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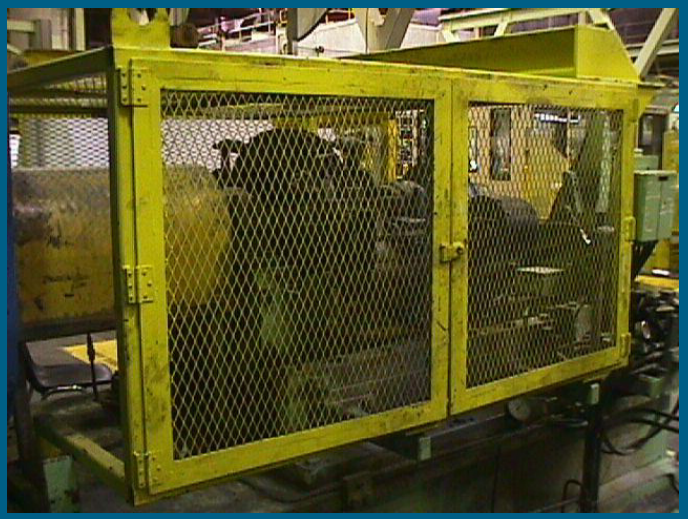
Health and Safety in Environmental Operations

Plant Safety Considerations

Machine Safeguarding

Hazards and Controls



Insperity

Washington State Department of
Labor & Industries

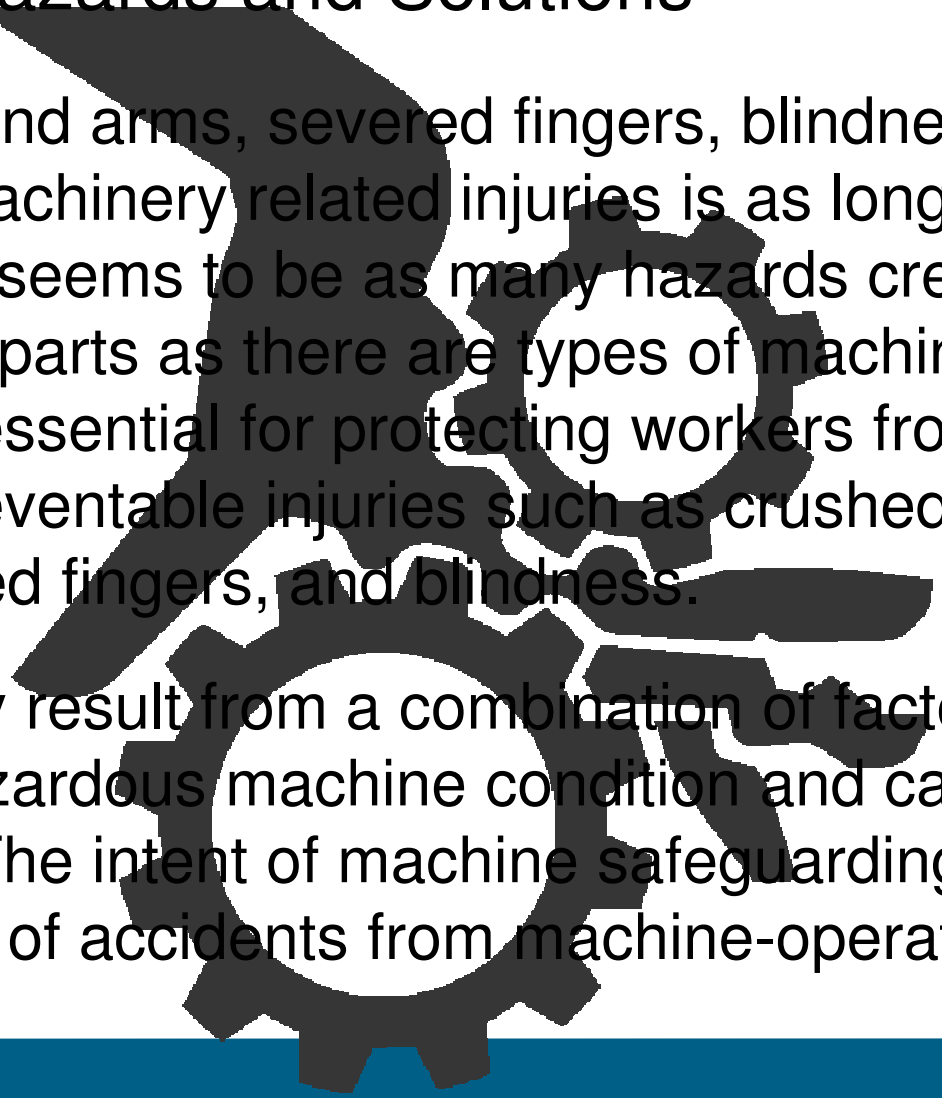
Basics of Machine Guarding

Hazards and Solutions

March, 2011

Basics of Machine Safeguarding

Hazards and Solutions



Crushed hands and arms, severed fingers, blindness -the list of possible machinery related injuries is as long as it is horrifying. There seems to be as many hazards created by moving machine parts as there are types of machines. Safeguards are essential for protecting workers from needless and preventable injuries such as crushed hands and arms, severed fingers, and blindness.

Accidents usually result from a combination of factors that includes both hazardous machine condition and careless human actions. The intent of machine safeguarding is to minimize the risk of accidents from machine-operator contact.

Topics Covered

- Identify dangerous parts of machinery
- Identify hazardous actions and motions of machinery
- Identify methods of safeguarding

Rule of Thumb....

Any machine part, function or process that may cause injury must be safeguarded. Where the operation of a machine or accidental contact with it can injure the operator or others in the vicinity, the hazards must be either eliminated or controlled.

Where Dangerous Mechanical Hazards Occur

Dangerous moving parts in these basic areas require safeguarding:

1. *Point of operation*
2. *In running nip points*
3. *Pinch points*
4. *Power transmission*
5. *Other moving parts*

Safeguarding can be accomplished by either machine guards or machine devices.

Steps of Machine Guarding

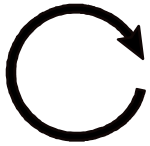
Machine safeguarding is the application of safety, engineering, work practices and administrative controls to prevent the injury of employees who operate machines or who are in the vicinity of machine operations. The primary steps of machine safeguarding include:

1. *Recognize the hazards by identifying hazardous actions and motions.*
2. *Analyze the workplace and prioritize safeguarding efforts based on the most predictable injury, the probability of occurrence and available resources.*
3. *Develop and implement a systematic safeguarding program which includes identifying safeguarding methods, selection and installation.*
4. *Ensure use of safeguarding and reinforce program by training, education and enforcement.*

Types of Mechanical Motions

A wide variety of mechanical motions and actions may present hazards to the worker. These can include the movement of rotating members, reciprocating arms, moving belts, meshing gears, cutting teeth, and any parts that impact or shear. These different types of hazardous mechanical motions and actions are basic to nearly all machines . The basic types of hazardous mechanical motions are traverse motions, rotating motions and reciprocating motions.

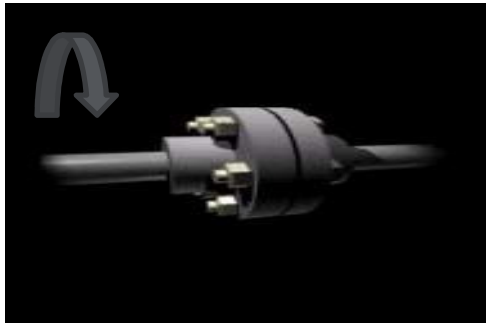
Transverse motion – one way 

Rotating motion - spinning 

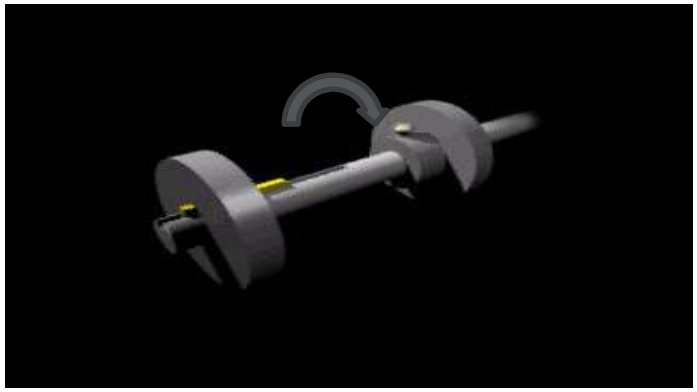
Reciprocating motion – back & forth 

What are the hazards of rotating motion?

Rotating motion can be dangerous; even smooth, slowly rotating shafts can grip hair and clothing, and through minor contact force the hand and arm into a dangerous position. Injuries due to contact with rotating parts can be severe. The danger increases when projections such as set screws, bolts, nicks, abrasions, and projecting keys or set screws are exposed on rotating parts. Rotating motion is found in such equipment as collars, couplings , cams clutches, flywheels, shaft ends, spindles and meshing gears



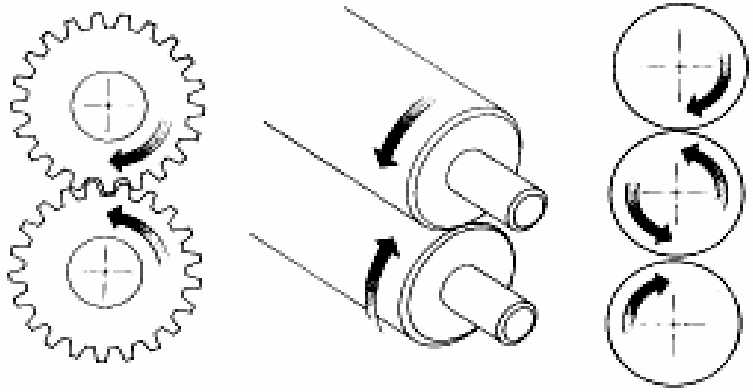
Rotating Coupling with Projecting Bolt Heads



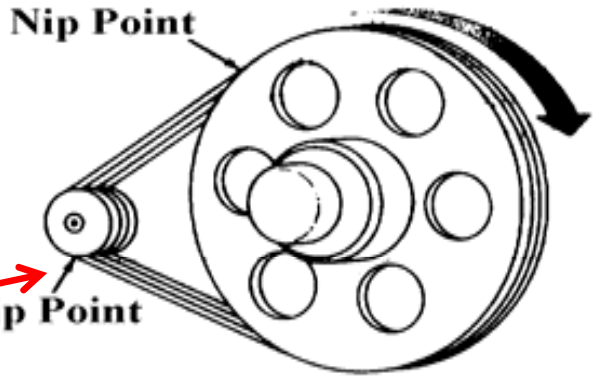
Rotating Shaft and Pulleys with Projecting Key and Set Screw

Rotating Parts

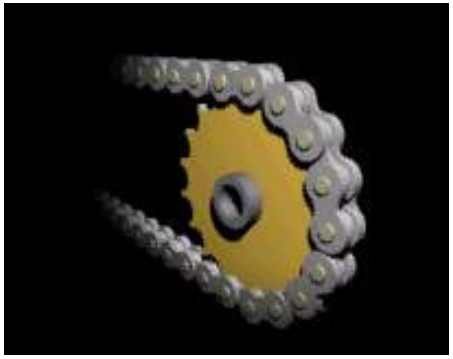
In-running nip point hazards



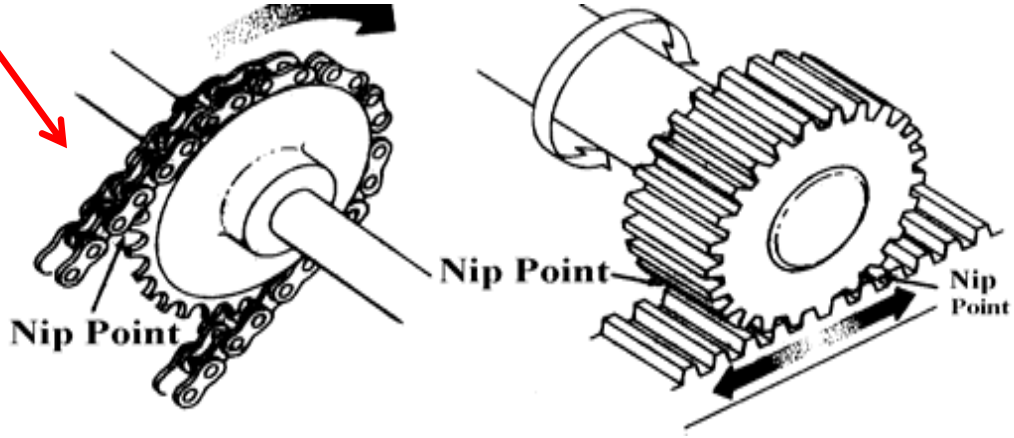
Parts rotating in opposite direction



Rotating and tangentially moving parts



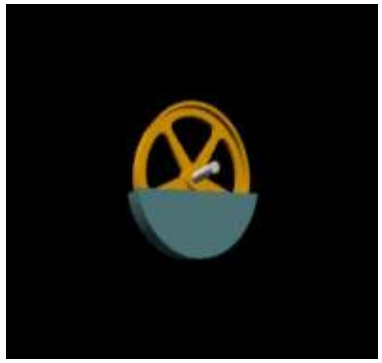
Point of contact between a chain and a sprocket



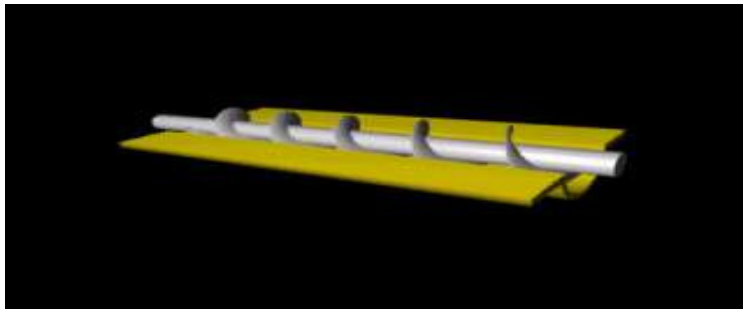
Rotating Parts

Nip Points Between Rotating and Fixed Parts

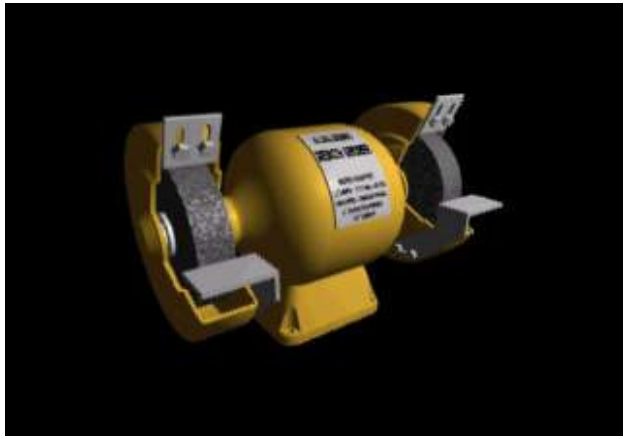
Nip points can occur between rotating and fixed parts which create a shearing, crushing, or abrading action. Examples include: spoked hand wheels or flywheels, screw conveyors, or the periphery of an abrasive wheel and an incorrectly adjusted work rest and tongue.



Spoked flywheel



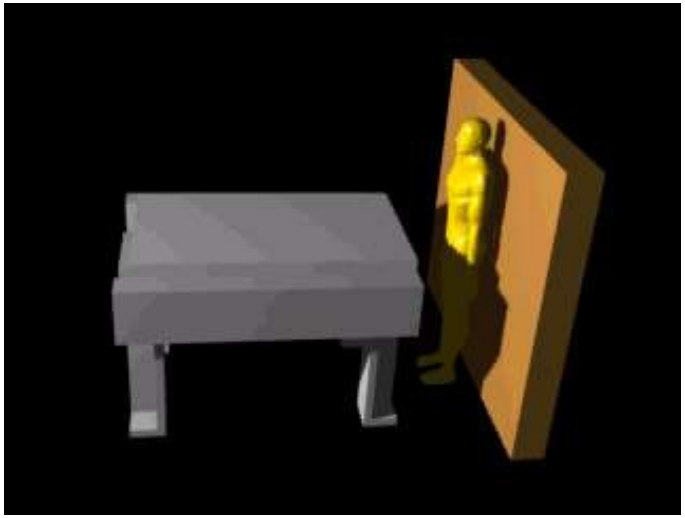
Nip point between rotating screw conveyor and fixed trough

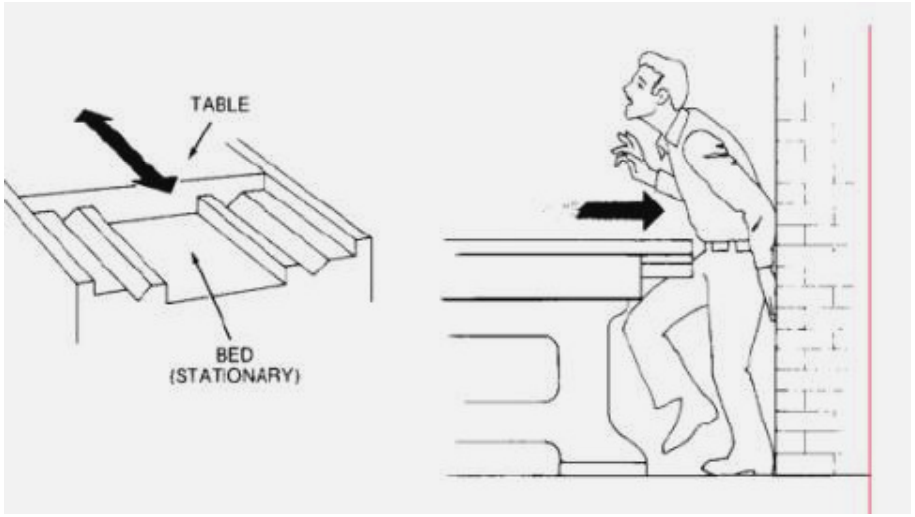


Rotating abrasive wheel on a grinder

Reciprocating motions

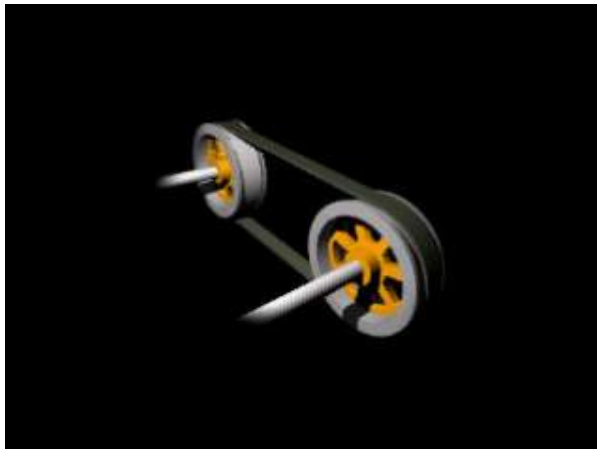
Reciprocating motions may be hazardous because, during the back-and-forth or up-and-down motion, a worker may be struck by or caught between a moving and a stationary part.

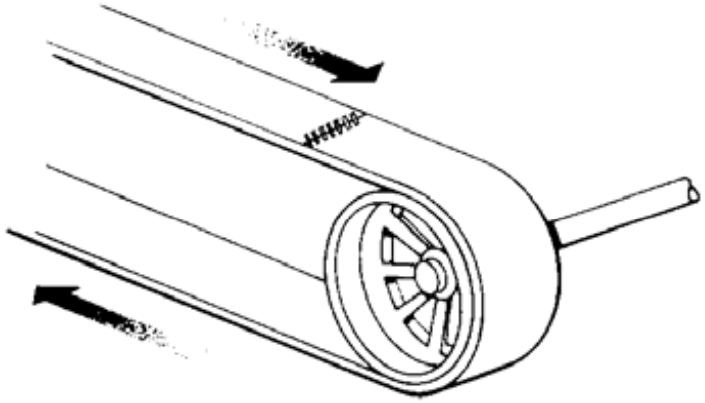




Transverse Motion

Transverse motion (movement in straight, continuous line) creates a hazard because a worker may be struck or caught in a pinch or shear point by the moving part.





Transverse Motion of Belt

Examples of 3 Types of Motion

Rotating and fixed parts

Transverse motion

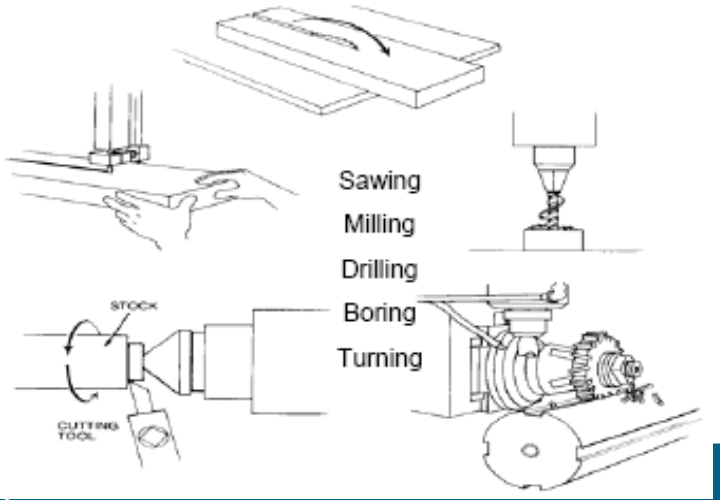
Rotating and tangential motion

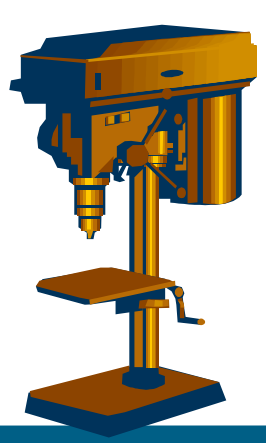
Hazardous Machine Actions

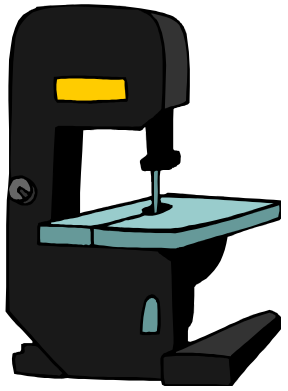
Cutting

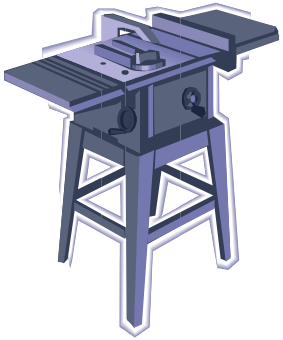
Cutting action may involve rotating, reciprocating, or transverse motion. The danger of cutting action exists at the point of operation where finger, arm and body injuries can occur and where flying chips or scrap material can strike the head, particularly in the area of the eyes or face. Such hazards are present at the point of operation in cutting wood, metal, and other materials. Examples of mechanisms involving cutting hazards include band saws, circular saws, boring and drilling machines, turning machines (lathes), or milling machines

Cutting action





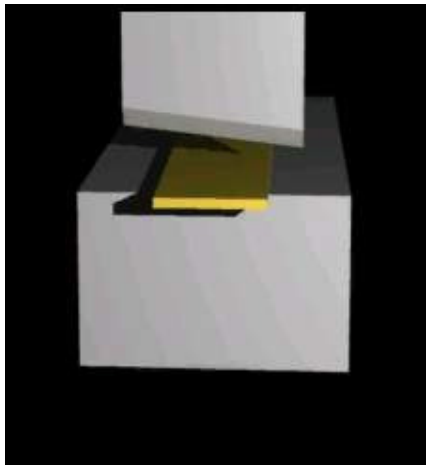


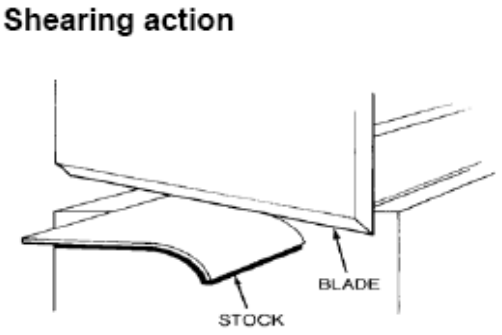


Hazardous Machine Actions

Shearing

Shearing action involves applying power to a slide or knife in order to trim or shear metal or other materials. A hazard occurs at the point of operation where stock is actually inserted, held, and withdrawn. Examples of machines used for shearing operations are mechanically, hydraulically, or pneumatically powered shears.

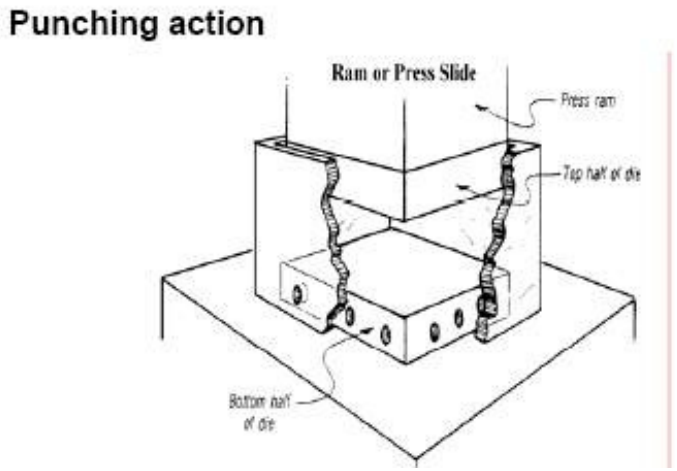


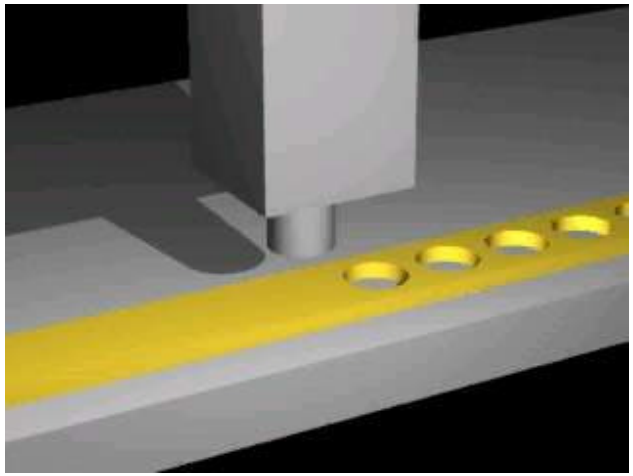


Hazardous Machine Actions

Punching

Punching action results when power is applied to a slide (ram) for the purpose of blanking, drawing, or stamping metal or other materials. The danger of this type of action occurs at the point of operation where stock is inserted, held, and withdrawn by hand. Typical machines used for punching operations are power presses.

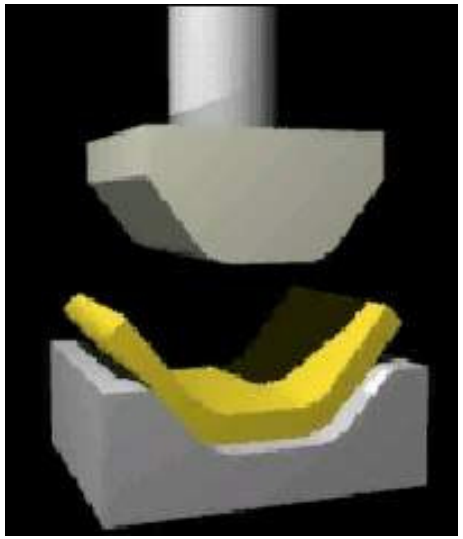


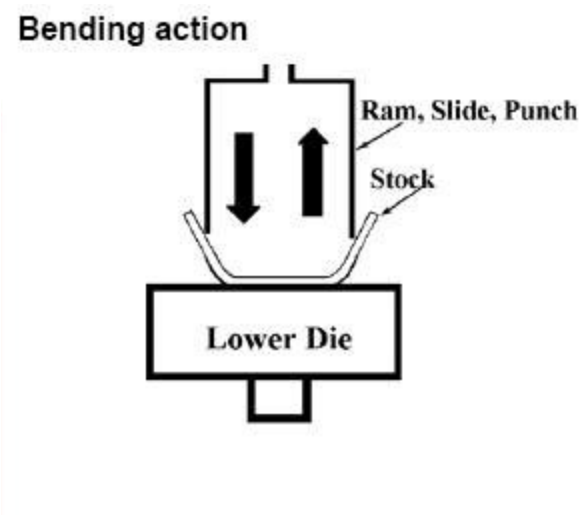


Hazardous Machine Actions

Bending

Bending action results when power is applied to a slide in order to draw or stamp metal or other materials. A hazard occurs at the point of operation where stock is inserted, held, and withdrawn. Equipment that uses bending action includes power presses, press brakes, and tubing benders.





Methods of Safeguarding

There are many ways to safeguard machinery, and that means any method of preventing employee contact with the moving part.

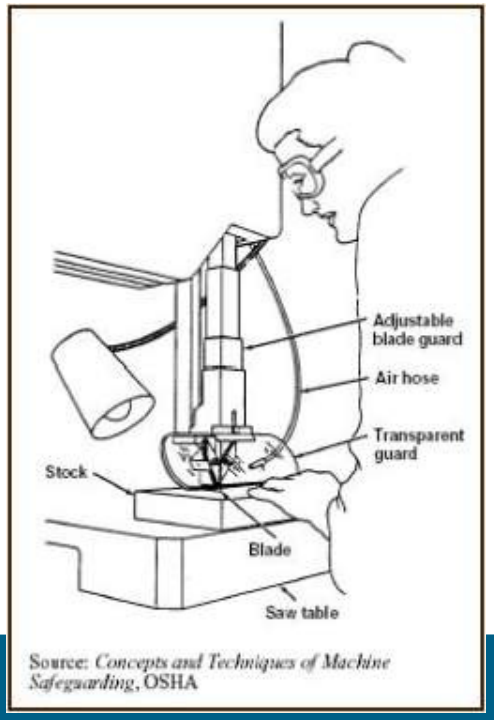
You should first determine the machine hazards and then select a suitable guarding method based on the type of operation, the size or shape of stock, the method of handling, the physical layout of the work area, and the type of material.

Production requirements or limitations will also help determine the appropriate safeguarding method for the individual machine. The guarding system must protect the operator and other exposed workers from all machine hazards.

It is helpful to get the machine operator and machine supervisor involved in the design of the safeguarding system.

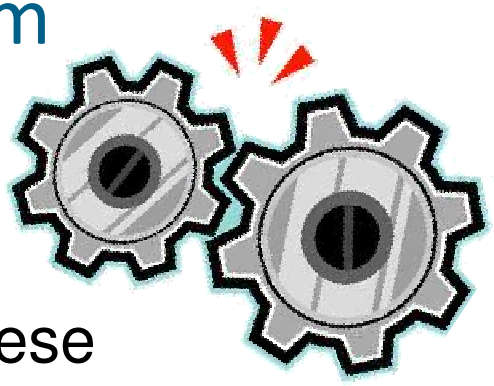
Develop & Implement Program

As a general rule, power transmission apparatus is best protected by fixed guards that enclose the danger area. For hazards at the point of operation, where moving parts actually perform work on stock, several kinds of safeguarding are possible. You must always choose the most effective and practical means available.

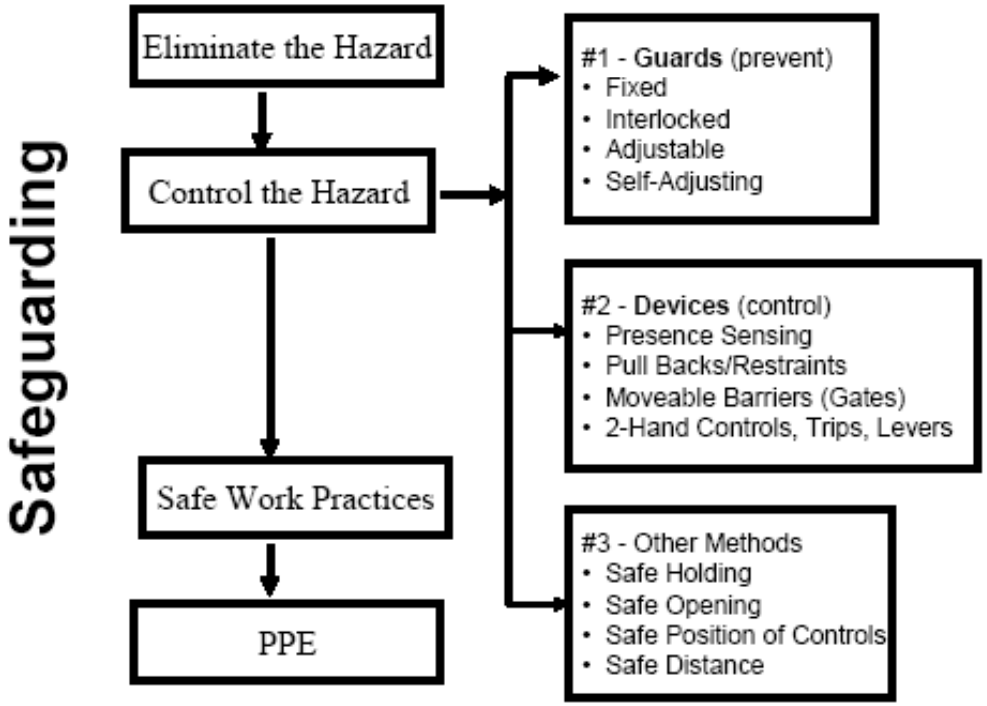


Source: *Concepts and Techniques of Machine Safeguarding*, OSHA

Develop & Implement Program



Safeguarding strategies are grouped under these general classifications:



Effective Guards

An effective guard must . . .

1. Prevent contact: The safeguard must prevent hands, arms, or any part of a worker's body or clothing from making contact with dangerous moving parts. A good safeguarding system eliminates the possibility of the operator or other workers placing any part of their bodies near hazardous moving parts.

2. Secured & well-constructed: Workers should not be able to easily remove or tamper with the safeguard, because a safeguard that can easily be made ineffective is no safeguard at all. They must be firmly secured to the machine. Guards should be made of durable material that will withstand the conditions of normal use. They may be constructed of sheet metal, screen, wire cloth, bars, plastic, or any other material that is substantial enough to withstand whatever impact it may receive and to endure prolonged use.

3. Protect from falling objects/contain the hazard: The safeguard should ensure that no objects can fall into moving parts. A small tool which is dropped into a cycling machine could easily become a projectile that could strike and injure someone.

4. Create no new hazards: A safeguard defeats its own purpose if it creates a hazard of its own such as a shear point, a jagged edge, or an unfinished surface which can cause a laceration or creates a pinch point between the guard and moving machine parts. The edges of guards, for instance, should be rolled or bolted in such a way that they eliminate sharp edges.

5. Create no interference: Any safeguard which impedes a worker from performing the job quickly and comfortably might soon be overridden or disregarded. Proper safeguarding can actually enhance efficiency since it can relieve the worker's apprehensions about injury.

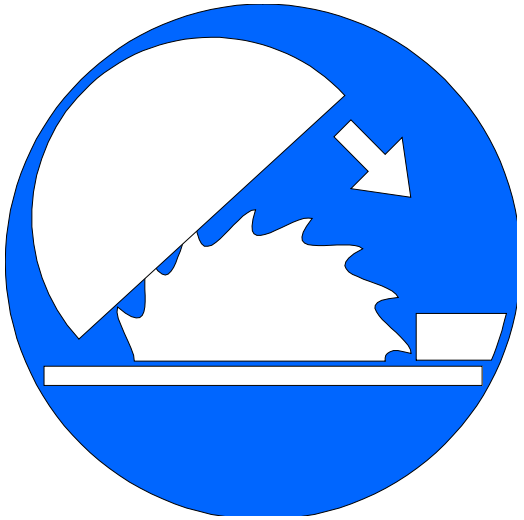
6. Allow safe lubrication: If possible, one should be able to lubricate the machine without removing the safeguards. Locating oil reservoirs outside the guard, with a line leading to the lubrication point, will reduce the need for the operator or maintenance worker to enter the hazardous area.

Machine Guards/Guarding

A “guard” prevents entry into the danger area.

There are four types of machine guards:

1. *Fixed*
2. *Interlocked*
3. *Adjustable*
4. *Self-adjusting*



Fixed Guards

Fixed guards are usually a permanent part of the machine that prevent access to the danger area.

Fixed Guards

- Permanent part of the machine
- Not dependent upon moving parts to perform its intended function
- Constructed of sheet metal, screen, wire cloth, bars, plastic or other substantial material.
- Usually preferable to all other types because of its relative simplicity and permanence.

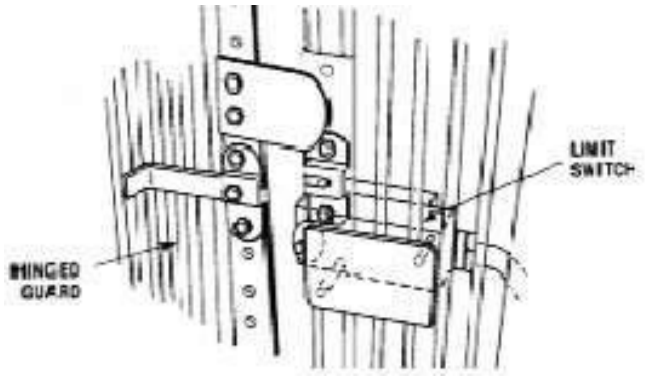
Transmission Guards

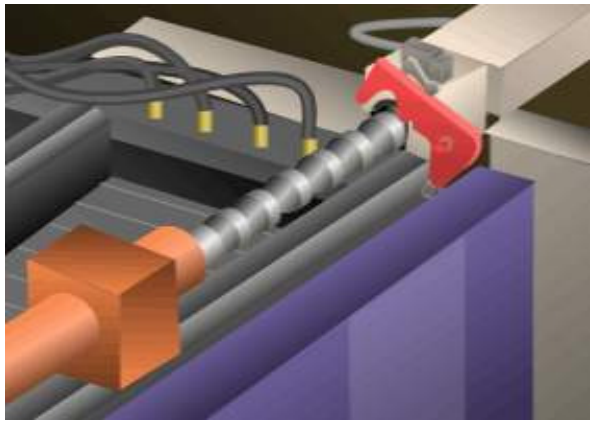
Transmission Guarding

- Desirable Arrangement?

Interlocked Guards

When this type of guard is opened or removed, the tripping mechanism and/or power automatically shuts off or disengages, and the machine cannot cycle or be started until the guard is back in place.

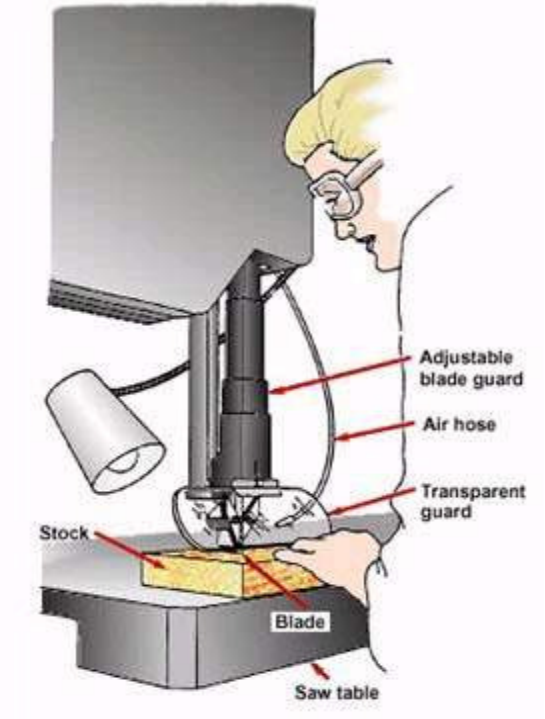




- Guards the dangerous part before the machine can be operated.
- Keeps the guard closed until the dangerous part is at rest.
- Prevent operation of the machine if the interlocking device fails
- May use electrical, mechanical, hydraulic, or pneumatic power or any combination of these.
- Should not prevent “inching” by remote control, if required.
- Replacing the guard should not automatically restart the machine.
- All moveable guards must be interlocked to prevent hazards.

Adjustable Guards

Self-Adjusting Guard: The openings of these barriers are determined by the movement of the stock. As the operator moves the stock into the danger area, the guard is pushed away, providing an opening which is only large enough to admit the stock. After the stock is removed,
the guard returns to the rest position. This guard protects the operator by placing a barrier between the danger area and the operator. The guards may be constructed of plastic, metal, or other substantial material. Self-adjusting guards offer different degrees of protection. An example of this type of guard include: a radial arm saw with a self-adjusting guard. As the blade is pulled across the stock, the guard moves up, staying in contact with the stock.

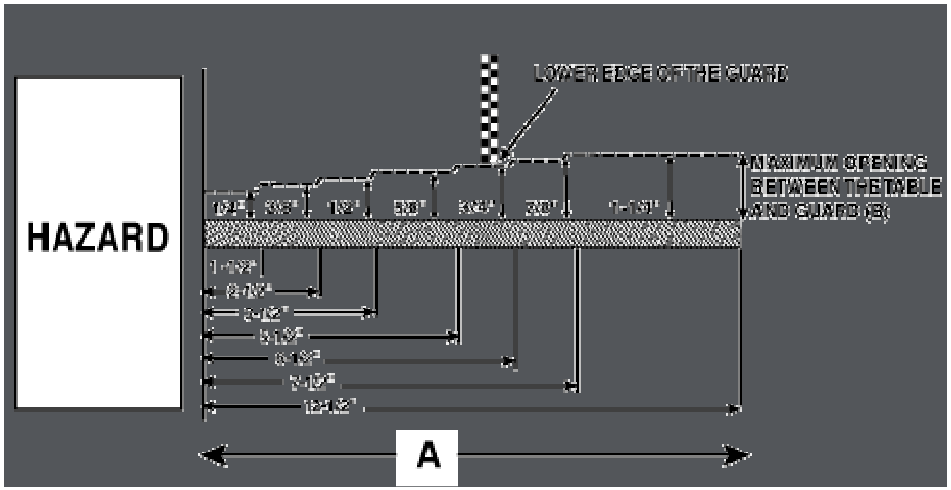


Adjustable guards **a**llow flexibility in accommodating various sizes of stock.

Placing guards at a safe distance

There is not usually a problem when designing guards for power transmission apparatus, as these guards do not require openings for material feeding. However, point of operation guarding requires openings. These material openings must conform to the maximum permissible openings of Table 200-1 in the Machine Safeguarding Standard

Table 200-1		
	Distance of opening from point of operation Hazard (inches) POO	Maximum width of opening (inches)
	* 1/2 to 1-1/2	1/4
Over	1-1/2 to 2-1/2	3/8
Over	2-1/2 to 3-1/2	1/2
Over	3-1/2 to 5-1/2	5/8
Over	5-1/2 to 6-1/2	3/4
Over	6-1/2 to 7-1/2	7/8
Over	7-1/2 to 12-1/2	1-1/4
Over	12-1/2 to 15-1/2	1-1/2
Over	15-1/2 to 17-1/2	1-7/8
Over	17-1/2 to 31-1/2	2-1/8
Over	Over 31-1/2	6



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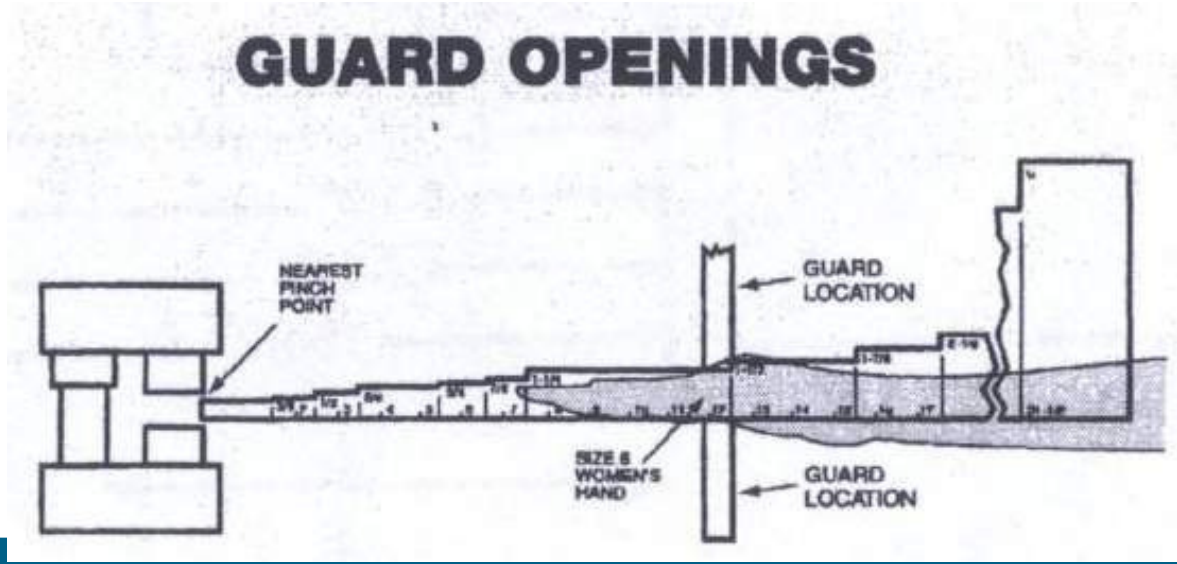
Placing guards at a safe distance

This diagram shows the accepted safe openings between the bottom edge of a guard at various distances from the danger line or point of operation hazard. The clearance line marks the distance required to prevent contact between guard and moving parts. The minimum guarding line is the distance between the in-feed side of the guard and the nearest point of operation, which is one-half inch from the nearest point of operation hazard line. Openings in the guard or between the guard and working surface must not be greater than shown.



Second Choice – Devices (control access)

Devices control access to the point of operation and may replace or supplement guards. To qualify as a device, it may perform one of several functions.

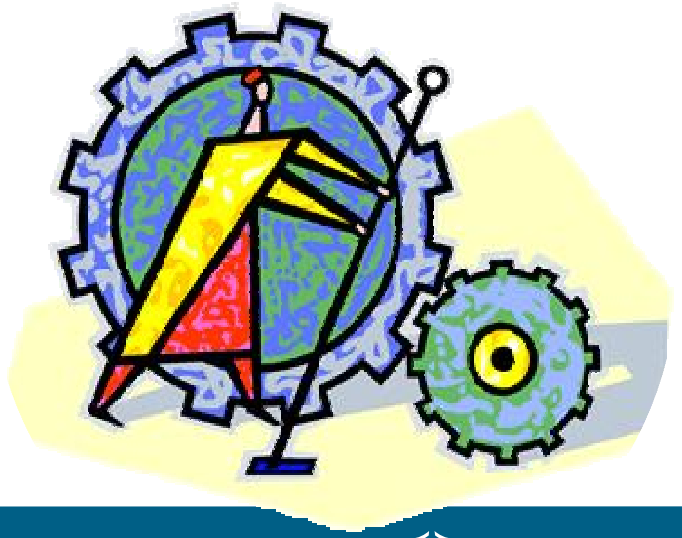
- Stop the machine if a hand or any part of the body is inadvertently placed in the danger area
- Restrain or withdraw the operator's hands from the danger area during operation.
- Require the operator to use both hands on machine controls, thus keeping both hands and body out of danger.
- Provide a barrier which is synchronized with the operating cycle of the machine in order to prevent entry to the danger area during the hazardous part of the cycle.
- Allow safe lubrication and maintenance and not create hazards or interfere with normal machine operation.
- Be secure, tamper-resistant and durable.

Machine Guarding Devices

A “device” controls entry into the danger area.

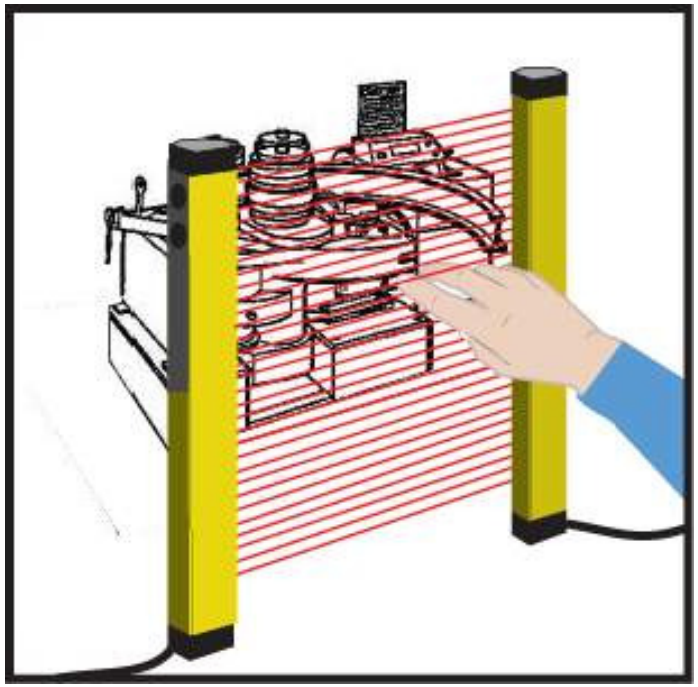
Six types of Machine Devices:

1. *Presence sensing device*
2. *Two hand control*
3. *Pullbacks/restraints*
4. *Moveable barriers (gates)*
5. *Safety trip controls*



Presence Sensing Devices

These devices either stop the machine, or will not start the cycle, if a hand or any part of the body is inadvertently placed in the danger area. There are 4 types of presence sensing devices.



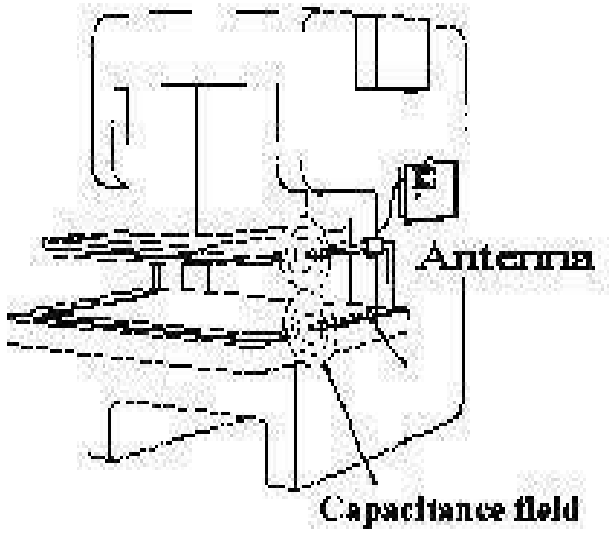
The light curtain (photoelectric-optical) presence sensing device uses a system of light sources and controls that can interrupt the machine's operating cycle. If the light field is broken, the machine stops and will not cycle. This device must be used only on machines which can be stopped before the worker can reach the danger area. The light curtain must be positioned at a minimum safe distance from the machine's point of operation. If the light curtain is too close to the point of operation, the workers hand could reach a danger zone before the machine has time to stop.

Presence sensing devices

Radiofrequency presence-sensing device

Uses a radio beam that is part of the machine control circuit. When the capacitance field is broken, the machine will stop or will not activate. Like the light curtain, this device shall only be used on machines which can be stopped before the worker can reach the danger area and must be adjusted to the minimum safe distance.

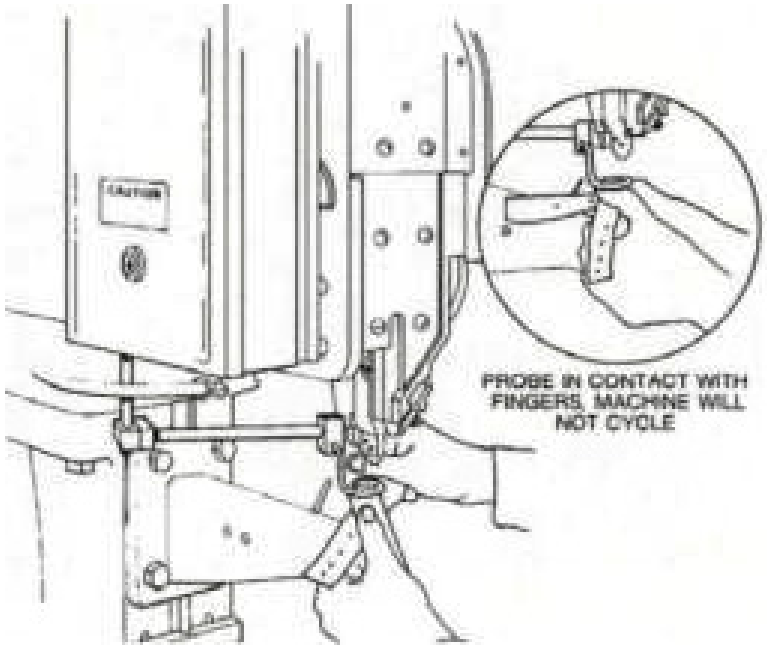
This requires the machine to have a friction clutch or other reliable means for stopping. Because the radiofrequency device is very sensitive, the antenna design requires a great deal of experience and for other technical reasons it is no longer being used in the machine guarding area.



Presence sensing devices

Electro-mechanical sensing device

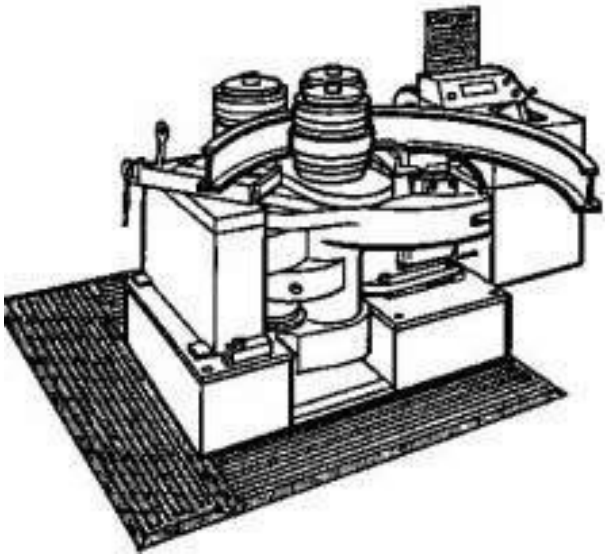
Has a probe or contact bar which descends to a predetermined distance when the operator initiates the machine cycle. If there is an obstruction preventing it from descending its full predetermined distance, the control circuit does not actuate the machine cycle.

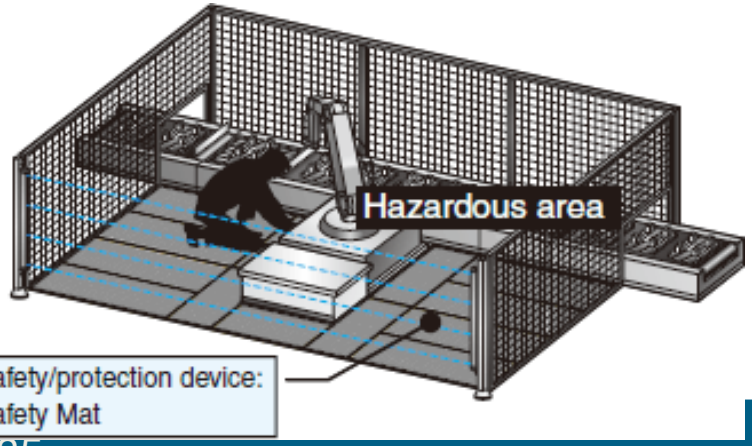


An electro-mechanical sensing device is shown on a riveter. The sensing probe in contact with the operator's finger is also shown. The machine will not operate until the probe comes in contact with the material. The finger prevents this by not allowing the probe to come all the way down and contact the material. The electro-mechanical sensing device is sometimes called a “Touch O-Matic”.

Presence sensing devices

Safety Mat





The safety mat is a pressure sensitive safeguarding product that is designed to detect the presence of people on its sensing surface. Picture shows guarding application using pressure sensitive floor mats. It can be used to detect the presence of someone or something within the protected area and can be used to safeguard a floor area around a machine or robot.

A matrix of interconnected mats (safety mat system) can be laid around the hazardous area and any pressure (e.g. an operator's footstep) will cause the controller unit to send a stop signal to the machine. They can also be used as a point of entry alert method. Other safeguarding devices such as pressure sensitive safety edges and bumpers also fall into this family of devices.

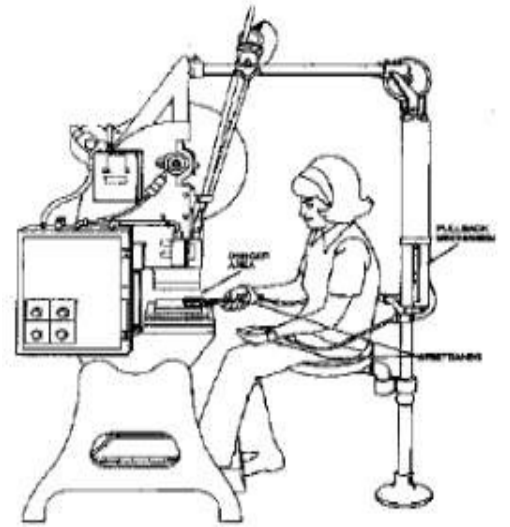
Source: Omron Industrial Automation

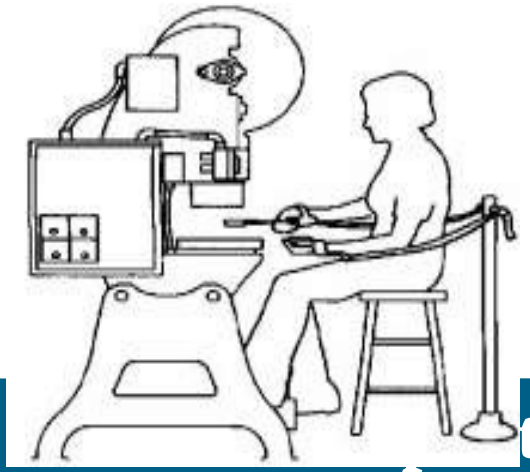
Guarding Devices – Pullback/Restraints

Uses a series of cables attached to the operator's hands, wrists, and/or arms and to a moving or fixed point.

The ***pullback*** is primarily used on machines with stroking action. When the slide/ram is up, the operator is allowed access to the point of operation. When the slide/ram begins to descend, a mechanical linkage automatically assures withdrawal of the hands from the point of operation.

The ***restraint*** (holdout) device uses cables or straps that are attached to the operator's hands and a fixed point. The cables or straps must be adjusted to let the operator's hands travel within a predetermined safe area. There is no extending or retracting action involved. Consequently, hand-feeding tools are often necessary if the operation involves placing material into the danger area.





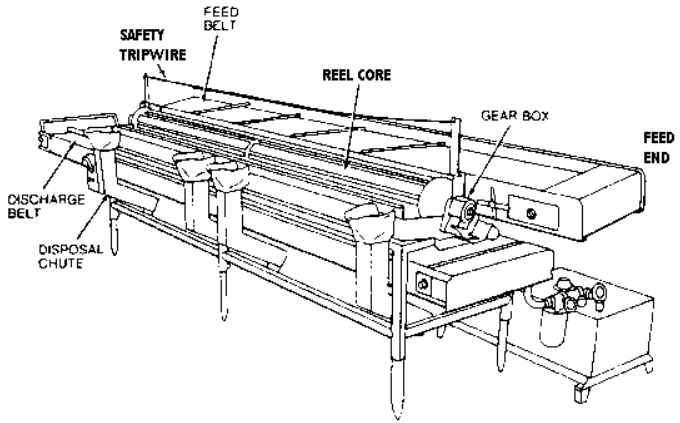
Guarding Devices – Safety Trip Controls

These devices provide a quick means for deactivating the machine in an emergency situation.

- A ***pressure-sensitive body bar****,* when depressed, will deactivate the machine. If the operator or anyone trips, loses balance, or is drawn toward the machine, applying pressure to the bar will stop the operation. The positioning of the bar, therefore, is critical. It must stop the machine before a part of the employee's body reaches the danger area.

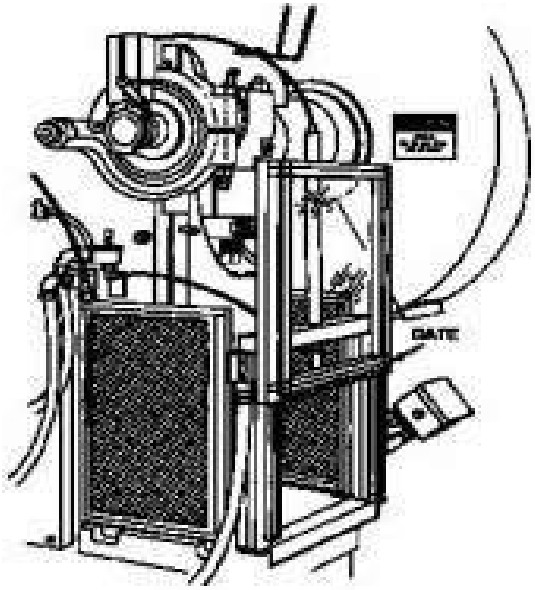
- When pressed by hand, the ***safety trip-rod*** deactivates the machine. Because it has to be actuated by the operator during an emergency situation, its proper position is also critical.

- ***Safety tripwire cables*** are located around the perimeter of or near the danger area. The operator must be able to reach the cable with either hand to stop the machine. All of these tripwires, rods or other safety devices must be manually reset to restart the machine.



Guarding Devices – gates & moveable barriers

A gate is a moveable barrier which protects the operator at the point of operation before the machine cycle can be started.



Gates are, in many instances, designed to be operated with each machine cycle. If the gate is not permitted to descend to the fully closed position, the press will not function. Another potential application of this type of guard is where the gate is a component of a perimeter safeguarding system. Here the gate may provide protection not only to the operator but to pedestrian traffic as well. There are two types of gate functions:

A type *"A" gate* remains closed during the entire cycle of the machine. Use for full or part revolution clutches.

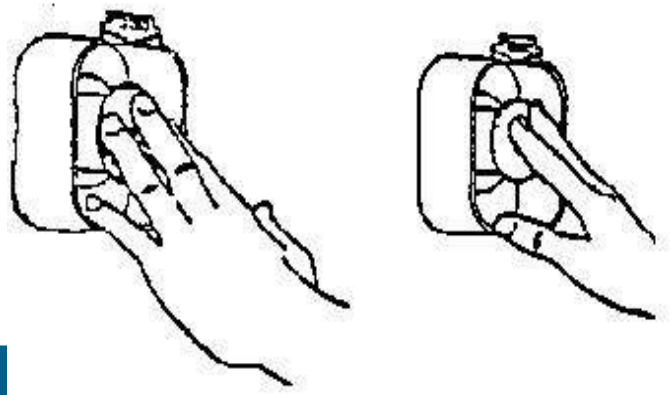
A type *"B" gate* opens after the die closing portion of the machine cycle has been completed. Use for part revolution clutch only.

Guarding Devices – Two hand controls/trips

These devices prevent the operator from reaching into the point of operation when the machine cycles by requiring the hands to be on palm buttons or levers.

The ***two-hand control*** requires constant, concurrent pressure by the operator to activate the machine. This kind of control requires a part-revolution clutch, brake, and brake monitor if used on a power press as shown. With this type of device, the operator's hands are required to be at a safe location (on control buttons) and at a minimum safe distance from the danger area while the machine completes its closing cycle.

The ***two-hand trip*** requires concurrent application of both of the operator's control buttons to activate the machine cycle, after which the hands are free. This device is usually used with machines equipped with full-revolution clutches. The trips must be placed far enough from the point of operation to make it impossible for the operator to move his or her hands from the trip buttons or handles into the point of operation before the first half of the cycle is completed. Thus the operator's hands are kept far enough away to prevent them from being accidentally placed in the danger area prior to the slide/ram or blade reaching the full "down“ position.



Other Methods

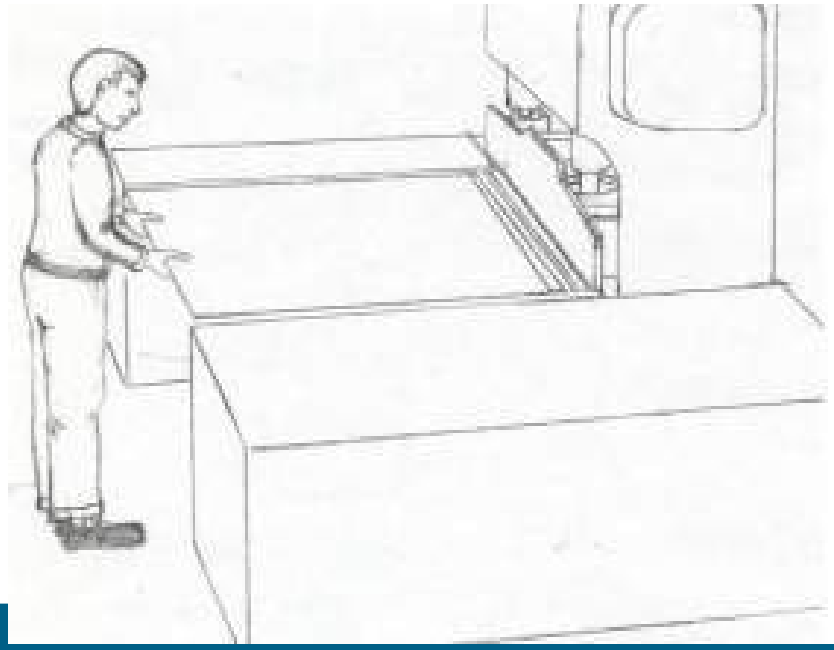
When guards or devices cannot be used, “Other Methods” can be selected. These other methods (safe distance, safe holding, safe opening, safe position of controls) are methods of safeguarding that can be applied to machines with unique safeguarding problems.

Other methods do not provide the protection of guards or devices. These methods require placement or adjustment for each operation. They depend upon specific procedures, work rules, extensive training and supervision to prevent the tendency to circumvent the method used.

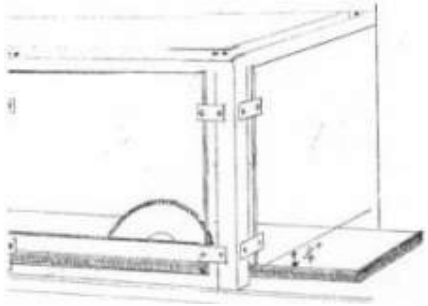
Other Methods

Safe Holding

This method is one that is designed and constructed so when the operator is required to hold or support the work piece, the operator is prevented from inadvertently reaching into the hazard area.



Other Methods



Safe Opening

This method is one that provides small opening to the hazardous area. It meets one of the following conditions:

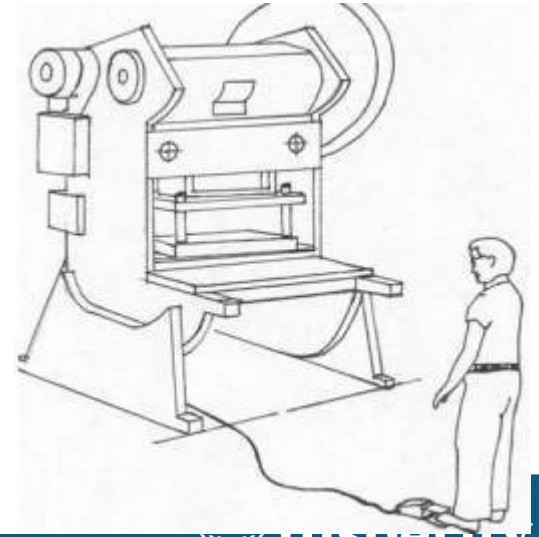
1. The opening, when no work piece is in place is small enough to prevent any part of operator's body from entering the area (1/4 inch or less opening); or
2. When part is in place, opening is only 1/4 inch to prevent any part of the operator's body from entering the hazardous area. The machine cannot cycle unless the work piece is in place. Openings for two-dimensional work pieces meet the following conditions:
   - Maximum area of any guard opening should be 7 square inches (example: opening 2-1/2 inches by 2-1/2 inches has an area of 6-1/4 inches);
   - Longest dimension of a rectangular opening should be 3.5 inches;
   - The maximum shorter dimension of the rectangular opening should be 2 inches;
   - The minimum distance from the guard to any point of operation is 4 inches.

Other Methods

Safe Position of Controls

Operating controls are properly positioned by one of these methods:

1. Controls that require continuous actuation to complete the hazardous portion of the cycle positioned so that no part of the operator's body can reach the hazardous area during the hazardous portion of the cycle or until cessation of hazardous motion; or
2. Controls for single-cycle machines located far enough from the hazardous area that no part of the operator's body can enter before the machine completes the hazardous portion of its cycle or until cessation of motion. Remote controls cannot be easily moved or are securely fixed in position.

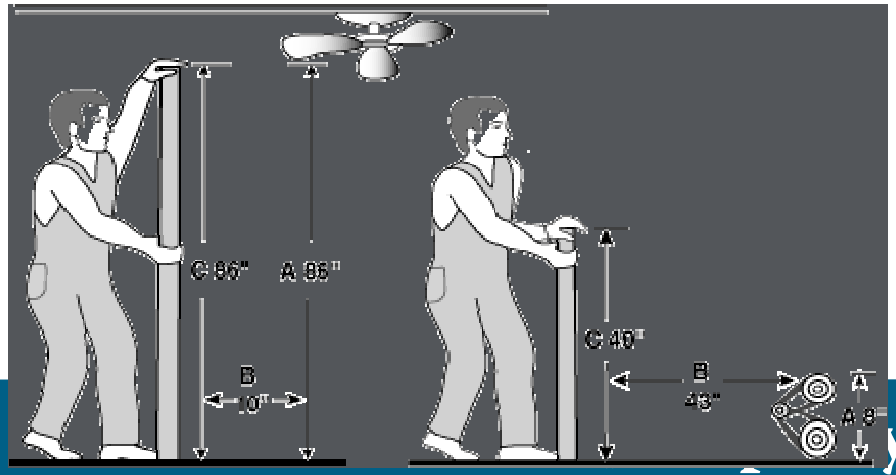


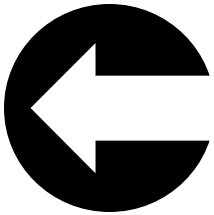
Other Methods

Safe Distance

Eliminates the need for operator's hands or other parts of the body to be in or near the hazardous area during the hazardous portion of the cycle by one of the following:

1. Work practice;
2. Size and location of work piece; or
3. Operator location where the operator is not required to place any part of body within the established safe distance during hazardous portion of cycle, nor is the operator required to enter the safe distance for the purpose of loading, unloading, adjusting, measuring, cleaning.





Managing the Safeguarding Program

There is more to machine safeguarding than just guarding machines. The employer must:

- Ensure that employees are trained to do the job
- Ensure that employees wear personal protective equipment to protect against other hazards
- Establish safe operating procedures
- Supervise to ensure compliance with company rules

Managing the Safeguarding Program

Even the most elaborate safeguarding system cannot offer effective protection unless the worker knows how to use it and why. Specific and detailed training is therefore a crucial part of any effort to provide safeguarding against machine-related hazards. Thorough operator training should involve instruction or hands-on training in the following key areas:

1. Parts and functions of the machine
2. Basic operator controls
3. Operator Responsibilities
4. Safeguarding
    - A description and identification of the hazards associated with particular
    - How to use the safeguards and why
    - How and under what circumstances safeguards can be removed, and by whom (in most cases, repairs or maintenance personnel only).
    - What to do (e.g., contact the supervisor) if a safeguard is damaged, missing, or unable to provide adequate protection.

This training is necessary for new operators and maintenance or setup personnel, when any new or altered safeguards are put in service, or when workers are assigned to a new machine or operation.

Checklist

Printable Checklist in MS Word format

	Yes	No
Do the safeguards provided meet the minimum rule requirements?		
Do the safeguards prevent workers hands, arms and other body parts from making contact with dangerous moving parts?		
Are the safeguards firmly secured and not easily removable?		
Do the safeguards ensure that no objects will fall into the moving parts?		
Do the safeguards permit safe, comfortable and relatively easy operation of the machine?		
Can the machine be oiled without removing the safeguard?		
Is there a system for shutting down the machinery before safeguards are removed?		
Can the existing safeguards be improved?		
Mechanical Hazards	**Yes**	**No**
Is there a point of operation safeguard provided for the machine?		
Does it keep the operator's hands, fingers, body out of the danger area?		
Is there evidence that the safeguards have been tampered with or removed?		
If there is more than one operator, are separate controls provided?		
Could you suggest a more practical, effective safeguard?		
Could changes be made on the machine to eliminate the point of operation hazard entirely?		
Are there any unguarded gears, sprockets, pulleys or flywheels on the apparatus?		
Are there any exposed belts or chain drives?		
Are there any exposed set screws, keyways, collars, etc.?		
Are starting and stopping controls within easy reach of the operator?		
Are safeguards provided for all hazardous moving parts of the machine including auxiliary parts?		

Further Information

L & I – DOSH – Machine Safeguarding ideas bank

Oregon OSHA – Machine Safeguarding at the Point of Operation

OSHA – Machine Guarding eTool

OSHA – Concepts & Techniques of Machine Guarding

OSHA – Safeguarding Equipment for Small Business

OSHA – Guide for Protecting Workers from Woodworking Hazards

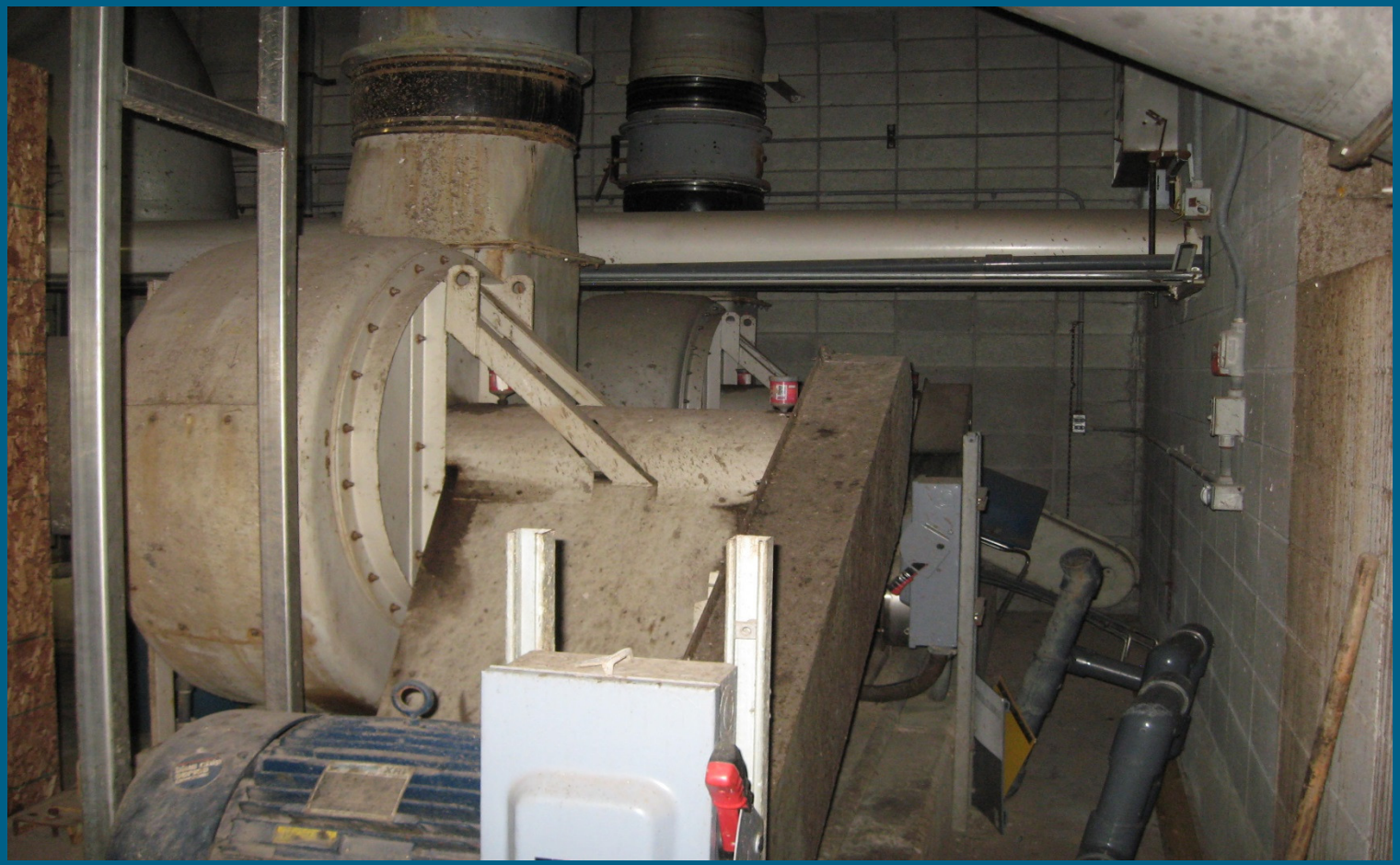
WorkSafe BC – Safeguarding in Metal Products Manufacturing

WorkSafe BC – Safeguarding in Food Products Manufacturing

WorkSafe BC – Guarding for Woodworking

Lockout / Tagout

Controlling Hazardous Energy



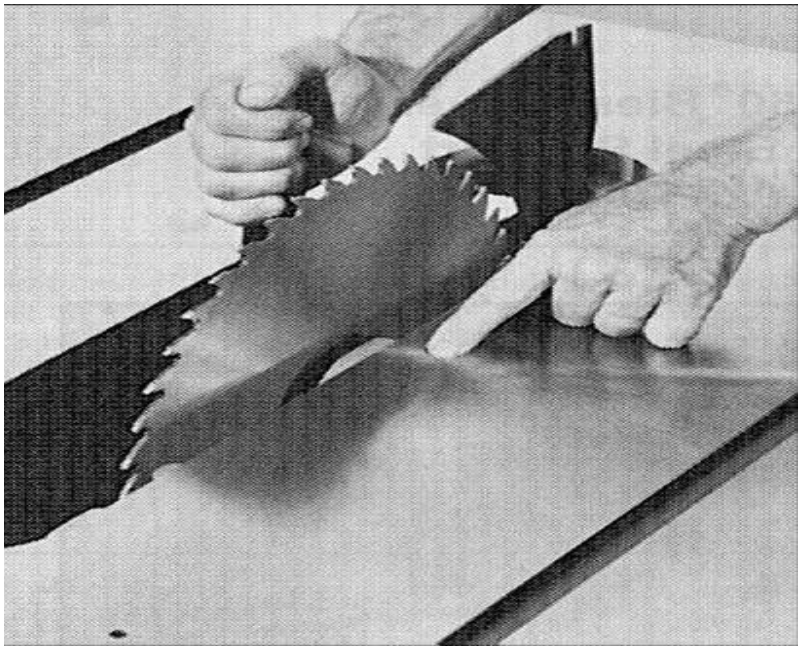
LOTO vs. Machine Guarding

Machine guarding protects the operator from the hazards of the machine while under NORMAL operating conditions.

Lockout / Tagout refers to the practice of safeguarding employees from the unexpected energization or startup of machinery and equipment, or the release of hazardous energy during service or maintenance activities. Lockout devices hold energy-isolation devices in a safe or “off” position.

When is Lockout / Tagout required?

When someone will be servicing or repairing machinery or equipment and the unexpected machinery start-up or release of stored energy could cause injury



Service and Maintenance Examples

- Installing, constructing,
- Adjusting, modifying,
- Unjamming, cleaning,
- Lubrication, inspecting,
- Setup - preparing for normal function, including die changes

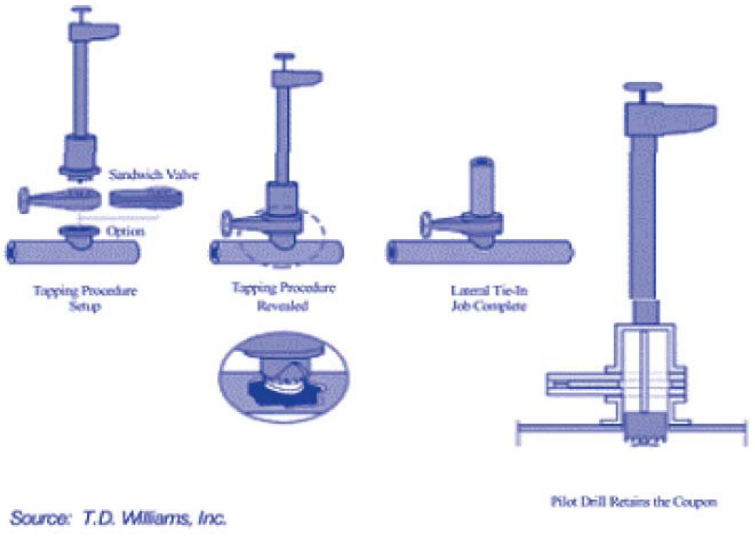
These activities often require workers to position themselves in the machine's danger zone.

OSHA's Requirements

- Establish Energy-Control (EC) Procedures
  - Application of lockout/tagout devices
  - Address stored/re-accumulated energy
- Train Employees
  - Safe application of EC devices
  - Use of EC devices
  - Removal of EC devices
- Evaluate Procedures at Least Annually
  - Execution
  - Reliability
  - Effectiveness

Lockout / Tagout Procedures Are Not Required When…

- Cord / Plug Electrical Equipment
- Hot Tap Operations



Energy Control Procedures

- Written Procedures Required
- Exceptions?
- Similar Machines
- Separate Procedures for Each Machine
  - If multiple energy sources
  - Different power connections
  - Different control sequences
- Procedures
  - Statement of intended use
  - Procedural steps
  - Verification requirements
- Example Provided in My Notes

ENERGY-CONTROL PROCEDURES MUST:

Outline the scope, purpose, authorization, rules and techniques that employees will use to control hazardous energy sources, as well as the means that will be used to enforce compliance. These procedures must provide employees at least the following information:

- A statement on how to use the procedures
- Specific procedural steps to shut down, isolate, block, and secure machines
- Specific steps designating the safe placement, removal and transfer of LOTO devices and identifying who has responsibility for the LOTO devices
- Specific requirements for testing machines to determine & verify the effectiveness of LOTO devices and other energy-control measures

Lockout Procedures

Six Steps to Follow:

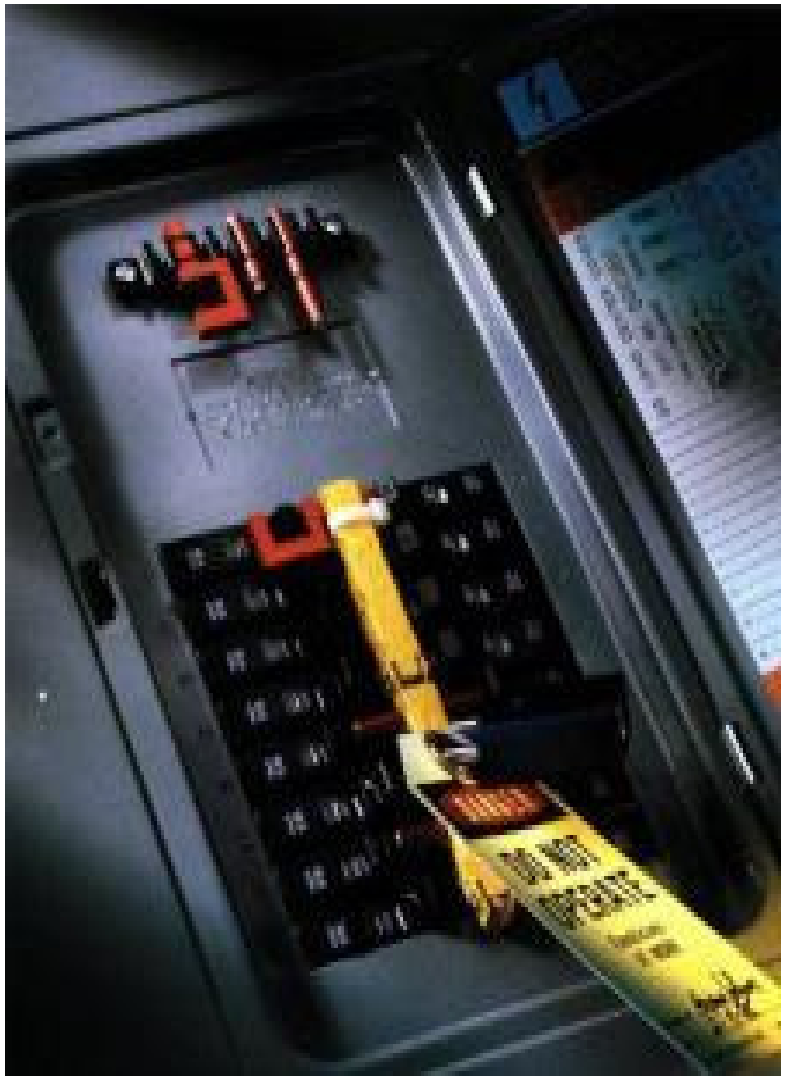
1. Notify affected employees that machine or equipment will be shut down and locked out
2. Shut down the machinery or equipment
3. Isolate energy sources with energy-isolating devices
4. Lock out energy-isolating devices with assigned locks.
5. Release or restrain stored or residual energy
6. Test equipment to ensure that all forms of energy are controlled

Last Step: Verification

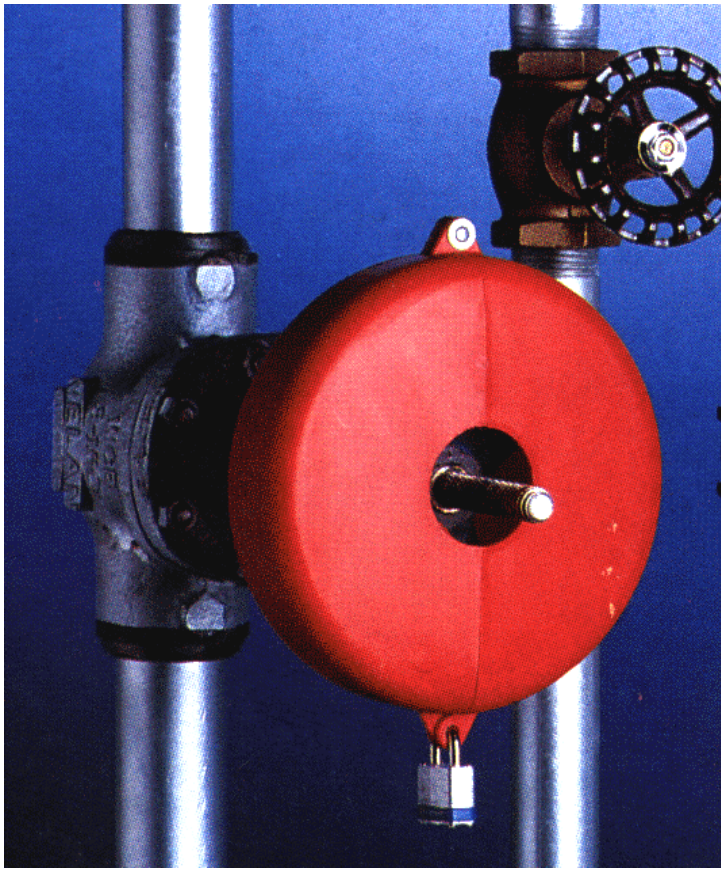
Attempt to Operate

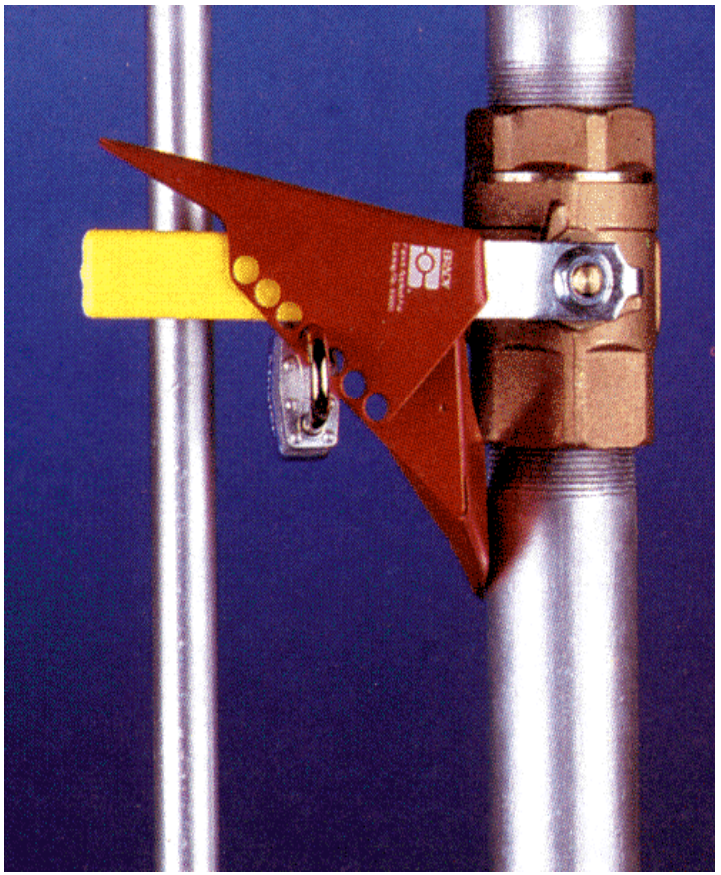
- "…adjust the temperature cycle thermostat to check that all electrical energies have been shut off."
- "Push the start function button to verify that electric power has been removed."
- "Crack the steam inlet and discharge line outlet valves…"

Electrical Lockout Devices

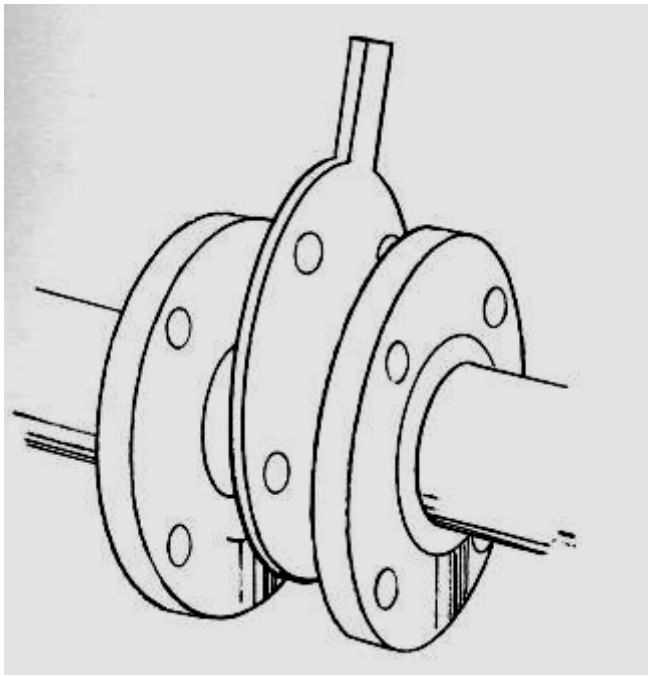


Fluid & Gas Lockout Devices





Pipe Lockout Examples



What is Tag-out?

Tags are warning devices only

- They provide no physical restraint and less protection than lockout devices.
- Tags may evoke a false sense of security.
- They can only be removed by an authorized person.
- They must be legible, securely attached and resistant to degradation.

Confined Space Hazards

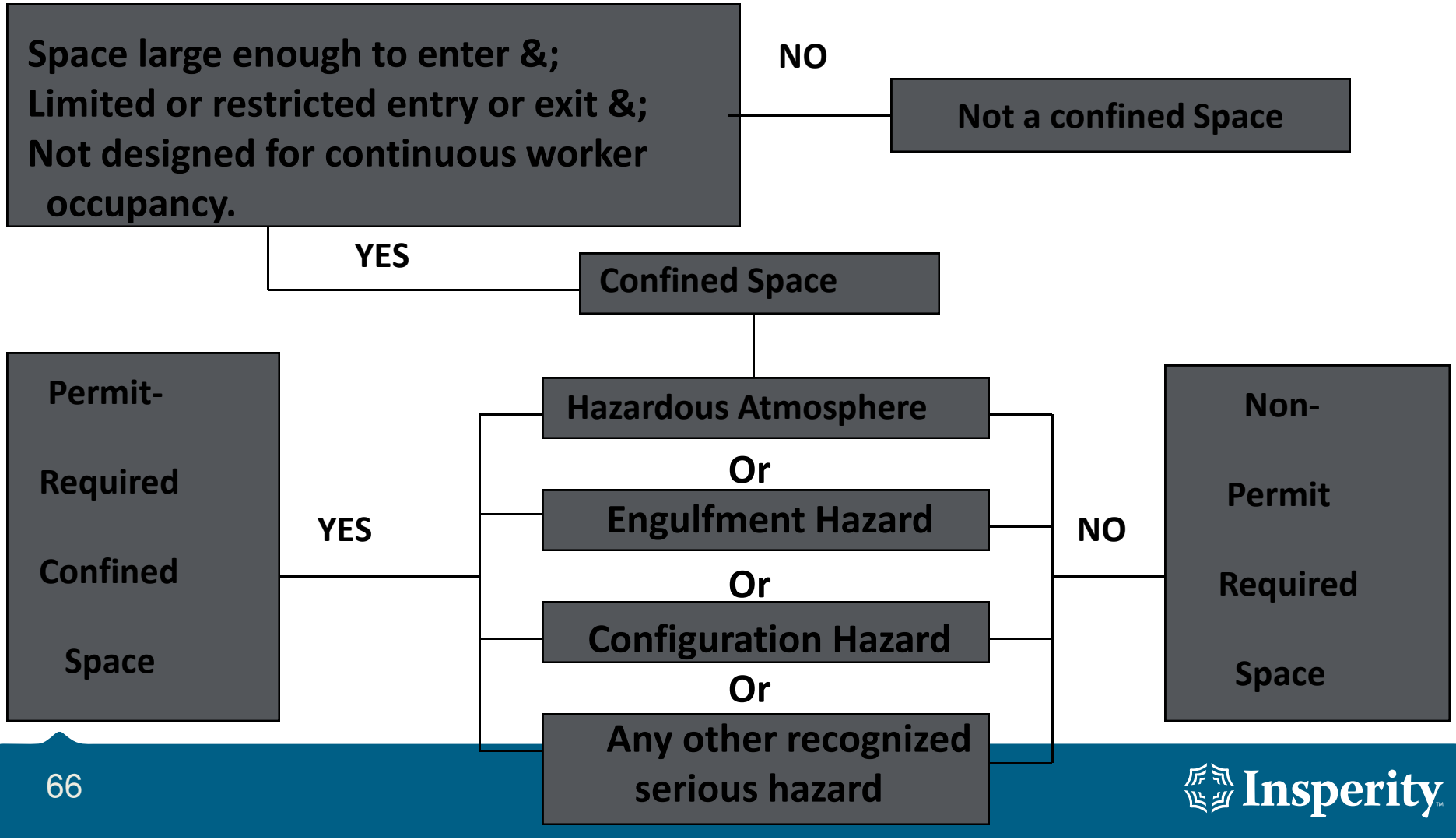
Typical Confined Spaces

- Boiler, Degreaser, Furnace
- Pipeline, Pit, Pumping Station
- Reaction or Process Vessel, Mills
- Septic Tank, Sewage Digester
- Silo, Storage Tank, Barges
- Sewer, Utility Vault, Manhole
- Trenches, Shafts, Caissons

How to Identify Confined Spaces

- Limited Openings for Entry/Exit
- Unfavorable Natural Ventilation
- Not Designed for Continuous Worker Occupancy

Categorizing Work Space



CONFINED SPACE SIGNAGE

Limited Openings for Entry/Exit

- Openings as small as 18 inches in diameter
- Difficult to enter with SCBA or other life-saving equipment
- Difficult to remove downed worker in folded up or bent over position
- Exit from large openings may be difficult due to presence of ladders, hoists, etc.

Unfavorable Natural Ventilation

- Lack of air movement in and out of the space can create an atmosphere much different than the outside atmosphere
- Deadly gases can be trapped inside
- Organic materials can decompose
- May not be enough oxygen due to presence of other gases or chemical reactions such as rusting.

Not Designed for Continuous Worker Occupancy

- Most confined spaces are not designed to enter and work in regularly
- Designed to store a product
- Enclose materials or processes
- Transport products or substances
- Occasional worker entry for inspection, repair, cleanup, maintenance, etc.

Dangerous Combinations

- Presence of all three confined space characteristics can complicate the situation
- Working in and around the space
- Rescue operations during emergencies
- Worsened conditions due to work activities:
  - Welding and cutting, use of bonding agents
  - Cleaning with solvents, use of other chemicals
  - Use of gas-powered equipment

Hazards of Confined Spaces

- Oxygen Deficient / Enriched Atmospheres
- Flammable Atmospheres
- Toxic Atmospheres
- Temperature Extremes
- Engulfment Hazards
- Noise, Slick/Wet Surfaces, Falling Objects
- Mechanical Hazards

Hazardous Atmosphere Definitions

"Hazardous atmosphere" means an atmosphere that could expose employees to the risk of death, incapacitation, impairment of ability to self-rescue (escape unaided from a permit space), injury or acute illness from one or more of the following causes:

Hazardous Atmosphere Definitions

“Hazardous atmosphere” (cont’d)

- **Flammable gas, vapor, or mist in excess of 10 percent of its Lower Flammable Limit**
- **Airborne combustible dust at a concentration that meets or exceeds its Lower Explosive Limit**
- **Atmospheric oxygen concentration below 19.5 percent or above 23.5 percent**
- **Atmospheric concentration of a chemical in excess of OSHA published dose or permissible exposure level**
- **Any other atmospheric condition that could be immediately dangerous to life and health**

Toxic Atmospheres

- Product stored in a confined space:
  - Gases released while cleaning.
  - Materials absorbed into walls of confined space.
  - Decomposition of materials in the confined space.
- Work performed in a confined space:
  - Welding, cutting, brazing, soldering.
  - Painting, scraping, sanding, degreasing.
  - Sealing, bonding, melting.
- Areas adjacent to a confined space.
  - Exhaust , pumps, generators

Hazardous Atmosphere Definitions

"Hazardous atmosphere" (cont'd)

(4) Atmospheric concentration of any substance for which a dose or a permissible exposure limit is published in Subpart G, Occupational Health and Environmental Control, or in Subpart Z, Toxic and Hazardous Substance , of this Part (CFR 1910) which could result in employee exposure in excess of its dose or permissible exposure limit.

(5) Any other atmospheric condition that could be immediately dangerous to life and health.

Oxygen Deficient Atmospheres

19.5 %	Minimum acceptable oxygen level.
15 - 19%	Decreased ability to work strenuously. Impaired coordination. Early symptoms.
12-14%	Respiration increases. Poor judgment.
10-12%	Respiration increases. Lips blue.
8-10%	Mental failure. Fainting. Nausea Unconsciousness. Vomiting.
6-8%	8 minutes - fatal, 6 minutes - 50% fatal 4-5 minutes - possible recovery.
4-6%	Coma in 40 seconds. Death

Oxygen Enriched Atmospheres

- Oxygen level above 21%.
- Causes flammable and combustible materials to burn violently when ignited.
- Hair, clothing, materials, etc.
- Oil soaked clothing and materials.
- Never use pure oxygen to ventilate.
- Never store or place compressed tanks in a confined space.

Flammable Atmospheres

- Critical Factors:
  - Oxygen content in the air.
  - Presence of a flammable gas, or vapor
  - Presence of dust (visibility of 5’ or less)
- Proper air/gas mixture can lead to explosion
- Typical Ignition Sources:
  - Sparking or electric tool.
  - Welding / cutting operations.
  - Smoking

Hydrogen Sulfide

- Decomposition of materials. Human waste.
- Rotten egg odor at low concentrations.
- Possibly no warning at higher concentrations.

PPM	Effect	Time
10 ppm	Permissible Exposure Level	8 Hours
50 - 100	Mild Irritation - eyes, throat	1 Hour
200 - 300	Significant Irritation	1 Hour
500 -700	Unconsciousness, Death	1/2 - 1 Hour
>1000	Unconsciousness, Death	Minutes

Carbon Monoxide

- Odorless, Colorless Gas.
- Combustion By-Product.
- Quickly collapse at high concentrations.

PPM	Effect	Time
50	Permissible Exposure Level	8 Hours
200	Slight headache, discomfort	3 Hours
600	Headache, discomfort	1 Hour
1000-2000	Confusion, nausea, headache	2 Hours
1000-2000	Tendency to stagger	1 1/2 Hours
1000-2000	Slight heart palpitation	30 Min.
2000-2500	Unconsciousness	30 Min.

Temperature Extremes

- Extremely hot or cold temperatures.
- Steam cleaning of confined spaces.
- Humidity factors.
- Extremely cold liquids.
- Work processes inside the confined space can increase temperature extremes.
- Personal protective equipment.

Engulfment Hazards

- Loose, granular materials stored in bins and hoppers - grain, sand, coal, etc.
- Crusting and bridging below a worker.
- Flooding of confined space.
- Water or sewage flow.

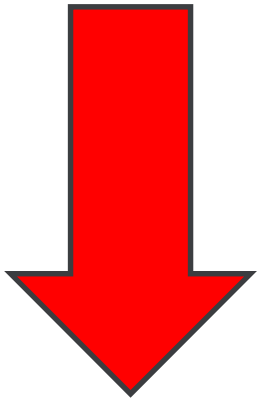
Other Hazards

- Noise
  - Amplified due to acoustics within the space.
  - Damaged hearing, hamper communication.
- Slick / Wet Surfaces
  - Slips and falls.
  - Increased chance of electric shock.
- Falling Objects
  - Topside openings expose workers inside confined space to falling objects.
- Mechanical
  - Drive Shafts
  - Drive Gears

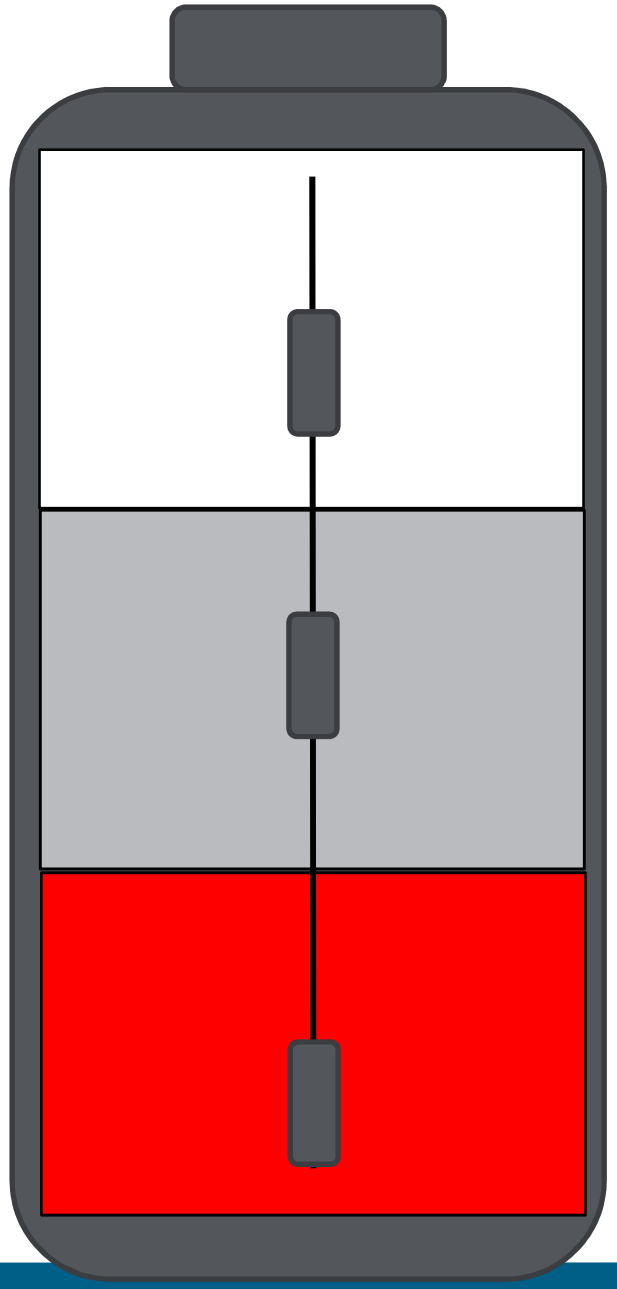
Testing The Atmosphere

- Verify presence of safe work atmosphere
- Test all areas of a confined space
- Methane is lighter than air
- Carbon Monoxide is the same as air
- Hydrogen Sulfide is heavier than air
- Oxygen Deficiency

Always test the air at various levels to be sure that the entire space is safe.



Good air near the opening does NOT mean there is good air at the other end!



Good Air

Poor Air

Deadly Air

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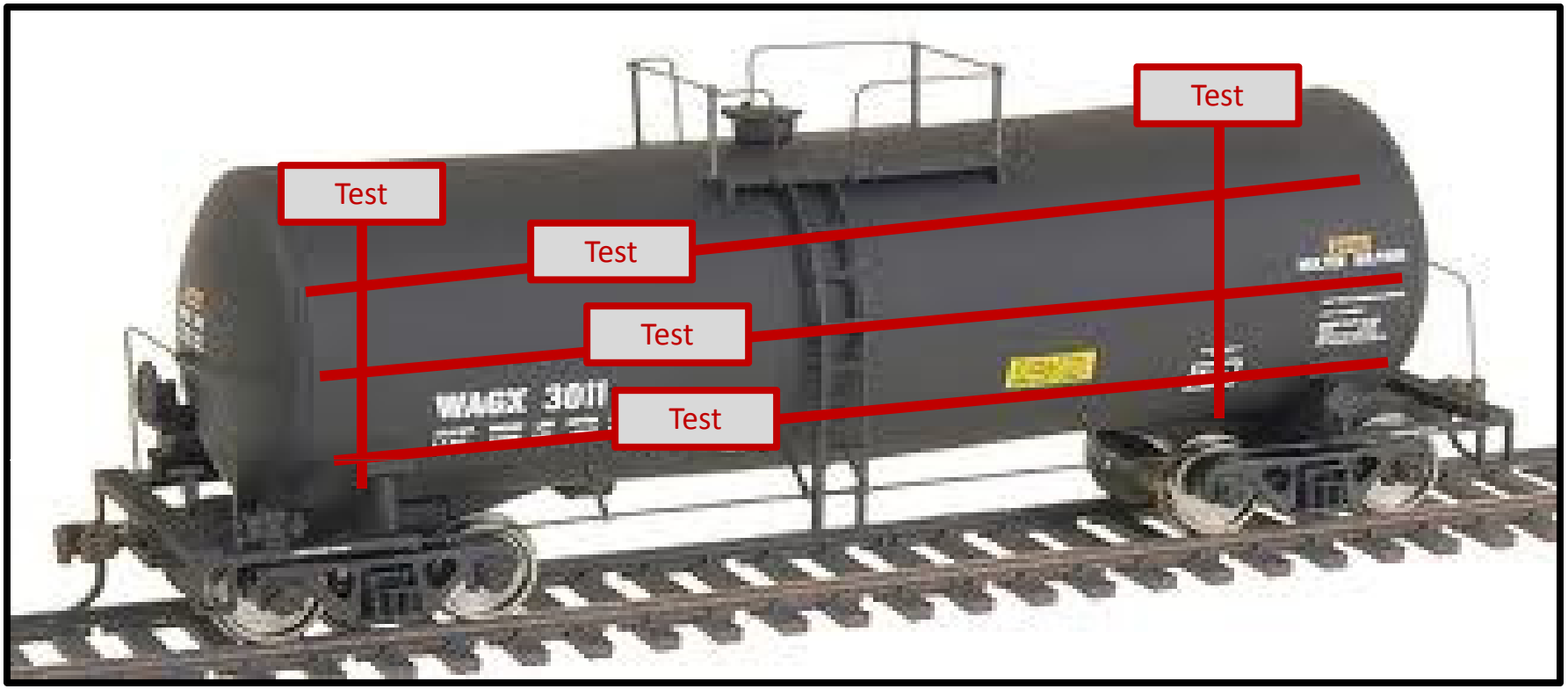
Tanker Cars



- Atmospheric testing for tanker cars MUST be tested in 9 locations prior to entry. Testing must be conducted on each end of the car (1 - 6) and in the middle – top (7) middle (8) and bottom (9).

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Atmosphere Testing Must Be Performed…

- Prior to every entry when the space is vacant;
- After a 10 minute ventilation period (if ventilation is necessary);
- At least hourly for permit-required confined spaces. NOTE: A good practice is to re-test the atmosphere after breaks or having been out of the confined space for a period of time.
- More frequently, if conditions or suspicions warrant.

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Ventilation

- First option to correct problems;
- Must be aware of hazards you are trying to correct in the confined space;
- Air intake in a safe location to draw fresh air only;
- Continuous ventilation whenever possible; and
- Retest the confined space before entry.

Isolation / Lockout

- Locking and tagging out electrical sources.
- Blanking and bleeding pneumatic and hydraulic lines.
- Disconnecting mechanical drives and shafts.
- Securing mechanical parts.
- Blanking sewer and water flow.
- Locking and tagging out shutoff valves.

Respirators

- Air-Purifying Respirators
  - Filter dangerous substances from the air.
  - Must know the type and amount of hazardous substance present in the confined space.
  - NEVER use with oxygen deficiency!
- Air-Supplying Respirators
  - Deliver a safe supply of breathing air from a tank or an uncontaminated area nearby.
  - Must be adequately monitored.

Standby / Rescue

- Worker assigned to remain outside the confined space and be in constant contact with the workers inside;
- Know emergency rescue procedures;
- 50% of workers who die in confined spaces are would-be rescuers; and
- Trained in use of emergency rescue equipment and PPE.

Hygiene Practices

Sanitation Items to Consider

"Sewer Plant" by Rjgalindo - Own work. Licensed under CC BY 3.0 via Commons - https://commons.wikimedia.org/wiki/File:Sewer_Plant.jpg#/media/File:Sewer_Plant.jpg

Centers for Disease Control and Prevention (CDC)

- Basic Hygiene Practices
- Personal Protective Equipment
- Training
- Vaccination Recommendations

Basic Hygiene Practices

- Hand Washing
- Open wounds
- Eyewash Stations
- Remove Clothing at Shift End
- Clean Work Clothing Daily

Personal Protective Equipment

- Goggles
- Face Shield
- Coveralls
- Gloves
- Boots

Training for Workers

- Disease Prevention
- Personal Protective Equipment
- When to Seek Medical Attention

Vaccinations

- Tetanus
- Give Consideration to:
  - Polio
  - Typhoid Fever
  - Hepatitis A
  - Hepatitis B
- Consult Your Local Health Department or Occupational Physician
- Guidance Document from Centers for Disease Control and Prevention (CDC)

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Comments or Questions?

Other Areas of Consideration