Basics of Machine Safeguarding

Hazards and Solutions

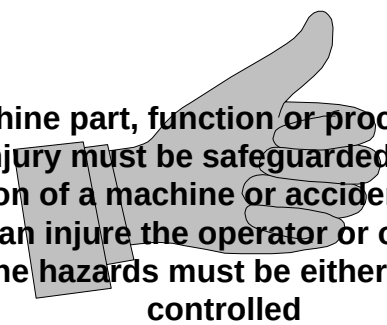
Crushed hands and arms, severed fingers, blindness - the list of possible machinery related injuries is as long as it is horrifying. There seems to be as many hazards created by moving machine parts as there are types of machines. Safeguards are essential for protecting workers from needless and preventable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

Objectives

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

Rule of Thumb



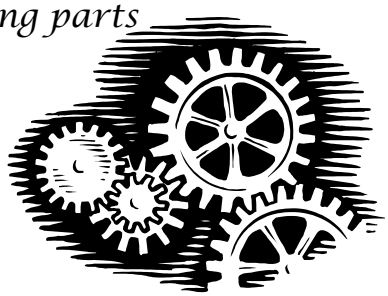
Any machine part, function or process that may cause injury must be safeguarded. Where the operation of a machine or accidental contact with it can injure the operator or others in the vicinity, the hazards must be either eliminated or controlled

The Basics

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*



List four types of machine guards

A “guard” prevents entry into the danger area.

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

List six types of machine devices

A “device” controls entry into the danger area.

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

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:

Recognize the hazards by identifying hazardous actions and motions

Analyze the workplace and prioritize safeguarding efforts based on the most predictable injury, the probability of occurrence and available resources

Develop and implement a systematic safeguarding program which includes identifying safeguarding methods, selection and installation

Ensure use of safeguarding and reinforce program by training, education and enforcement

Recognize the hazards

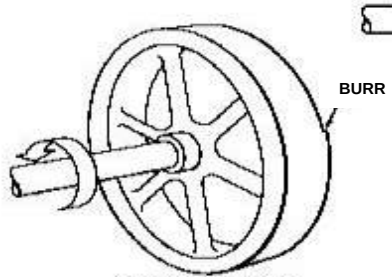
A wide variety of mechanical motions and actions may present hazards to the worker. These can include the movement of rotating members, reciprocating arms, moving belts, meshing gears, cutting teeth, and any parts that impact or shear. These different types of hazardous mechanical motions and actions are basic to nearly all machines, and recognizing them is the first step toward protecting workers from the danger they present. The basic types of hazardous mechanical motions and actions are motions and actions.

A. Motions

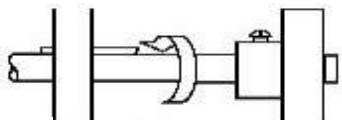
Rotating motion

Collars Couplings Cams Clutches Flywheels Shaft ends Spindles Meshing gears

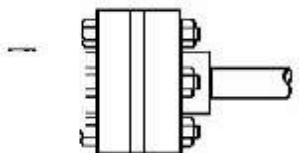
What are some of the hazards of rotating parts?



Rotating pulley with spokes and projecting burr on face of pulley



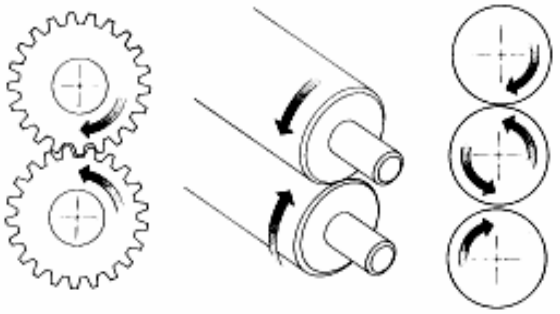
Rotating shaft and pulley with projecting key and set screw



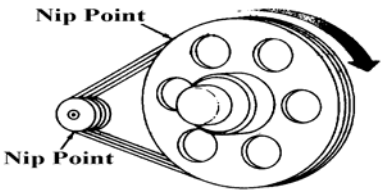
Rotating coupling with projecting bolt heads

See Any Hazards Here?

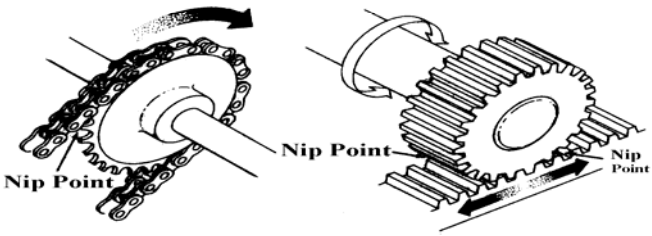
In-running nip point hazards

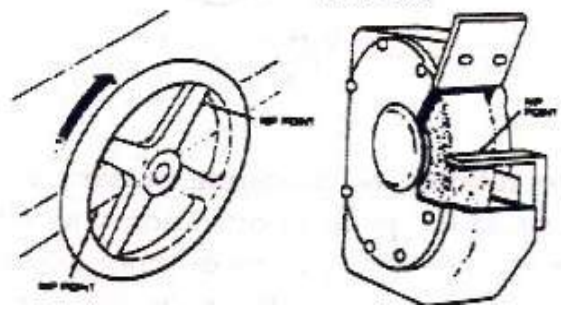


Parts rotating in opposite direction

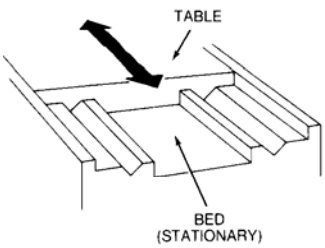


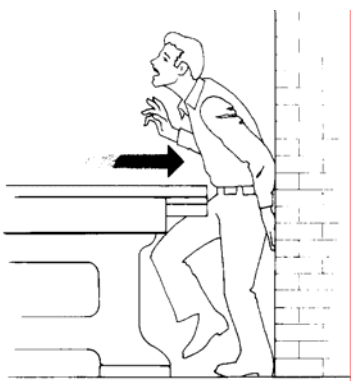
Rotating and tangentially moving parts



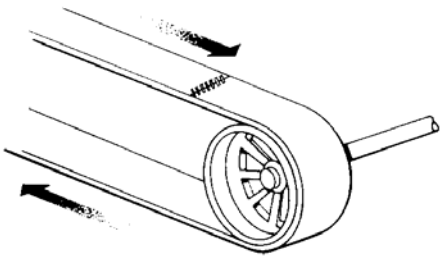


Rotating and fixed parts





Reciprocating motions



Transverse Motion of Belt

Transverse motion

Identify all motions and hazards associated with each piece of equipment or machinery below. (Click once for each answer to appear.)

Rotating and fixed parts

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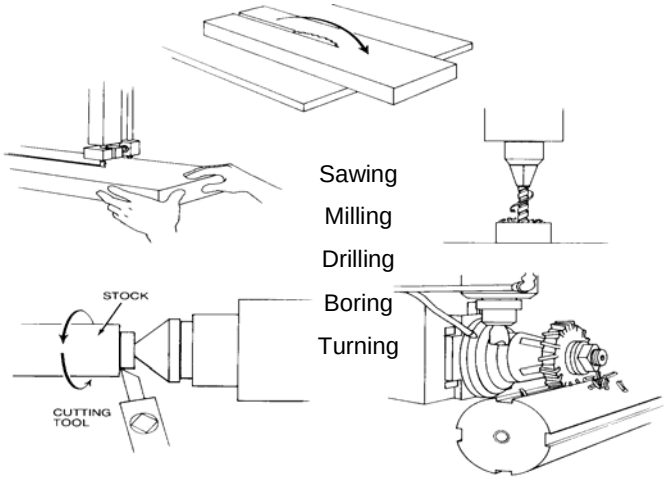
Transverse motion

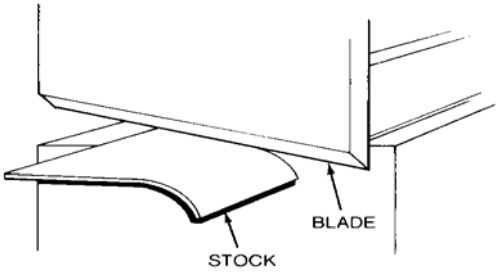
Rotating and tangentially moving parts

B. Actions

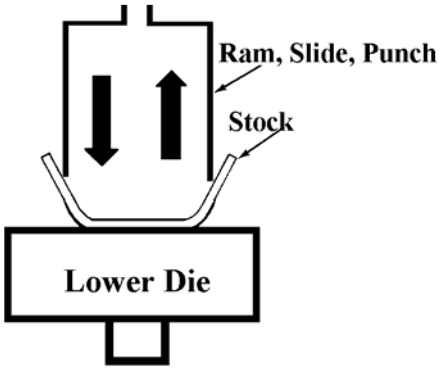
Cutting action



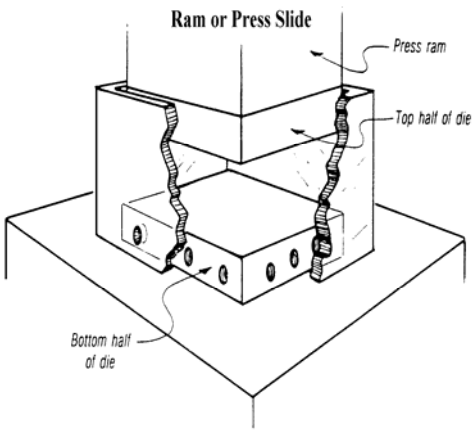
Shearing action



Bending action



Punching action



Identify all actions and hazards associated with each piece of equipment or machinery below.

Cutting action

Bending action

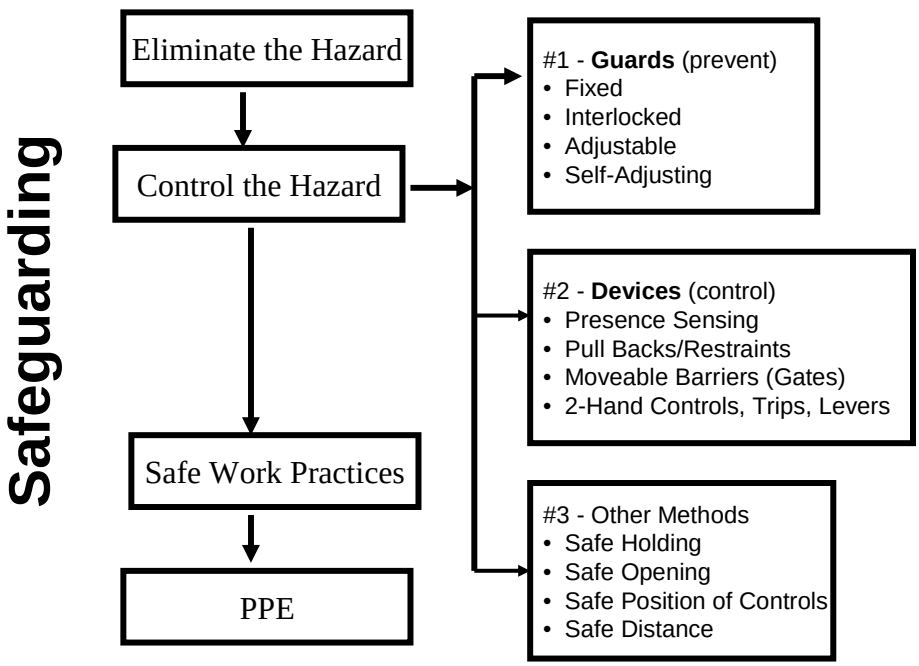
Methods of Safeguarding

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. One must always choose the most effective and practical means available.

Safeguarding strategies are grouped under these general classifications:



Effective Guards

What are the criteria or characteristics of an effective guard?

The safeguard 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.

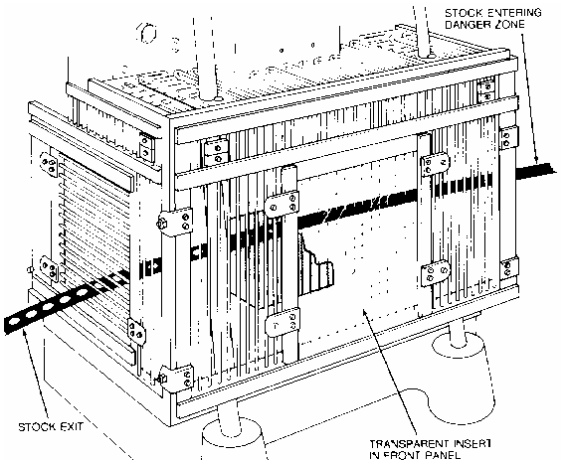
6. Allow safe lubrication: If possible, one should be able to lubricate the machine without removing the safeguards. Locating oil reservoirs outside the guard, with a line leading to the lubrication point, will reduce the need for the operator or maintenance worker to enter the hazardous area.

First Choice – Guards (barriers that prevent access)

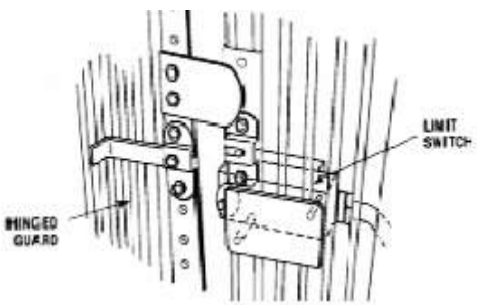
Guards are usually a permanent part of the machine that prevent access to the danger area.

Fixed Guards

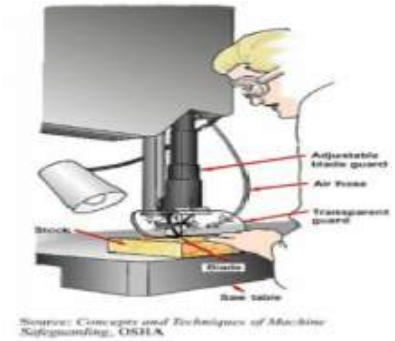
- ❑ Permanent part of the machine
- ❑ Not dependent upon moving parts to perform its intended function
- ❑ Constructed of sheet metal, screen, wire cloth, bars, plastic or other substantial material.
- ❑ Usually preferable to all other types because of its relative simplicity and permanence.



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.



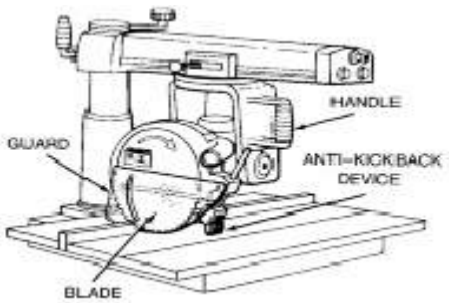
- ❑ Guards the dangerous part before the machine can be operated
- ❑ Keeps the guard closed until the dangerous part is at rest
- ❑ Prevent operation of the machine if the interlocking device fails
- ❑ May use electrical, mechanical, hydraulic, or pneumatic power or any combination of these.
- ❑ Should 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.**



Source: Concepts and Techniques of Machine Safeguarding, OSHA

Adjustable Guards: Allow flexibility in accommodating various sizes of stock.

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.



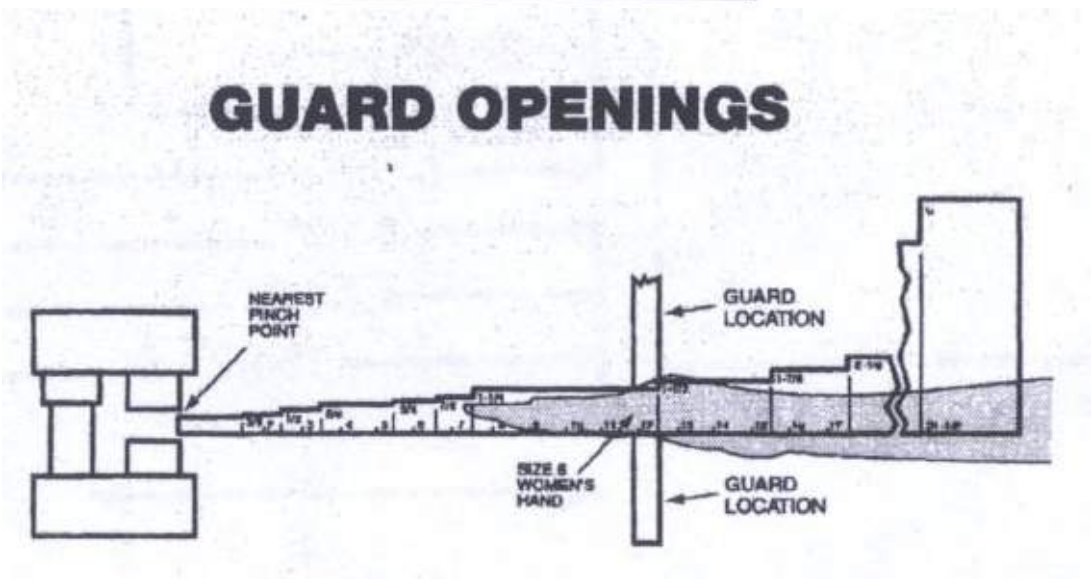
Placing guards at a safe distance

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 (POO) guarding requires openings. These material openings must conform to the maximum permissible openings of WISHA's Table 200-1.

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.

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



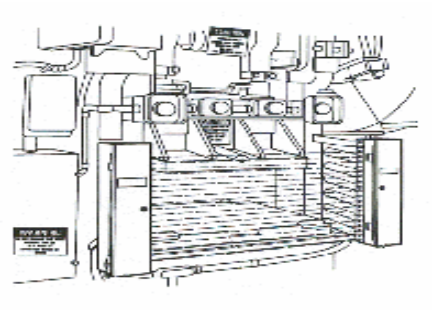
Second Choice – Devices (controls access):

Devices controls 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.
- Devices must allow safe lubrication and maintenance and not create hazards or interfere with normal machine operation.
- Should be secure, tamper-resistant and durable.

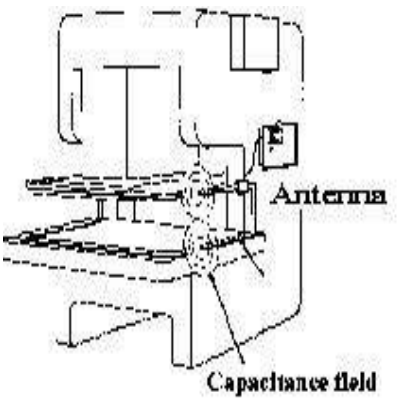
Here are five (5) common types of devices.

1. Presence-Sensing: 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.

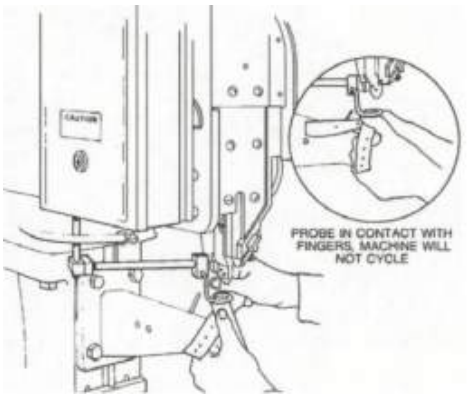


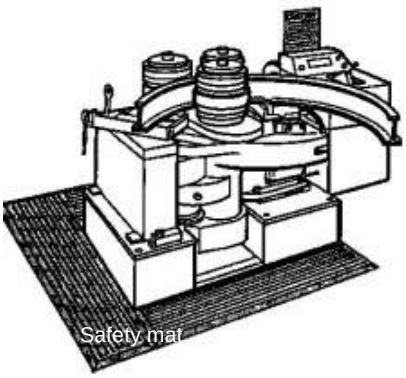
The ***light curtain*** (photoelectric-optical) presence sensing device uses a system of light sources and controls that can interrupt the machine's operating cycle. If the light field is broken, the machine stops and will not cycle. This device must be used only on machines which can be stopped before 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.

The ***radiofrequency*** (capacitance) 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.



The ***electro-mechanic****al* 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”.

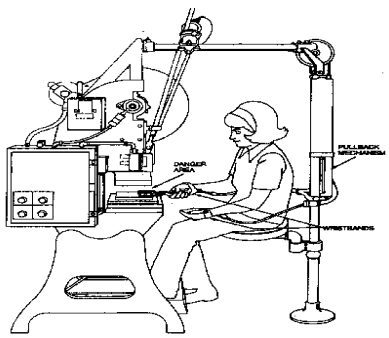



Safety mat

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.

2. 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.

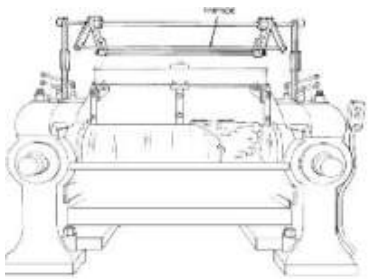


The **restraint (holdout)** device uses cables or straps that are attached to the operator's hands and a fixed point. The cables or straps must be adjusted to let the operator's hands travel within a predetermined safe area. There is no extending or retracting action involved. Consequently, hand-feeding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

3. Safety Trip Controls: These devices provide a quick means for deactivating the machine in an emergency situation.

A ***pressure-sensitive body ba***r, 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 triprod*** deactivates the machine. Because it has to be actuated by the operator during an emergency situation, its proper position is also critical. A triprod is shown and is located above a rubber mill.



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.

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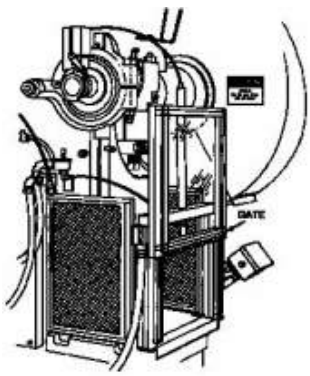
4. Gates & Moveable Barrier: A gate is a movable barrier which protects the operator at the point of operation before the machine cycle can be started.



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:

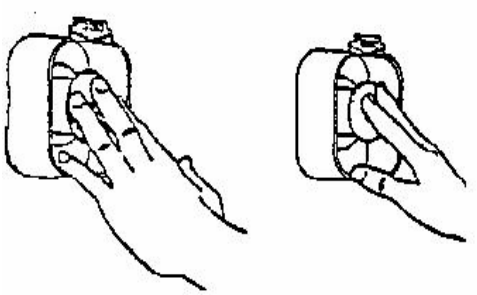
A **type "A" gate** remains closed during the entire cycle of the machine. Use for full or part revolution clutches.

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

5. Two Hand: 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.



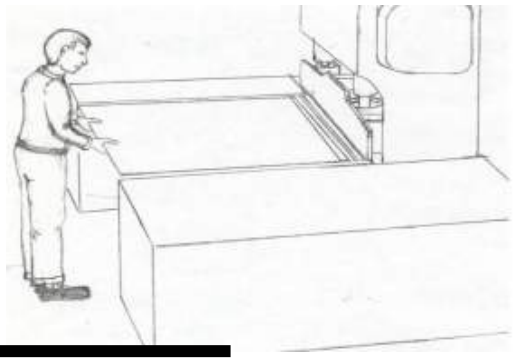
Third Choice - Other Methods

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.

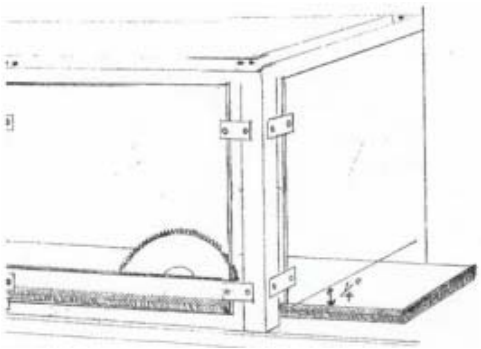
Safe Holding

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



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 workpiece 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 workpiece is in place. Openings for two-dimensional workpieces meet the following conditions:

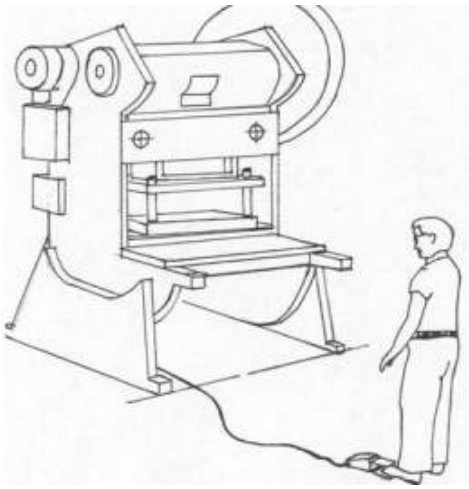
   - maximum area of any guard opening should be 7 square inches (example: opening 2-1/2 inches by 2-1/2 inches has an area of 6-1/4 inches);
   - longest dimension of a rectangular opening should be 3.5 inches;
   - the maximum shorter dimension of the rectangular opening should be 2 inches;
   - the minimum distance from the guard to any point of operation is 4 inches.

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.



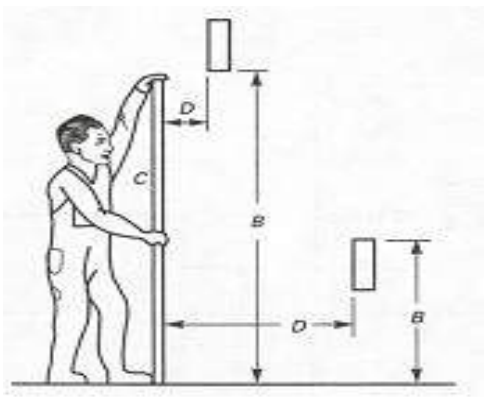
Safe Distance

Eliminates the need for operator's hands or other parts 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 workpiece; 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 guarding machines. The employer must ensure that employees are trained to do the job, wears personal protective equipment to protect against other hazards, establishes safe operating procedures, supervises to ensure compliance with company rules.

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 machines.
- The safeguards themselves, how they provide protection, and the hazards for which they are intended.
- How to use the safeguards and why
- How and under what circumstances safeguards can be removed, and by whom (in most cases, repair 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.

MACHINE SAFEGUARDING CHECKLIST

Answers to the following questions should help determine the safeguarding needs of the workplace, by drawing attention to hazardous conditions or practices requiring correction.

Requirements for All Safeguards	Yes	No
Do the safeguards provided meet the minimum WISHA 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?		

Non-mechanical Hazards	Yes	No
Have appropriate measures been taken to safeguard workers against noise hazards?		
Have special guards, enclosures or personal protective equipment been provided, where necessary, to protect workers from exposure to harmful substances used in machine operation?		
Have appropriate measures been taken to safeguard workers against ergonomic hazards?		
Electrical Hazards	**Yes**	**No**
Is the machine installed in accordance with National Fire Protection Association and National Electric Code requirements?		
Are there loose conduit fittings?		
Is the power supply correctly fused and protected?		
Do workers occasionally receive minor shocks while operating any of the machines?		
Is the machine properly grounded?		
Training	**Yes**	**No**
Do operators and maintenance workers have the necessary training in how to use the safeguards and why?		
Have operators and maintenance workers been trained in where the safeguards are located, how they provide protection and what hazards they protect against?		
Have operators and maintenance workers been trained in how and under what circumstances guards can be removed?		
Have workers been trained in the procedures to follow if they notice guards that are damaged, missing or inadequate?		
Protective Equipment and Clothing	**Yes**	**No**
Is protective equipment required?		
If protective equipment is required, is it appropriate for the job, in good condition, kept clean and sanitary and stored carefully when not in use?		
Is the operator dressed safely for the job (i.e. no loose-fitting clothing or jewelry)?		
Machinery Maintenance and Repair	**Yes**	**No**
Have maintenance workers received up-to-date instructions on the machines they service?		
Do maintenance workers lock out the machine from its power sources before beginning repairs?		
Where several maintenance persons work on the same machine, are multiple lockout devices used?		
Do maintenance persons use appropriate and safe equipment in their repair work?		
Are maintenance and servicing workers trained in the requirements of WAC 296-803, lockout/tagout hazard, and do the procedures for lockout/tagout exist **before** they attempt their task?		
Is the maintenance equipment itself properly guarded?		