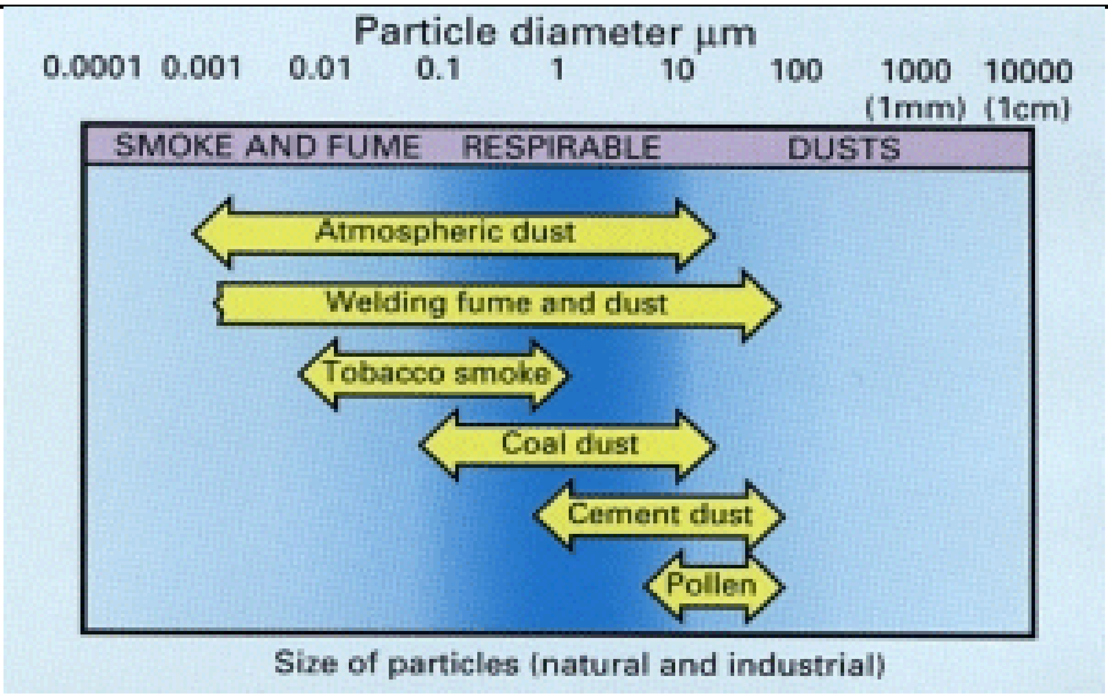
*Reference:Job Knowledge 30 http://www.twi-global.com/technical-knowledge/job-knowledge/health-safety-and-accident-prevention-welding-fume-assessment-030/*

## Fume/gases

Welding fume is a mixture of airborne fine particles. Toxic gases may also be generated during welding and cutting.

### Fume

More than 90% of the fume arises from vaporisation of the consumable electrode, wire or rod as material is transferred across the arc or flame. The range of welding fume particle size is shown in relation to more familiar types of dust and fume. The respirable fraction of particles (especially less than 3µm) are potentially more harmful as they can penetrate to the innermost parts of the lung.




The range of welding fume particle size in relation to more familiar types of dust and fume

**Gases**

Gases encountered in welding may be:

- Fuel gases which, on combustion, form carbon dioxide and, if the flame is reducing, carbon monoxide
- Shielding gases such as argon, helium and carbon dioxide, either alone or in mixtures with oxygen or hydrogen
- Carbon dioxide and monoxide produced by the action of heat on the welding flux or slag
- Nitric oxide, nitrogen dioxide and ozone produced by the action of heat or ultraviolet radiation on the atmosphere surrounding the welding arc
- Gases from the degradation of solvent vapours or surface contaminants on the metal.

The degree of risk to the welder's health from fume/gases will depend on:

- composition
- concentration
- the length of time the welder is exposed

**Health hazards from particulate fume**

The potential hazards from breathing in fume are:

**Irritation of the respiratory tract**

Fine particles can cause dryness of the throat, tickling, coughing and if the concentration is particularly high, tightness of the chest and difficulty in breathing.

**Metal fume fever**

Breathing in metal oxides such as zinc and copper can lead to an acute flu-like illness called 'metal fume fever'. It occurs most commonly when welding galvanised steel; symptoms usually begin several hours after exposure with athirst, cough, headache sweat, pain in the limbs and fever. Complete recovery usually occurs within 1 to 2 days of removal from the exposure, without any lasting effects.

Longer term effects

The continued inhalation of welding fume over long periods of time can lead to the deposition of iron particles in the lung, giving rise to a benign condition called siderosis.

There is evidence that welders have a slightly greater risk of developing lung cancer than the general population. In certain welding situations, there is potential for the fume to contain certain forms of chromium and/or nickel compounds - substances which have been associated with lung cancer in processes other than welding. As yet, no direct link has been clearly established. Nevertheless, as a sensible precaution and to minimise the risk, special attention should be paid to controlling fumes which may contain them.

**Additional hazards**

A number of other specific substances known to be hazardous to health can be found in welding fume such as barium and fluorides which do not originate from the metal. If the metal contains a surface coating, there will also be a potential risk from any toxic substances generated by thermal degradation of the coating.

**Health hazards from gases**

The potential hazards from breathing in gases during welding are:

**Irritation of the respiratory tract**

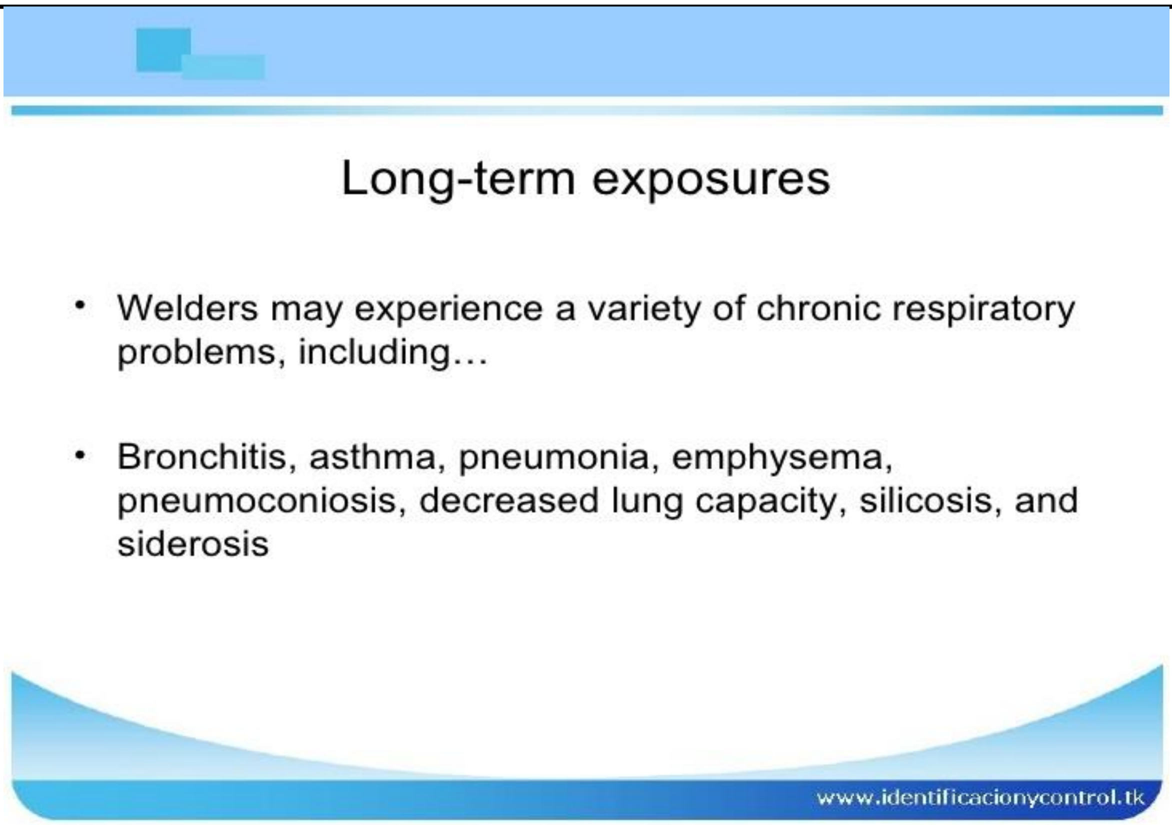
Ozone can cause delayed irritation of the respiratory tract which may progress to bronchitis and occasionally pneumonia.

Nitrogen oxides can cause a dry irritating cough and chest tightness. Symptoms usually occur after a delay of 4 to 8 hours. In severe cases, death can occur from pulmonary oedema (fluid on the lungs) or pneumonia.

Asphyxiation

Special precautions are needed when welding in confined spaces where there is the risk of asphyxiation due to the build up of inert shielding gases.

Carbon monoxide, formed as a result of incomplete combustion of fuel gases, can also cause asphyxiation by replacing the oxygen in the blood.




**Establishing safe levels of fume in the workplace**

Much of the regulatory framework applied to welding and allied processes is directed towards protecting the health of workers by maintaining their exposure to fume and gases within defined limits known as exposure limits. In the UK these limits are known as Workplace Exposure Limits (WELs). They are for use with the Control of Substances Hazardous to Health Regulation and are published annually in EH/40 from the Health and Safety Executive.

WELs are concentrations of hazardous substances in the air, averaged over a specified period of time referred to as a time weighted average.

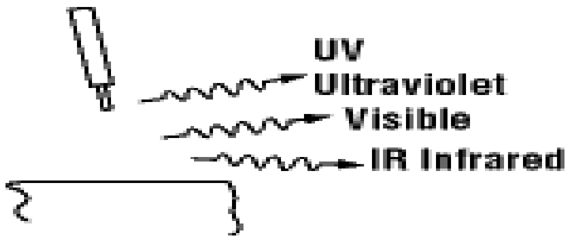
Two time periods are used: long term (8 hours) and short term (15 minutes). Short term exposure limits (STELs) are set to prevent effects, such as eye irritation, which may occur following exposure for a few minutes.

**Welding - Radiation and the Effects On Eyes and Skin**

*Reference: https://www.ccohs.ca/oshanswers/safety_haz/welding/eyes.html*

***radiation associated with welding***

Welding arcs give off radiation over a broad range of wavelengths - from 200 nm (nanometres) to 1,400 nm (or 0.2 to 1.4 µm, micometres). This includes ultraviolet (UV) radiation (200 to 400 nm), visible light (400 to 700 nm), and infrared (IR) radiation (700 to 1,400 nm).




UV-radiation is divided into three ranges - UV-A (315 to 400 nm), UV-B (280 to 315 nm) and UV-C (100 to 280 nm). UV-C and almost all UV-B are absorbed in the cornea of the eye. UV-A passes through cornea and is absorbed in the lens of the eye.

Some UV radiation, visible light, and IR radiation can reach the retina.

***symptoms of "Arc Eye"***

Certain types of UV radiation can produce an injury to the surface and mucous membrane (conjunctiva) of the eye called "arc eye," "welders' eye" or "arc flash." These names are common names for "conjunctivitis" - an inflammation of the mucous membrane of the front of the eye.

The symptoms include:

- pain - ranging from a mild feeling of pressure in the eyes to intense pain in severe instances
- tearing and reddening of the eye and membranes around the eye
- sensation of "sand in the eye" or abnormal sensitivity to light
- inability to look at light sources (photophobia)

The amount of time required to cause these effects depends on several factors such as the intensity of the radiation, the distance from the welding arc, the angle at which the radiation enters the eye, and type of eye protection that the welder or bystander is using. However, exposure to just a few seconds of intense UV light can cause arc eye. These symptoms may not be felt until several hours after exposure.

***Other possible effects to the eyes***

Long-term exposure to UV light can produce cataracts in some persons.

Visible light from welding processes is very bright and can overwhelm the ability of the iris of the eye to close sufficiently and rapidly enough to limit the brightness of the light reaching the retina. The result is that the light is temporarily blinding and fatiguing to the eye.

A serious concern is the "blue light hazard" which is the temporary or permanent scarring of the retina due to its sensitivity to blue light, around 440 nm wavelength. Blindness may result.

Exposure to infrared light can heat the lens of the eye and produce cataracts over the long term.

***Skin hazards associated with welding and radiation***

Welding arcs and flames emit intense visible, ultraviolet, and infrared radiation.

UV radiation in a welding arc will burn unprotected skin just like UV radiation in sunlight. This is true for direct exposure to UV radiation as well as radiation that is reflected from metal surfaces, walls, and ceilings. Surface finishes and certain paint colours can reduce the amount of UV radiation that is reflected.

- Long-term exposure to UV radiation can cause skin cancer.
- Infrared radiation and visible light normally have very little effect on the skin.

**Dangers associated with hoisting heavy object using chain hoist (manual chain hoist / electric chain hoist)**

Hoisting and Rigging Hazards

*Reference: www.ihsa.ca*

## Hoisting and Rigging Hazards

For safe rigging be sure to know the following:

- the weight of the load and rigging hardware
- the capacity of the hoisting device
- the working load limit of the hoisting rope, slings, and hardware.

When the weights and capacities are known, determine how to lift the load so that it is stable.

Identify hazards that can have an impact on a hoisting operation, elements that can affect hoisting safety, factors that reduce capacity, and safe practices in rigging, lifting, and landing loads.

Be familiar with the proper inspection and use of slings and other rigging hardware.

*Most crane and rigging accidents can be prevented by field personnel following basic safe hoisting and rigging practices. When a crane operator is working with a rigger or a rigging crew, it is vital that the operator is aware of the all aspects of the lift and that a means of communication has been agreed upon, including what signals will be used.*

**Elements that can Affect Hoisting Safety**

**Working Load Limit (WLL) not known.** Don't assume. Know the working load limits of the equipment being used. Never exceed these limits.

**Defective components.** Examine all hardware, tackle, and slings before use. Destroy defective components. Defective equipment that is merely discarded may be picked up and used by someone unaware of its defects.

**Questionable equipment.** Do not use equipment that is suspected to be unsafe or unsuitable, until its suitability has been verified by a competent person.

**Hazardous wind conditions.** Never carry out a hoisting or rigging operation when winds create hazards for workers, the general public, or property. Assess load size and shape to determine whether wind conditions may cause problems. For example, even though the weight of the load may be within the capacity of the equipment, loads with large windcatching surfaces may swing or rotate out of control during the lift in high or gusting winds.

Swinging and rotating loads not only present a danger to riggers—there is the potential for the forces to overload the hoisting equipment.

**Factors that Reduce Capacity**

The working load limits of hoisting and rigging equipment are based on ideal conditions. Such ideal circumstances are seldom achieved in the field.

**Swing.** The swinging of suspended loads creates additional dynamic forces on the hoist in addition to the weight of the load. The additional dynamic forces (see point below) are difficult to quantify and account for, and could cause tip-over of the crane or failure of hoisting hardware. The force of the swinging action makes the load drift away from the machine, increasing the radius and side-loading on the equipment. The load should be kept directly below the boom point or upper load block. This is best accomplished by controlling the load's movement with slow motions.

**Condition of equipment.** The rated working load limits apply only to equipment and hardware in good condition. Any equipment damaged in service should be taken out of service and repaired or destroyed.

**Dynamic forces.** The working load limits of rigging and hoisting equipment are determined for static loads. The design safety factor is applied to account, in part, for the dynamic motions of the load and equipment. To ensure that the working load limit is not exceeded during operation, allow for wind loading and other dynamic forces created by the movements of the machine and its load.
Avoid sudden snatching, swinging, and stopping of suspended loads. Rapid acceleration and deceleration also increases these dynamic forces.

**Weight of tackle.** The rated load of hoisting equipment does not account for the weight of hook blocks, hooks, slings, equalizer beams, and other parts of the lifting tackle. The combined weight of these items must be added to the total weight of the load, and the capacity of the hoisting equipment, including design safety factors, must be large enough to account for the extra load to be lifted.

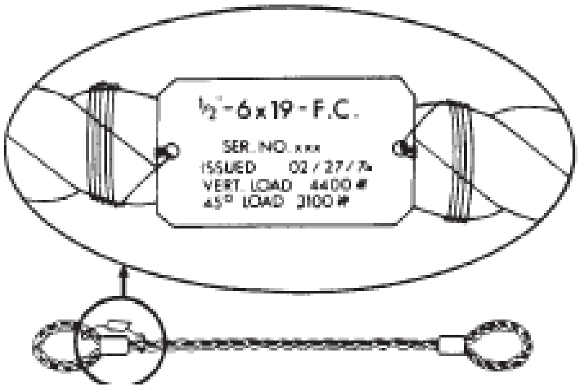
**Slings**

After the hoist rope, the sling is the most commonly used piece of rigging equipment.

Observe the following precautions with slings.

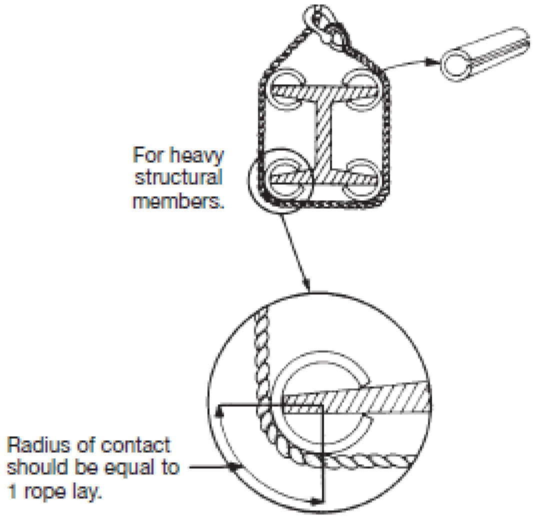
- Never use damaged slings. Inspect slings regularly to ensure their safety. Check wire rope slings for kinking, wear, abrasion, broken wires, worn or cracked fittings, loose seizings and splices, crushing, flattening, and rust or corrosion. Pay special attention to the areas around thimbles and other fittings.

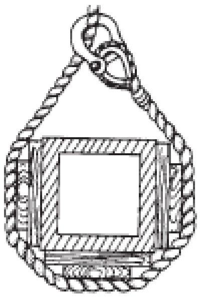
- Slings should be marked with an identification number and their maximum capacity on a flat ferrule or permanently attached ring. Mark the capacity of the sling for a vertical load or at an angle of 45°. Ensure that everyone is aware of how the rating system works.




- Avoid sharp bends, pinching, and crushing. Use loops and thimbles at all times. Corner path that prevent the sling from being sharply bent or cut can be made from split sections of large diameter pipe, corner saddles, padding, or blocking.

**Ensure that Slings are Protected at All Sharp Corners on Heavy Items**

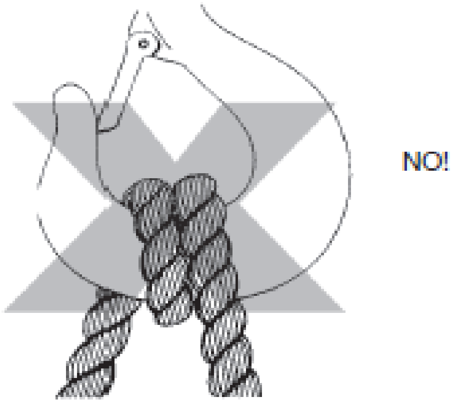


- Never allow wire rope slings, or any wire rope, to lie on the ground for long periods of time or ondamp or wet surfaces, rusty steel, or near corrosive substances.

- Avoid dragging slings out from underneath loads.
- Keep wire rope slings away from flame cutting and electric welding.
- Never make slings from discarded hoist rope.

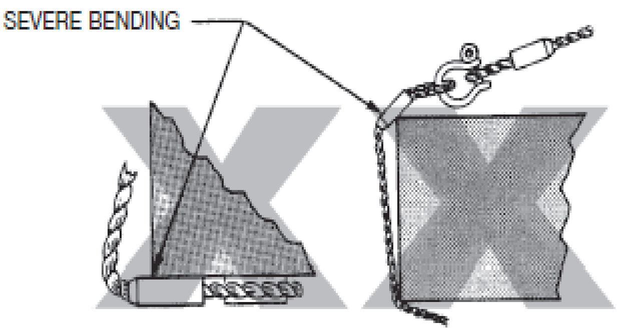
- Avoid using single-leg wire rope slings with hand-spliced eyes. The load can spin, causing the rope to unlay and the splice to pull out. Use slings with Flemish Spliced Eyes.




**Never Wrap a Sling Around a Hook**

- Never wrap a wire sling completely around a hook. The sharp radius will damage the sling. Use the eye.

**Do Not Permit Bending Near Any Splice or Attached Fitting**




- Avoid bending the eye section of wire rope slings around corners. The bend will weaken the splice or swaging. There must be no bending near any attached fitting.

***Field Calculation Formula (in the absence of manufacturers data)***

The **field calculation formula** can be used to compute the working load limit of a wire rope in tons (2,000 pounds).

The formula applies to new wire rope of Improved Plow steel and a design factor of 5.

WLL = DIAMETER x DIAMETER x 8
(where DIAMETER = nominal rope diameter in inches)

**OR**

WLL = D2 x 8

EFFECT OF SLING ANGLE ON SLING LOAD

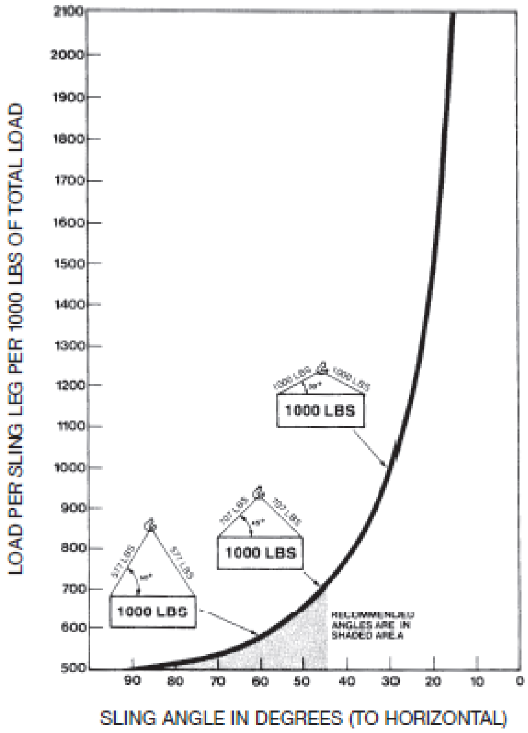
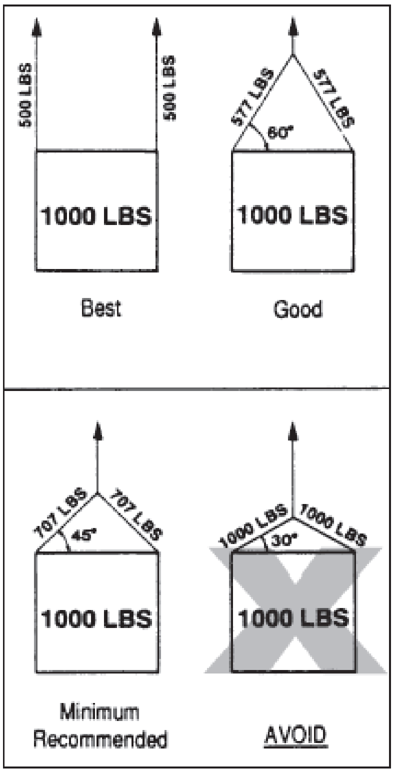
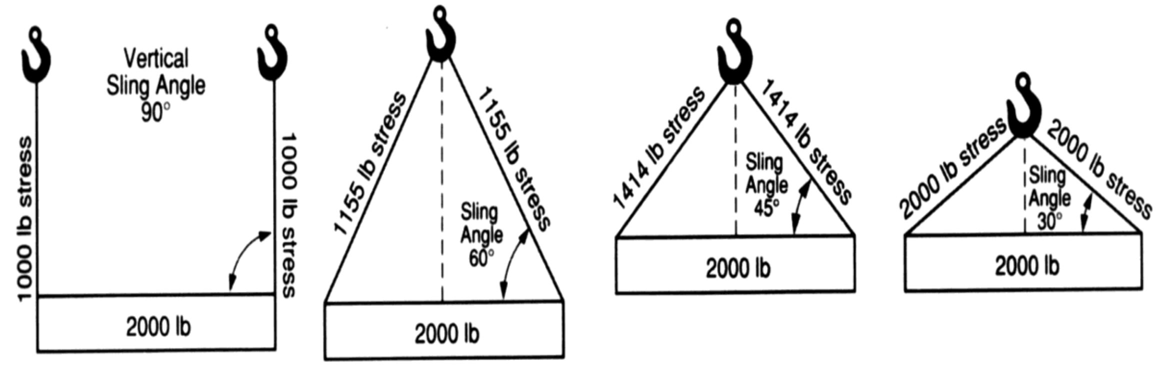



Figure 22a




For safe operation, always consult the manufacturer's data.
Below are sample of manufacturer's data

*Reference: dunlapindustrial.com/wirecalculating.loads*




*Reference: http://www.florida wire.com/load limits*

## WIRE ROPE

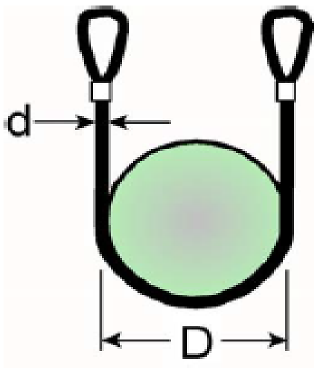
VERTICAL CHOKER BASKET — SINGLE LEG SLING
SLING ANGLE — MULTI-LEG SLING

| | Rope Dia. | SINGLE LEG SLINGS CAPACITY - TONS Vertical | Choker | Basket | Approx. Loop Size | MULTIPLE LEG SLINGS - CAPACITY - TONS 2 Legs 60° | 2 Legs 45° | 2 Legs 30° | 3 Legs 60° | 3 Legs 45° | 3 Legs 30° | 4 Legs 60° | 4 Legs 45° | 4 Legs 30° |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 6 x 19 XIP IWRC | 1/4" | 0.65 | 0.48 | 1.3 | 2 "x 4" | 1.1 | 0.92 | 0.65 | 1.7 | 1.4 | 0.97 | 2.2 | 1.8 | 1.3 |
| | 3/8" | 1.4 | 1.1 | 2.9 | 3" x 6" | 2.5 | 2.0 | 1.4 | 3.7 | 3.0 | 2.2 | 5 | 4.1 | 2.9 |
| | 1/2" | 2.5 | 1.9 | 5.1 | 4" x 8" | 4.4 | 3.6 | 2.5 | 6.6 | 5.4 | 3.8 | 8.8 | 7.1 | 5.1 |
| | 5/8" | 3.9 | 2.9 | 7.8 | 5" x 10" | 6.8 | 5.5 | 3.9 | 10 | 8.3 | 5.9 | 14 | 11 | 7.8 |
| | 3/4" | 5.6 | 4.1 | 11 | 6" x 12" | 9.7 | 7.9 | 5.6 | 15 | 12 | 8.4 | 19 | 16 | 11 |
| | 7/8 | 7.6 | 5.6 | 15 | 7" x 14" | 13 | 11 | 7.6 | 20 | 16 | 11 | 26 | 21 | 15 |
| | 1" | 9.8 | 7.2 | 20 | 8" x 16" | 17 | 14 | 9.8 | 26 | 21 | 15 | 34 | 28 | 20 |
| | 1-1/8" | 12 | 9.1 | 24 | 9" x 18" | 21 | 17 | 12 | 31 | 26 | 18 | 42 | 34 | 24 |
| 6 x 37 IWRC | 1-1/4" | 15 | 11 | 30 | 10" x 20" | 26 | 21 | 15 | 38 | 31 | 22 | 51 | 42 | 30 |
| | 1-3/8" | 18 | 13 | 36 | 11" x 22" | 31 | 25 | 18 | 46 | 38 | 27 | 62 | 50 | 36 |
| | 1-1/2" | 21 | 16 | 42 | 12" x 24" | 36 | 30 | 21 | 55 | 45 | 32 | 73 | 60 | 42 |
| | 1-3/4" | 28 | 21 | 57 | 14" x 28" | 48 | 40 | 28 | 74 | 60 | 42 | 98 | 80 | 57 |
| | 2" | 37 | 28 | 73 | 16" x 32" | 64 | 52 | 37 | 95 | 78 | 56 | 127 | 104 | 73 |
| | 2-1/4" | 44 | 35 | 88 | 18 "x 36" | 76 | 62 | 44 | 114 | 93 | 66 | n/a | n/a | n/a |

**D/d Ratio**

*Reference: Basic rigging workbook, BrookHaven National Library*

When a wire rope sling is used in a basket hitch, the diameterof the load where the sling contacts the load can reduce sling capacity. The method used to determine the loss of strength or efficiency is referred to as the *D/d Ratio*.
The "D" refers to the diameter of the object being lifted, while the "d" refers to the diameter of the wire rope sling, as shown in the figure 1.
For example, when a 1-inch wire rope sling is used to lift an object that measures 25 inches in diameter, the D/d Ratio is 25-to-1 (written 25/1).
Alternatively, the "D" can refer to the cross-sectional diameter of the eye, hook, or other object being used to hoist the load, as shown in the figure 2.
In both cases, the effective strength of the sling results. The table below (fig. 3) shows the D/d Ratio and corresponding efficiency percentage



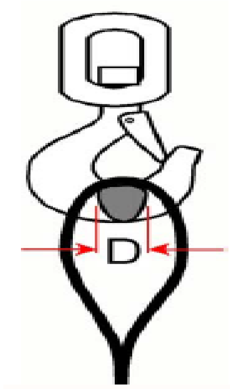




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Fig. 1

Fig. 2

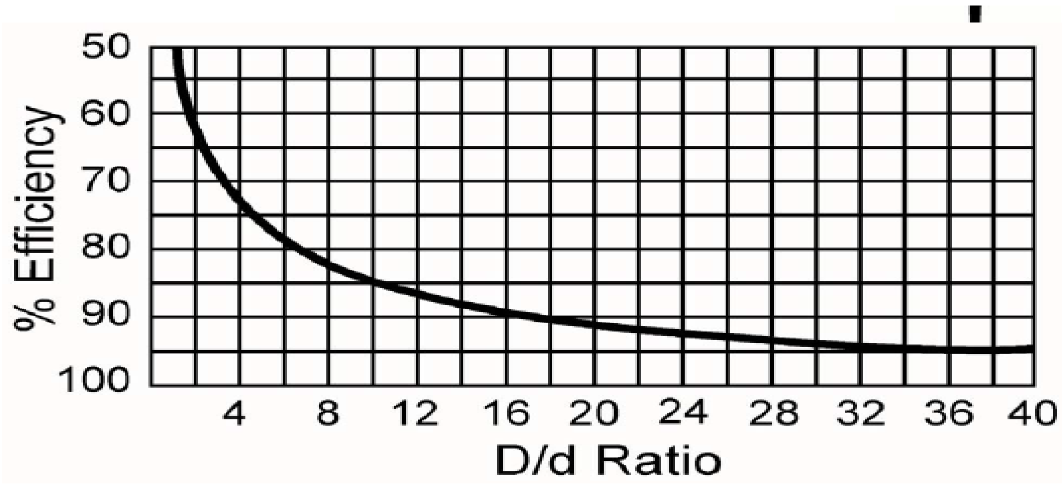


Fig. 3

**Dangers associated with electricity:**

**Hazards of electricity**

- Electric shock

- Burns
- Fire

Defective and poorly maintained electrical / electric circuit device will generate electrical leak.
This leak passes all over the conductive material of the device / electrical circuit and if someone touches the device he will receive electric shock.

**Common causes of electrical injuries / accidents**

- Touching live parts
- Short circuit
- Inadequate guarding
- Overloading
- Breaking of connections

When the electric current has sufficient potential difference to overcome the body resistance, it results in shock burns or even death. Although potential difference determines whether the body's resistance will be overcome, the damaging factor in electrical shock is the current flow.

**Factors affecting electric shock**

**a)** Amount of current that flows through the human body. The amount of current that flows through to the body depends on:
   - Voltage of the circuit; ohm's law states voltage is directly proportional to the current. A higher voltage means a higher current
   - Insulating quality

**b)** The path the current takes through the body affects the degree of injury. A small current that passes from one hand to the other hand through the heart is capable of causing severe injury or death. However, there have been cases where larger current caused an arm or leg to burn off without going through vital organs of the body. In many such cases the person was not killed; had the same current passed through the vital organ, the person easily could have been killed.

**c)** **Duration of current flow;** the longer the current flows through the body, the more devastating the result can be. That is the reason why immediate action should be taken to free co-workers when they shocked or burned by electricity.

**Action to take:**
Switch-off the electrical if the victim is still in contact with the energized circuit. While doing this, have someone else call for help. If you cannot quickly turn-off the current, pry the victim from the circuit with something that does not conduct electricity such as a dry wood broom stick.

**d) Type of electric energy involved;**

- **Alternating current (AC) –** the flow of electric charge whose magnitude and direction changes periodically. This can cause a person to maintain involuntary grip on the live metal or conductor and prolong current flow
- **Direct current (DC)** – the flow of electric charge that does not change direction

.

**e) Body condition –** Personal sensitivity to electric shock varies with age, sex, heart condition, etc.

An electrical current passing through the body can cause severe injury or death by:

- Contracting the chest muscles, resulting in breathing difficulty which would result to death due to asphyxiation.
- Affecting the central nervous system, resulting in malfunction of vital body function such as respiration.
- Interference with normal rhythm of the heart beat, resulting in ventricular fibrillation which is defined as "very rapid uncoordinated contractions of the ventricles of the heart resulting in loss synchronization between heartbeat and pulse beat" Once ventricular fibrillation occurs, it will continue and death will ensue within a few minutes.
- Electricity may also affect the heart muscle, resulting in sever heart muscle contraction and cessation of heart action.
- Heat generated when current overcomes tissue resistance may cause destruction of the body tissues

.

*The severity of an electric shock is the product of the current value and the time it flows through the human body.*

Based on the research of Charles F. Dalziel, professor at the University of California, the effects of alternating current (60Hz) on the human body are generally as follows:

| Current | Effect |
|---|---|
| 0-1mA | No sensation, not felt |

| | |
|---|---|
| 1 mA | Shock perceptible, reflex action to jump away, no direct Danger from shock but sudden motion may cause accident |
| >3mA | Painful shock |
| > 6mA | Let go current for women |
| > 9mA | Let go current for men |
| > 10mA | Local muscle contractions, sufficient to cause "freezing" to the circuit for 2.5 % of the population |
| > 15mA | Local muscle contractions, sufficiengt to cause "freezing" to the circuit for 50 % of the population |
| > 30mA | Breathing difficulty; can cause unconsciousness |
| > 50 - 100mA | Possible ventricular fibrillation of the heat |
| >100 - 200mA | Certain ventricular fibrillation of heart |
| >100 - 200mA | Sever burns and muscular contractions; heart more apt to stop than fibrillate |
| >1Ampere | Irreparable damage to tissue |

*Reference: Occupational and Environmental Safety Engineering and Management*

- **Let go current**
  The maximum current that a person can tolerate when holding a conductor and can still free himself / herself by muscular stimulation.

- **Ventricular fibrillation**
  Most death by electric shock are caused by ventricular fibrillation. It is a condition wherein the heart will not pulse regularly causing the heart to

cease functioning. Once this occurs, the victim will be dead in a few minutes even if the electric source is interrupted.

- Even small amounts of current can cause minor shock sensations and result to secondary accidents. *Reference: http:// www.ccohs.ca/oshanswer/safety_haz/electrical.html*

There are **four main type of injuries caused by electric currents- electrocution** (fatal), **electric shocks, burns, and falls**. These injuries can happen in various ways:

- Direct contact with the electrical energy.
- When the electricity arcs (jumps) through a gas (such as air) to a person who is grounded (that would provide an alternative route to the ground for the electricity).
- Thermal burns including flash burns from heat generated by an electric arc, and flame burns from material that catch fire from heating or ignition by electric currents. High voltage contact burns can burn internal tissues while leaving only very small injuries on the outside of the outside of the screen.
- Muscle contractions, or a startle reaction, can cause a person to fall from a ladder, scaffold or aerial bucket. The fall can cause serious injuries.

**Electric shock prevention**

**(a) Use of grounding system**

Grounding or earthing is any means of absorbing any leakage current and making it flow directly to earth by using an electrical conductor. It is a process of connecting metal parts/casing of the electrical equipment to earth through grounding wires. The voltage exist on the metal casing and earth resistance. Grounding means safety. There are two types of grounding:

**(1) System grounding –** means grounding the neutral point iron terminal or electrical circuits on power transformer of electrical system;

**(2) Equipment grounding –** grounding of a non-charged metal part of electrical equipment.

**(b) Use Double Insulating Materials**

Insulating materials have extremely high resistance values, virtually to prevent flow of electric current through it. The principle of insulation is used when worked must to be carried out near un-insulated live parts. Work on un-insulated parts are carried out by using protective devices such as insulating stands, mats or screens, or rubber insulating gloves to protect workers from electric shock.

**(c) Use Appropriate Disconnecting Means**

**(1) Fuse**

A fuse is essentially a strip of metal that melts at a pre-determined value of current flow, and therefore cuts off the current to that circuit. In the event of abnormal condition such as faults or when excess current flows. The fuse would blow and protect the circuit or apparatus from further damage. In effective and safe operation, the fuse should be placed in a live conductor and never in the neutral conductor. Otherwise, even with the fuse blown or removed, parts of the circuits such as switches or terminal will be affected. **Over-fusing** means using a fuse rating higher than that of the circuit it is meant to protect. This is dangerous because in the event of a fault, a current may flow to earth without blowing the fuse, endangering workers and the circuit or equipment concerned. It could also result in over heating of the cable carrying the excessive current, with the risk of fire.

**(2) Circuit Breaker**

A circuit breaker has several advantages for excess current circuit protection. The principle of the operation is that excess current flow is detected electromagnetically and mechanism of the breaker automatically trips and cuts off electric supply to the circuit it protects.

**(3) Earth Leakage Circuit Breaker**

Majority of electric shock injuries occur when the body act as conductor between line and earth. Protection against such shocks is provided by the inclusion of a current sensitive earth leakage circuit breaker (ELCB) in the supply line. ELCB may detect both over-current and earth leakage currents and thereby give very good circuit protection.

**(d) Proper Maintenance of Portable Power Tools**

The necessity to use flexible cables to supply electricity to the tools introduces hazards. Such cables are often misused and abused resulting in damage insulation and broken or exposed conductors. The tool itself could also become charged with electricity due to a fault. Constant care and adequate maintenance and storage are essential to safe use.

### Causes of electrical fires

The more frequent causes of electrical fires may be listed under the general classes namely, **arcs, sparks and overheating.** An arc is produced when an electric circuit carrying a current is interrupted, either intentionally – by knife switch or accidentally – where a contact at a terminal becomes loose. The intensity of the arc depends, to a great extent, on the current and voltage of the circuit. The temperature of the electric arc is very high and any combustible materials in its vicinity may be ignited by the heat.

An electric arc may not only ignite combustible materials in its vicinity such as The insulating covering of the conductor, but it may also fuse the metal with the conductor. Hot sparks from burning combustible material and hot metal are thrown about, and may set fire to other combustible material.

When an electric conductor carries a current, heat is generated in direct proportion to the resistance of the conductor and to the square of the current. The resistance of the conductors is used to convey current to the location where it is used, or to convey it through the windings of a piece of apparatus, except in resistance devices and heaters.

### Sample checklist for basic electrical safety:

Inspect Cords and Plugs

- Check power chords and plugs daily. Discard if worn or damaged. Have any cord that feels more than comfortably warm checked by an electrician.

Eliminate Octopus Connections

- Do not plugs several power chords into one outlet.
- Pull the plug not the cord.
- Do not disconnect power supply by pulling or jerking the cord from the outlet. Pulling the cord causes wear and may cause a shock.

Never Break OFF the Third Prong on a Plug

- Replace broken 3-prong plugs and make sure the third prong is properly grounded.

Never Use Extension Cords as Permanent wiring

- Use extension cords only to temporarily supply power to an area that does not have a power outlet.
- Keep power chords away from heat, water and oil. They can damage the insulation and causes a shock.
- Do not allow vehicles to pass over unprotected power cords. Cords should be put in conduit or protected by placing planks alongside them.

Electrical Incidents Photo Examples of Burns and Other Injuries
*Reference:https://www.osha.gov/SLTC/etools/construction/electrical_incidents/burn_examples.html*

Electrical Burns

*Entrance Wound*: High resistance of skin transforms electrical energy into heat, which produces burns around the entrance point (dark spot in center of wound). This man was lucky, the current narrowly missed his spinal cord.

=============================================================

*Exit Wound*: Current flows through the body from the entrance point, until finally exiting where the body is closest to the ground. This foot suffered massive internal injuries, which weren't readily visible, and had to be amputated a few days later.

Arc or Flash Burns

This man was near a power box when an electrical explosion occurred. Though he did not touch the box, electricity *arced* through the air and entered his body. The current was drawn to his armpits because perspiration is very conductive.

============================================================

Thermal Contact Burns

Current exited this man at his knees, catching his clothing on fire and burning his upper leg.

Internal Injuries

This worker was shocked by a tool he was holding. The entrance wound and thermal burns from the overheated tool are apparent.

Same hand a few days later, when massive subcutaneous tissue damage had caused severe swelling (swelling usually peaks 24-72 hours after electrical shock). To relieve pressure which would have damaged nerves and blood vessels, the skin on the arm was cut open.

Involuntary Muscle Contraction

This worker fell and grabbed a powerline to catch himself. The resulting electric shock mummified his first two fingers, which had to be removed. The acute angle of the wrist was caused by burning of the tendons, which contracted, drawing the hand with them.