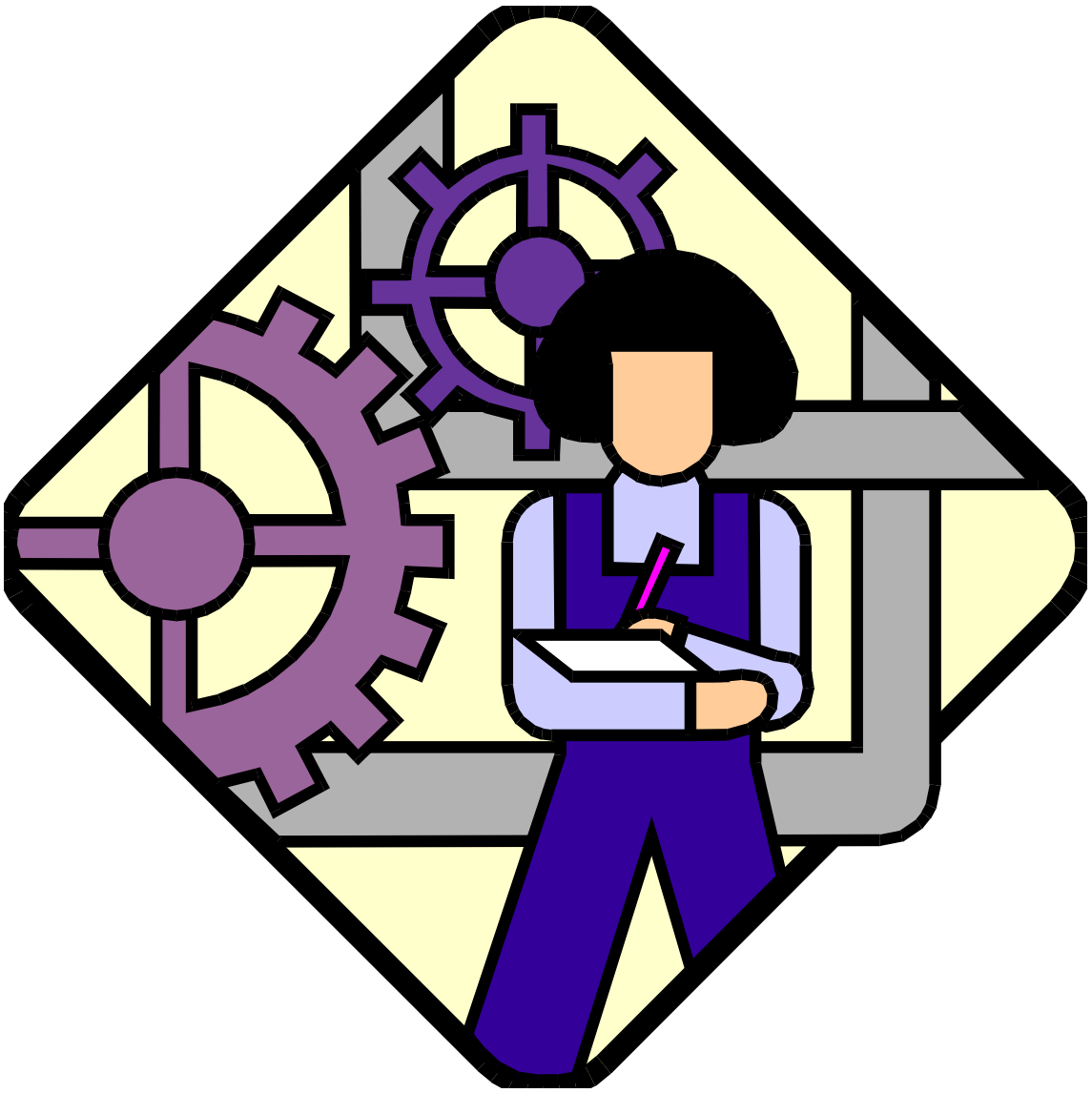
Introduction to principles and concepts of

Effective Machine Guarding



Welcome

Crushed hands and arms, severed fingers, blindness -- the list of possible machinery-related injuries is as long as it is horrifying. There seem 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.

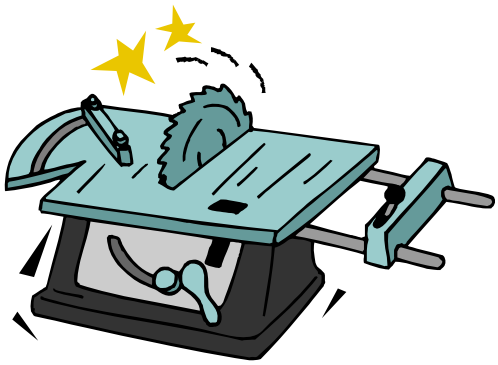
A good rule to remember is:

Any machine part, function, or process which 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 controlled or eliminated.

This workbook overviews the various hazards of mechanical motion and presents some techniques for protecting workers from these hazards. General information covered in this workbook includes where mechanical hazards occur, the hazards created by different kinds of motions and the requirements for effective safeguards, as well as a brief discussion on training guidelines.

Goals

- Describe the basic hazards involving machinery including point of operation and power transmission devices.
- Introduce control measures through effective machine guarding principles and methods.



Part One: The Principles

The purpose of machine guarding is to protect against and prevent injury from.…

_____ _____ _____ _____

_____ _____ _____ _____

Where Mechanical Hazards Occur

Dangerous moving parts in <u>three</u> basic areas require safeguarding:

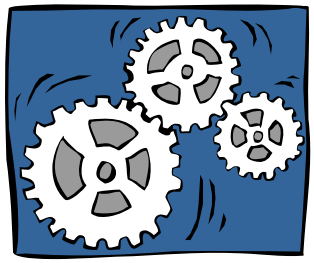
1. The point of operation

That point where work is performed.

Cutting	Shaping
Boring	Forming

2. Power transmission apparatus

All components of the mechanical system which transmit energy to the part of the machine performing the work.



Flywheels	Pulleys	Belts
Couplings	Cams	Spindles
Chains	Cranks	Gears
Sprockets	Shafts	Rods

3. Other moving parts

All parts of the machine which move while the machine is working.

Reciprocating Rotating Transverse

Feed mechanisms Auxiliary parts

Hazardous Mechanical Motions & Actions

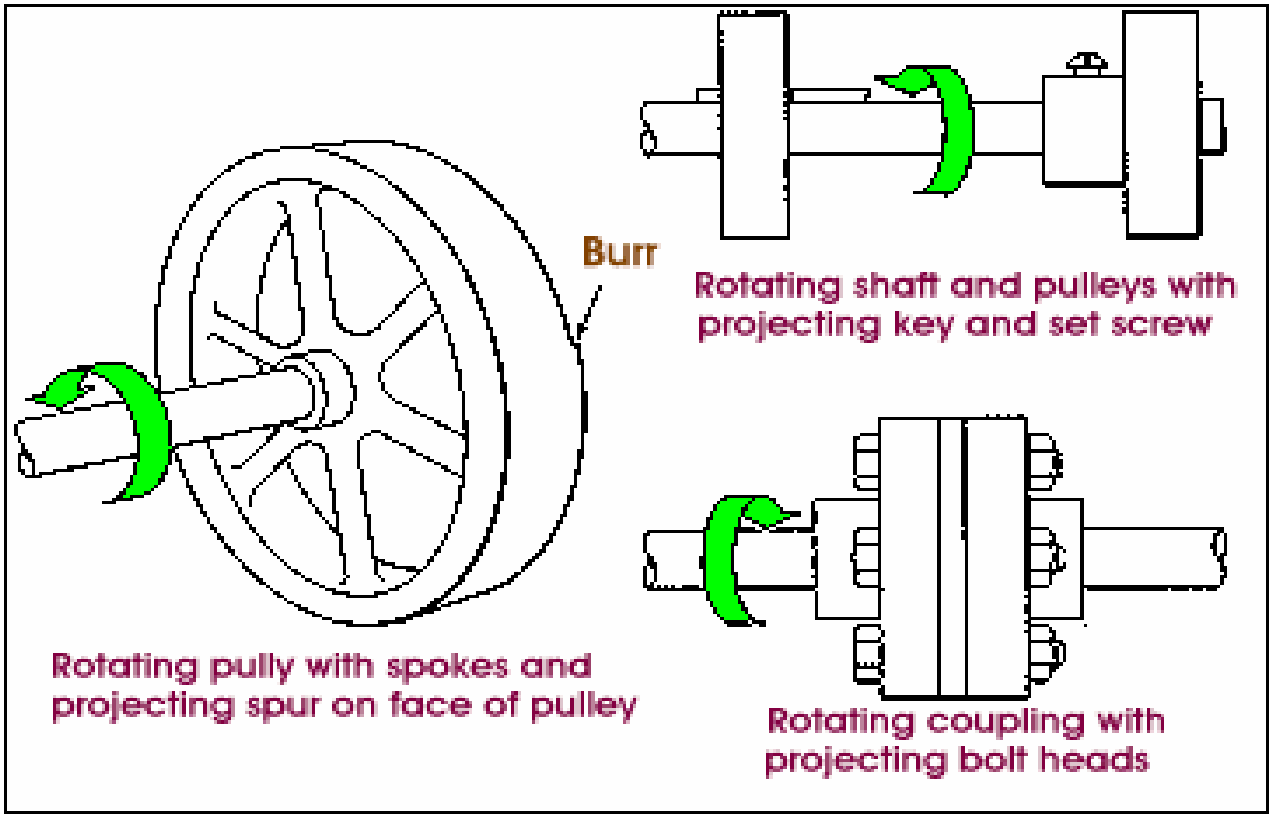
A wide variety of mechanical **motions** and actions may present hazards to the worker. These can include the movement of rotating members, reciprocating arms, moving belts, meshing gears, cutting teeth, and any parts that impact or shear.

These different types of hazardous mechanical **motions** and actions are basic in varying combinations to nearly all machines, and recognizing them is the first step toward protecting workers from the danger they present.

Motions

1. Rotating motion

- *Collars*
- *Couplings*
- *Cams*
- *Clutches*
- *Flywheels*
- *Shafts*
- *Spindles*
- *Meshing gears*
- *Fans*

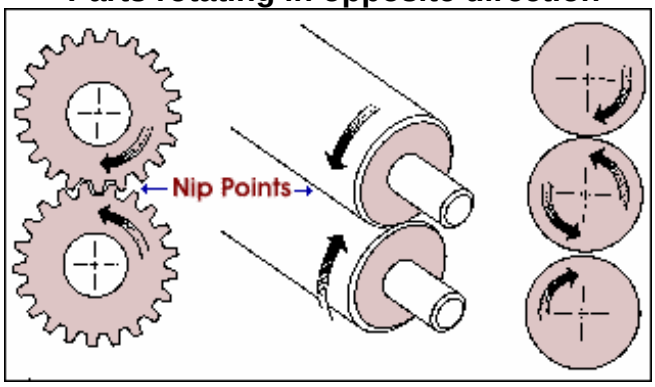


In-running nip point hazards

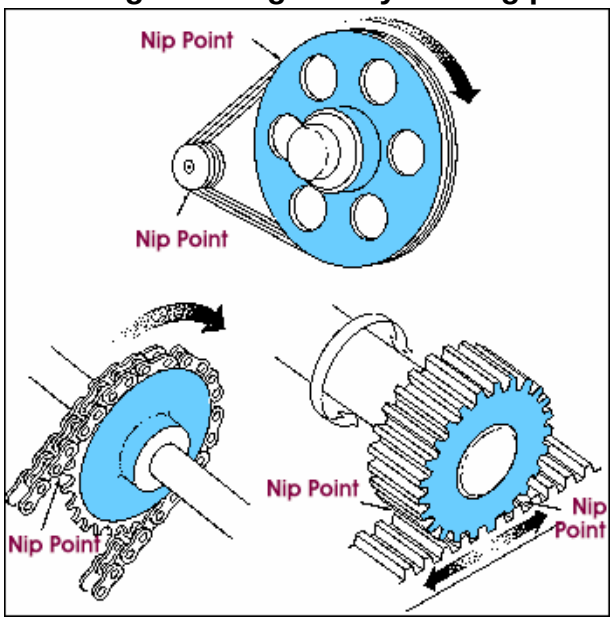
There are three main types of in-running nips.

- ✉ *Parts rotating in opposite direction*
- ✉ *Rotating and tangentially parts*
- ✉ *Rotating and fixed parts*

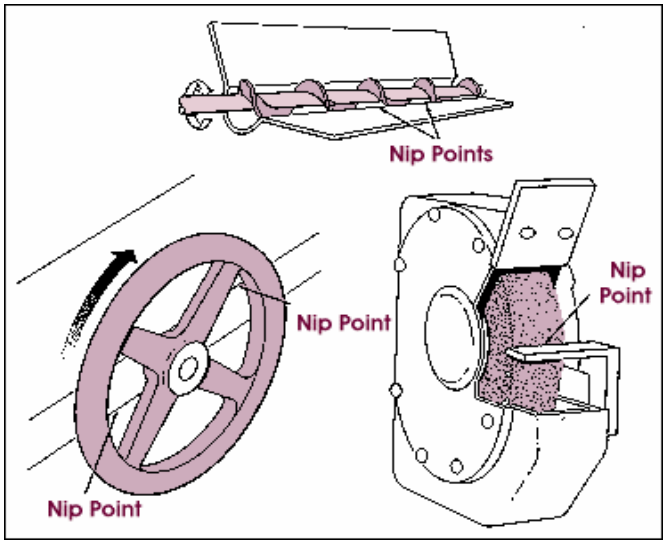
Parts rotating in opposite direction



Rotating and tangentially moving parts

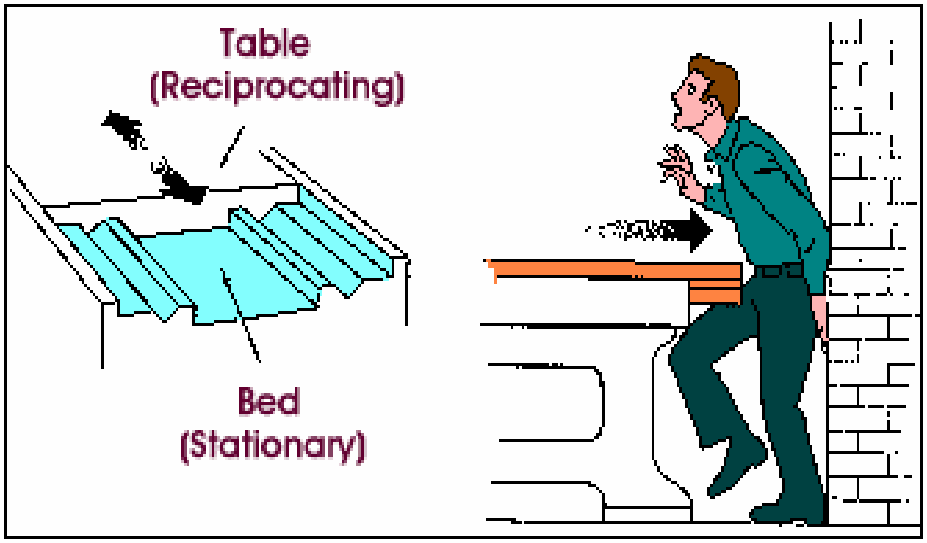


Rotating and fixed parts



Rotating hazard here?

2. Reciprocating motion

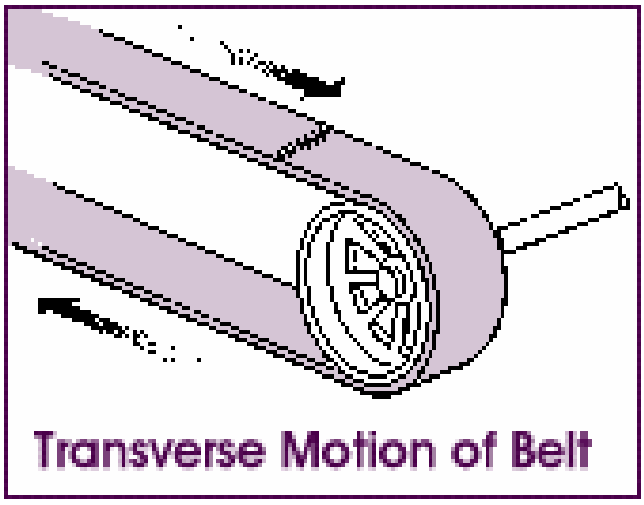


Do you have reciprocating motion in your facility? _____

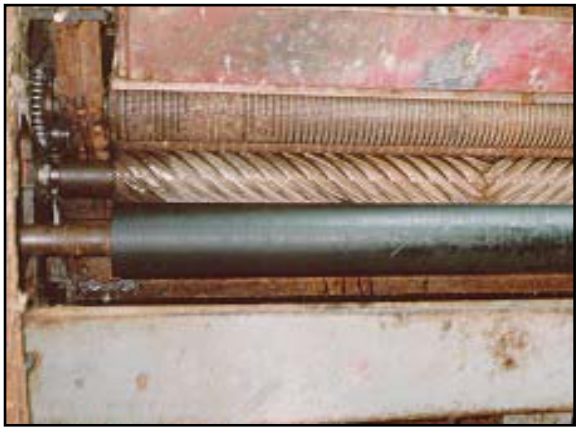
3. Transverse motion

Examples

- Conveyor lines
- Lengthy belts



Identify each in-running nip point below.



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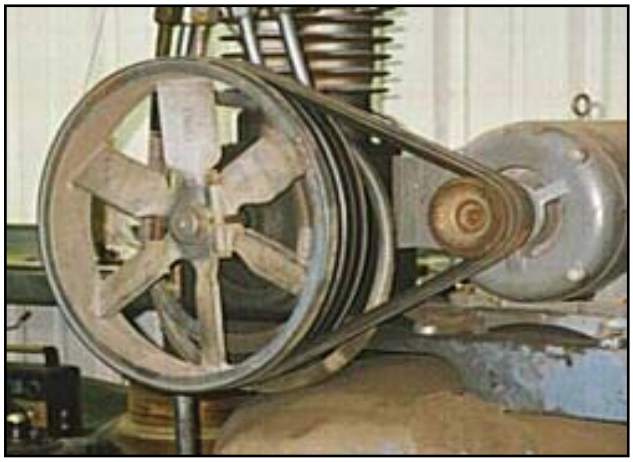

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Hazardous Mechanical Motions & Actions

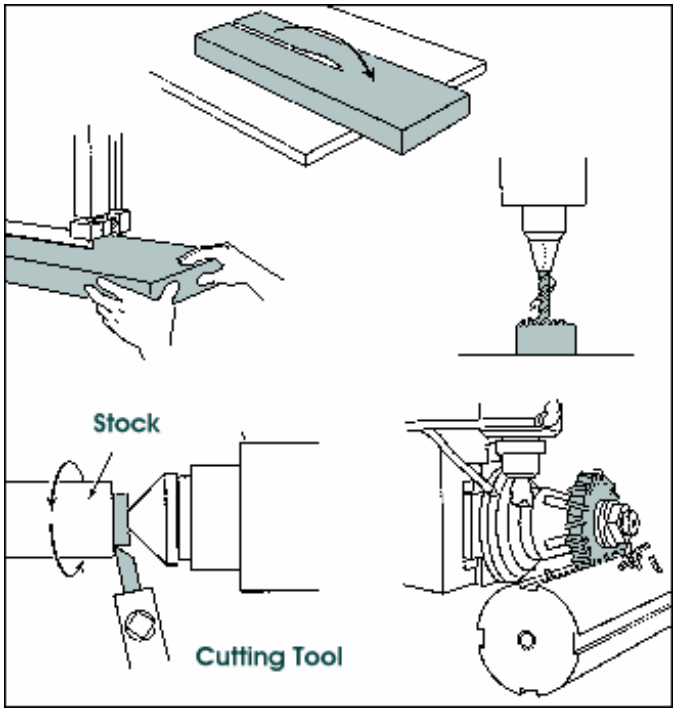
A wide variety of mechanical motions and **actions** may present hazards to the worker. These can include the movement of rotating members, reciprocating arms, moving belts, meshing gears, cutting teeth, and any parts that impact or shear.

These different types of hazardous mechanical motions and **actions** are basic in varying combinations to nearly all machines, and recognizing them is the first step toward protecting workers from the danger they present.

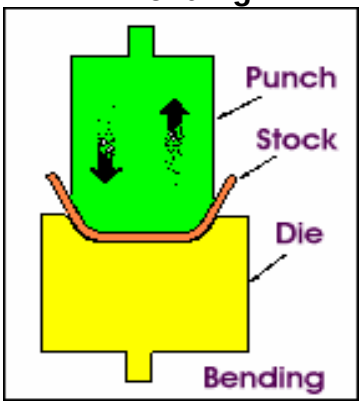
Actions

Cutting Shearing Bending Punching

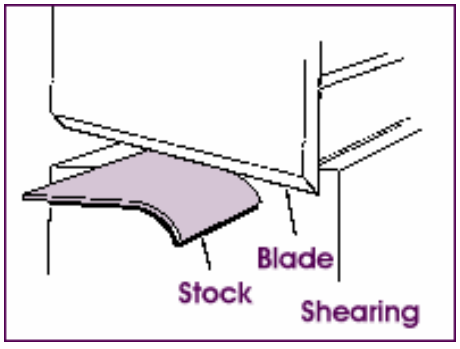
Cutting



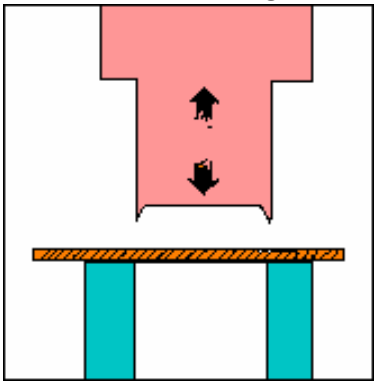
Bending



Shearing



Punching



Part Two: Methods of Machine Guarding

There are many ways to safeguard machines. The type of operation, the size or shape of stock, the method of handling, the physical layout of the work area, the type of material, and production requirements or limitations will help determine the appropriate safeguarding method for the individual machine.

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

Safeguarding strategies include:

1. Guards

- Fixed
- Interlocked
- Adjustable
- Self-adjusting

2. Devices

- Presence sensing
- Pullback
- Restraints
- Controls/Trips
- Gates

Other safeguarding strategies may include:

Location/Distance

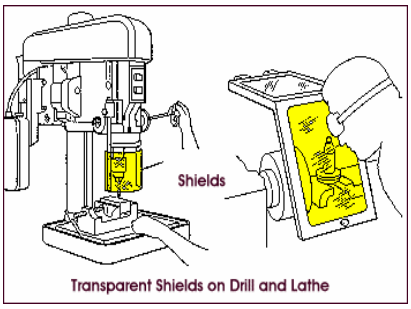
Feeding/Ejection Methods

Automatic/semi-auto feed Automatic/semi-auto ejection Robotics

Miscellaneous aids can help reduce exposure

Awareness barriers Protective shields

Hand-feeding tools and holding fixtures



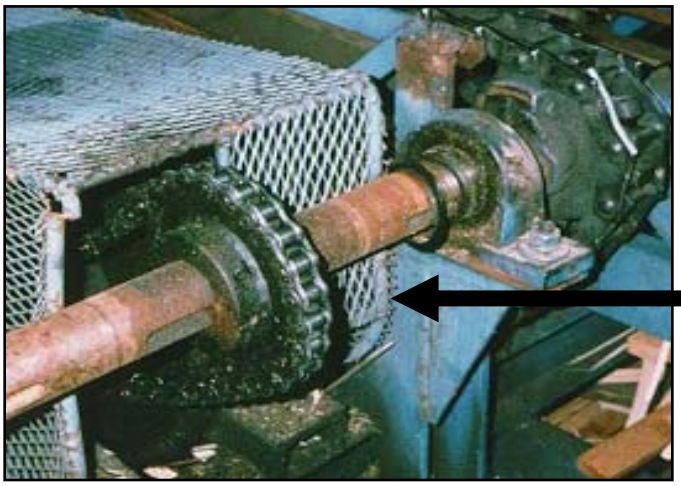
Transparent Shields on Drill and Lathe

What makes a guard effective?

- ➔ Must prevent any contact to the machine hazard and installed to prevent contact from around, over, through, or under the guard!

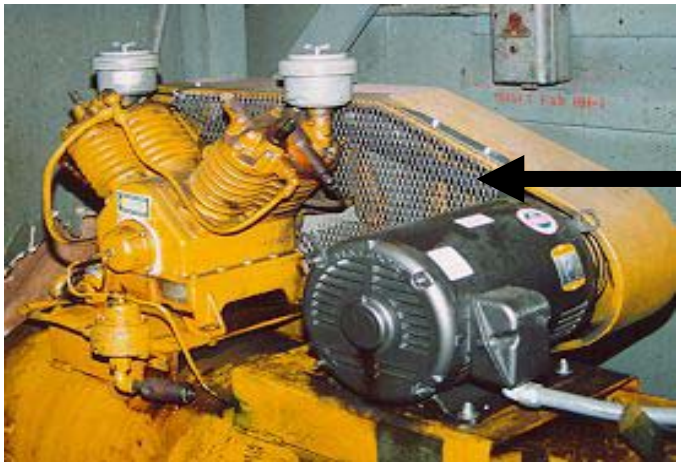
  "…so designed and constructed as to prevent the operator from having any part of his/her body in the danger zone during the operating cycle" [Division 2/Subdivision O 29 CFR 1910.212(a)(3)(ii)]

- ➔ Must not present a hazard in itself
- ➔ Must be affixed to the machine where possible
- ➔ Conformity with other appropriate standards: ANSI, etc.



Effective?

Y N



Effective?

Y N

First Safeguarding Strategy: Guards

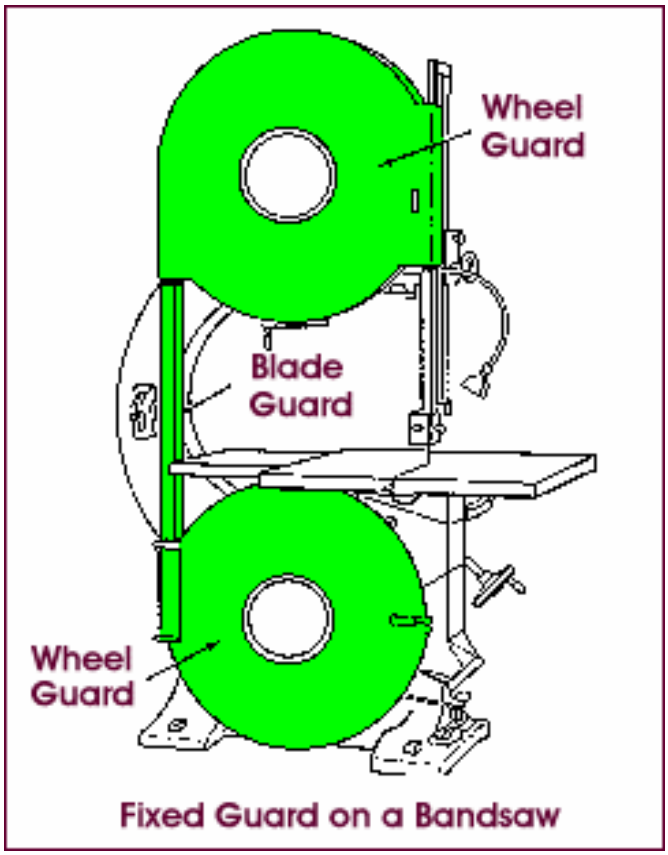
Guards are physical barriers which prevent access to danger areas.

Guards

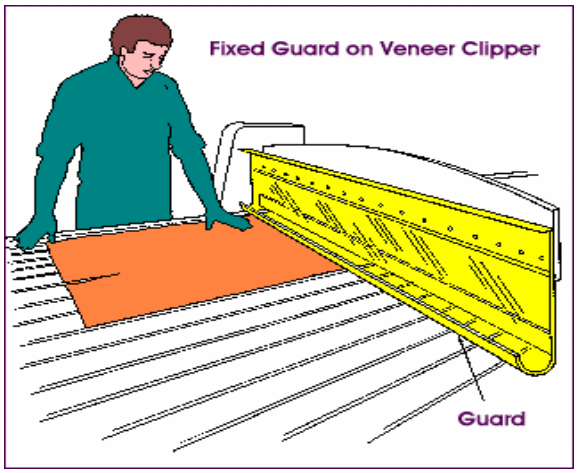
Fixed **Interlocked** **Adjustable** **Self-adjusting**

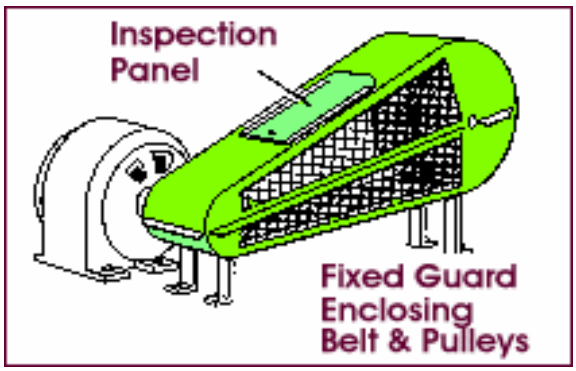
Fixed Guards

- 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.



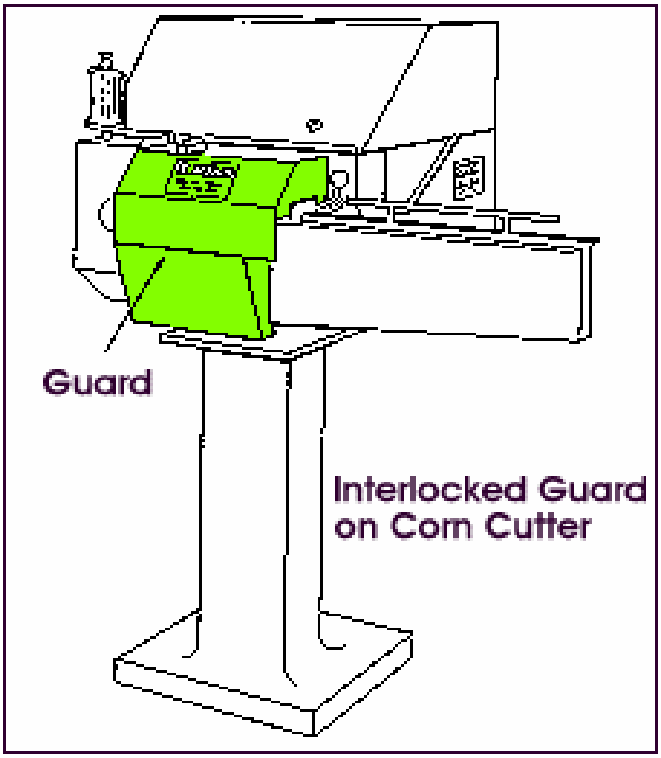
Fixed Guard on a Bandsaw

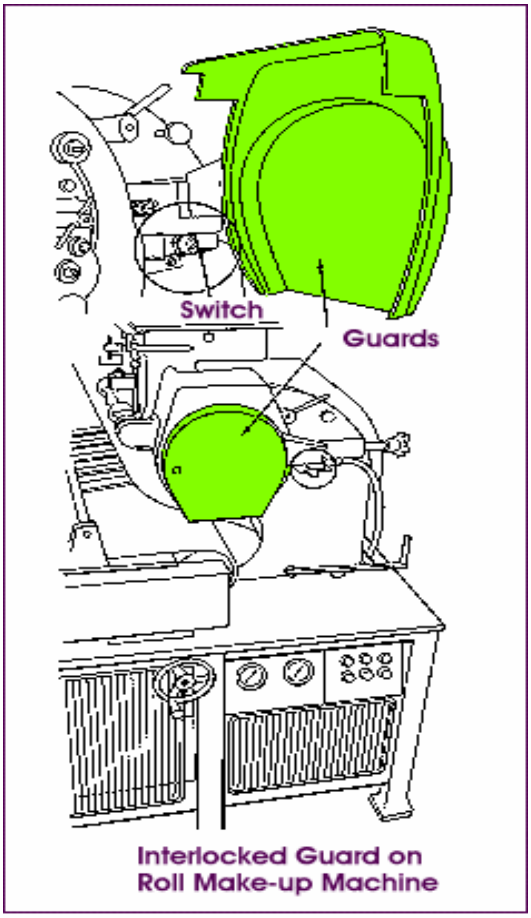


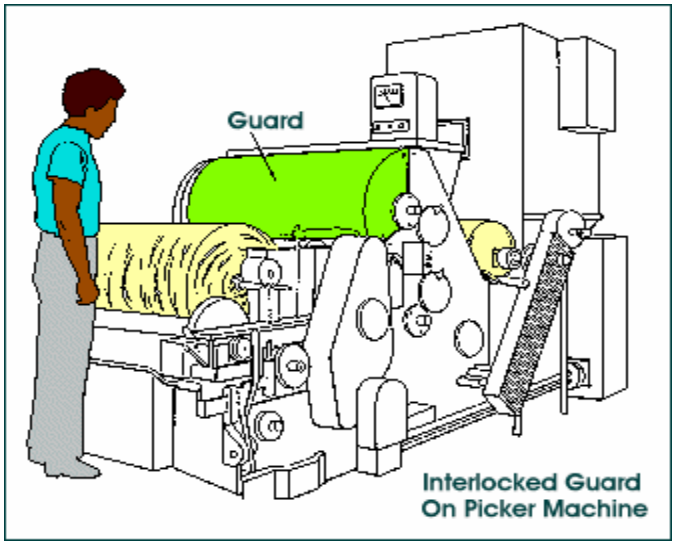


Interlocked Guards

- When opened or removed, the tripping mechanism and/or power automatically shuts off or disengages
- Machine cannot cycle or be started until the guard is back in place
- Electrical, mechanical, hydraulic, or pneumatic power
- Replacing the guard should not automatically restart the machine

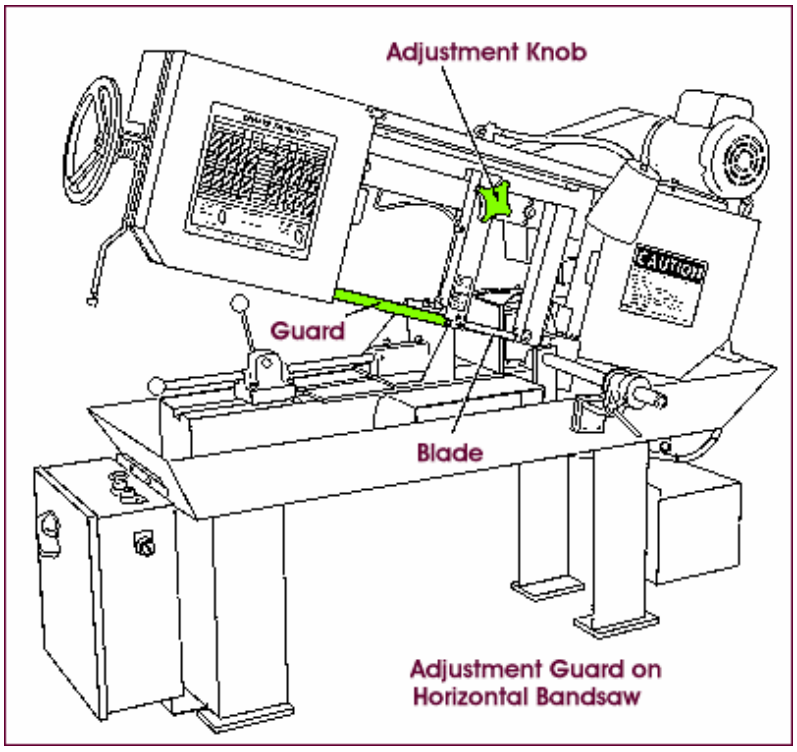


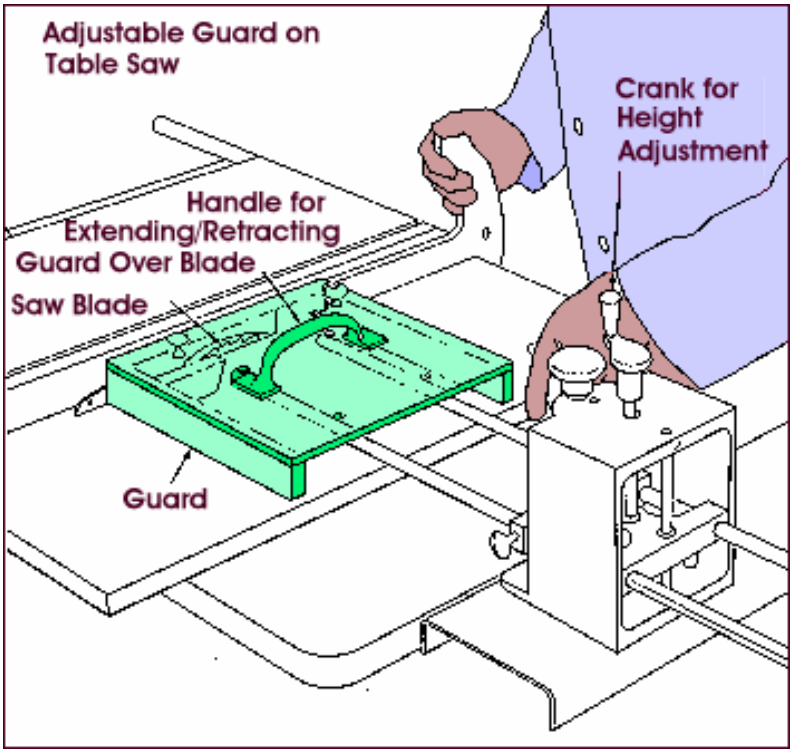




Adjustable Guards

- Allow flexibility in accommodating various sizes of stock

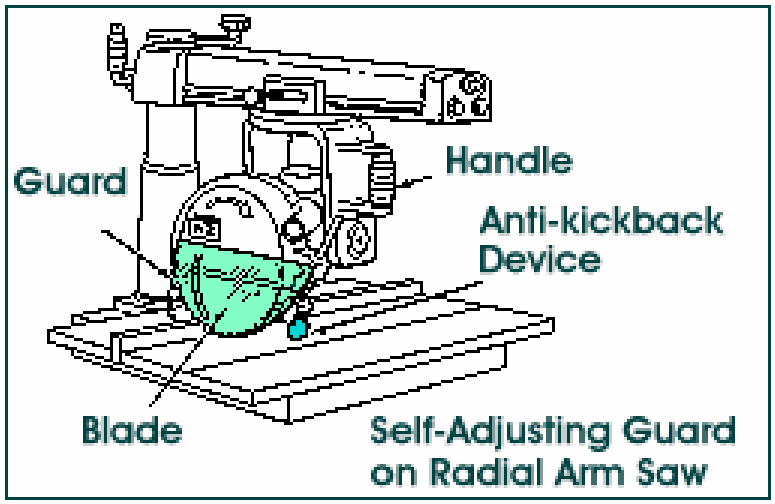


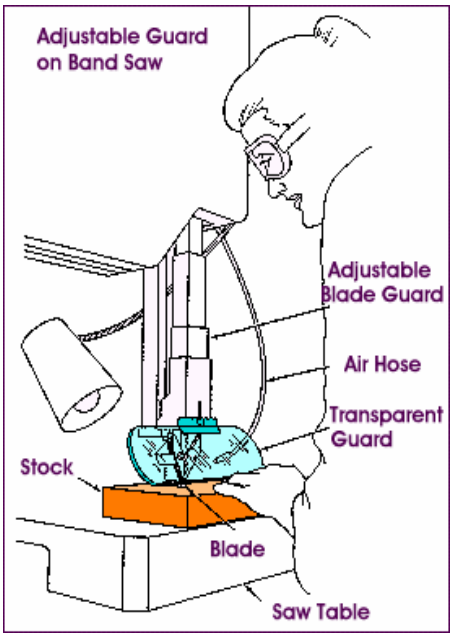


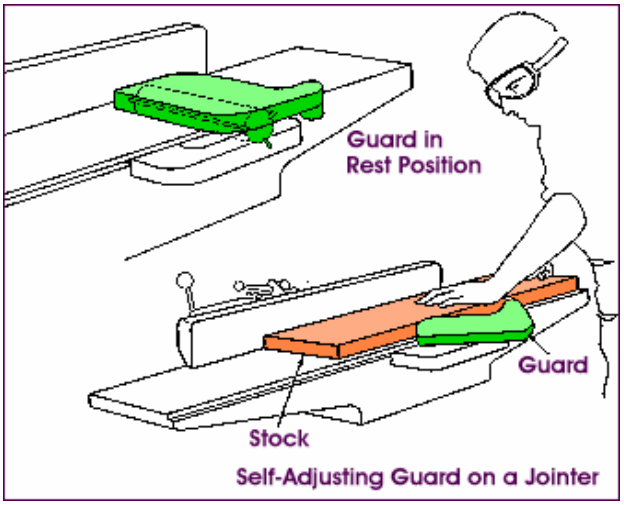
Self-adjusting Guards

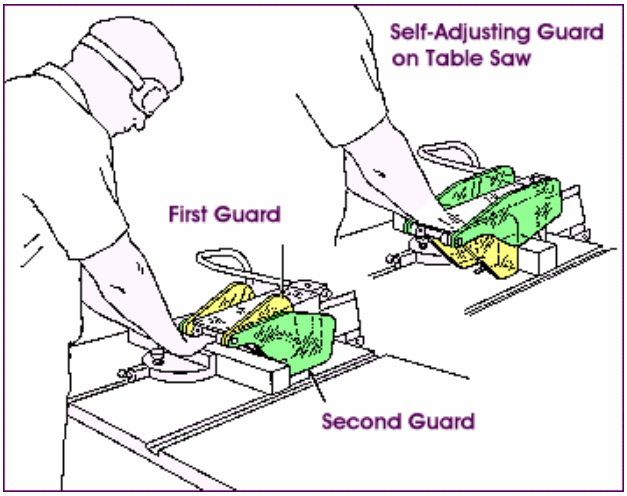
Openings are determined by the movement of stock

- Guard is pushed away as stock is introduced;
- Opening is only large enough to admit the stock;
- Guard returns to rest position after stock passes through.





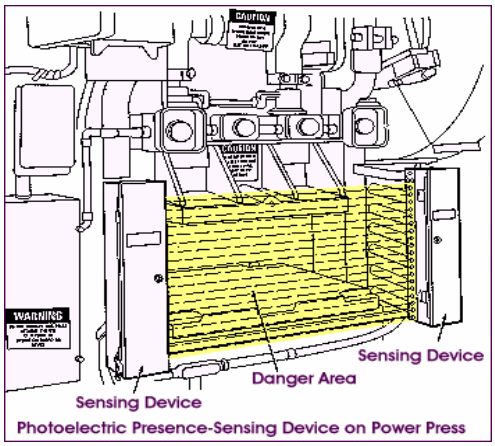




Second Safeguarding Strategy: Devices

A safety device may perform one of several functions.

- It may 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; or
- 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.

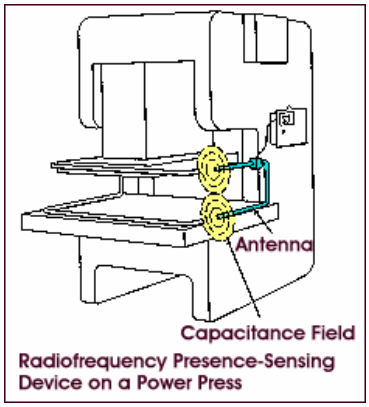


Photoelectric Presence-Sensing Device on Power Press

Presence-Sensing Devices

Photoelectric (optical)

Uses a system of light sources and controls which can interrupt the machine's operating cycle.



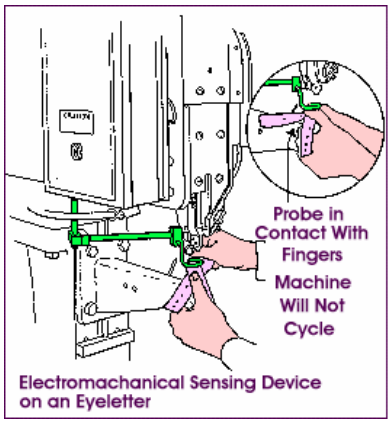
Radiofrequency Presence-Sensing Device on a Power Press

Radiofrequency (capacitance)

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.

Electromechanical

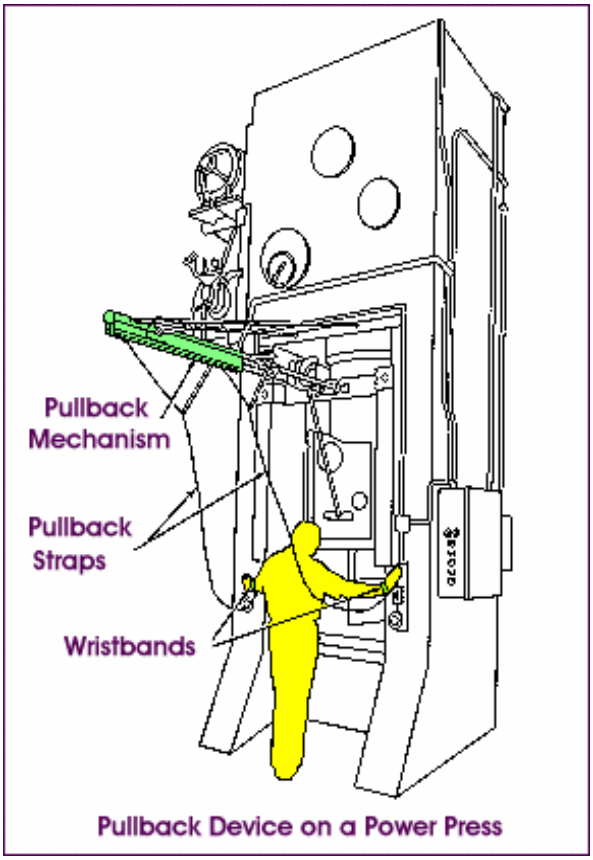
Has a probe or contact bar which descends to a predetermined distance when the operator initiates the machine cycle. If there is an obstruction preventing it from descending its full predetermined distance, the control circuit does not actuate the machine cycle.



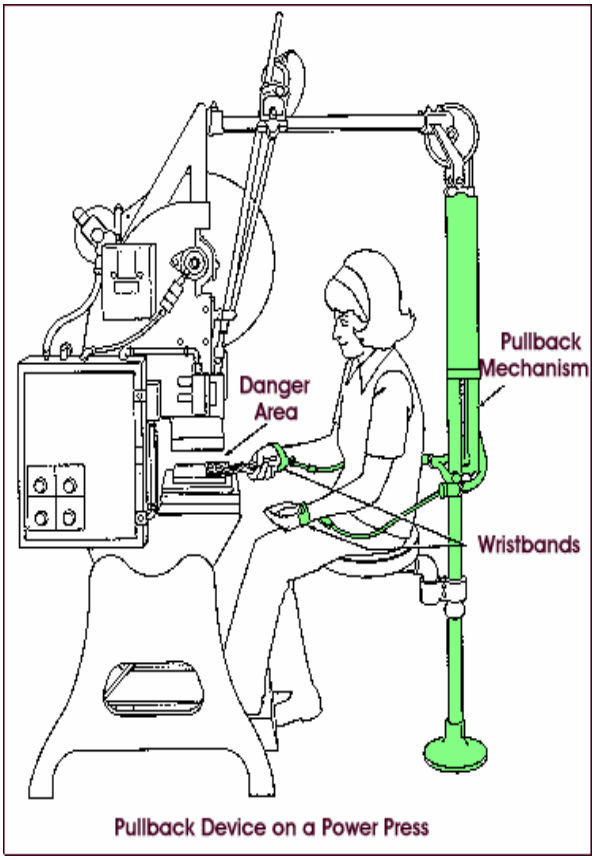
Electromachanical Sensing Device on an Eyeletter

Pullback

Pullback devices utilize a series of cables attached to the operator's hands, wrists, and/or arms. This type of device is primarily used on machines with stroking action. When the slide/ram is up between cycles, the operator is allowed access to the point of operation.



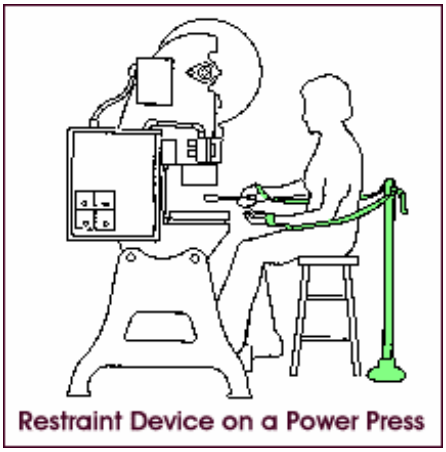
Pullback Device on a Power Press



Pullback Device on a Power Press

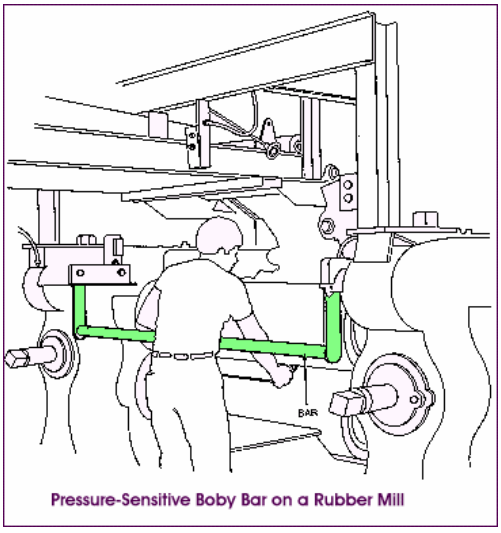
Restraint

The restraint (holdout) device utilizes cables or straps that are attached to the operator's hands at 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.

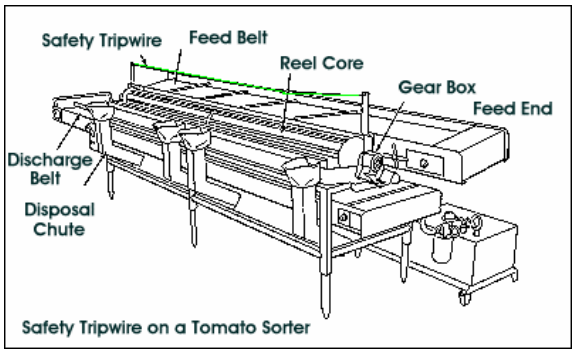

Restraint Device on a Power Press

Safety Trip Controls

Provide a quick means for deactivating the machine in an emergency situation. A **pressure-sensitive bar**, when depressed, will deactivate the machine.



Pressure-Sensitive Boby Bar on a Rubber Mill

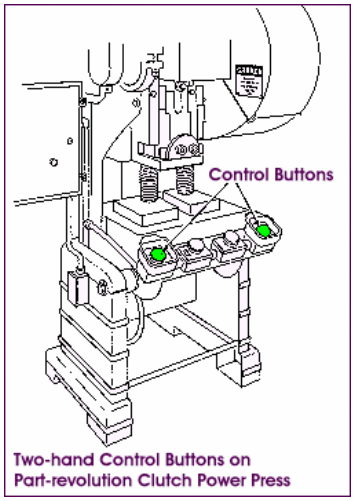


Safety Tripwire on a Tomato Sorter

Safety **tripwire cables** may also be located around the perimeter or near the danger area.

Two-Hand Controls

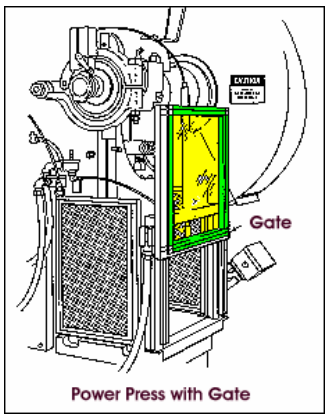
Requires constant, concurrent pressure by the operator to activate the machine. With this type of device, the operator's hands are required to be at a safe location (on the control buttons) and at a safe distance from the danger area.



Two-hand Control Buttons on Part-revolution Clutch Power Press

Two-Hand Trip

This device requires concurrent application of both the operator's control buttons to activate the machine cycle, after which the hands are free.



Power Press with Gate

Gate

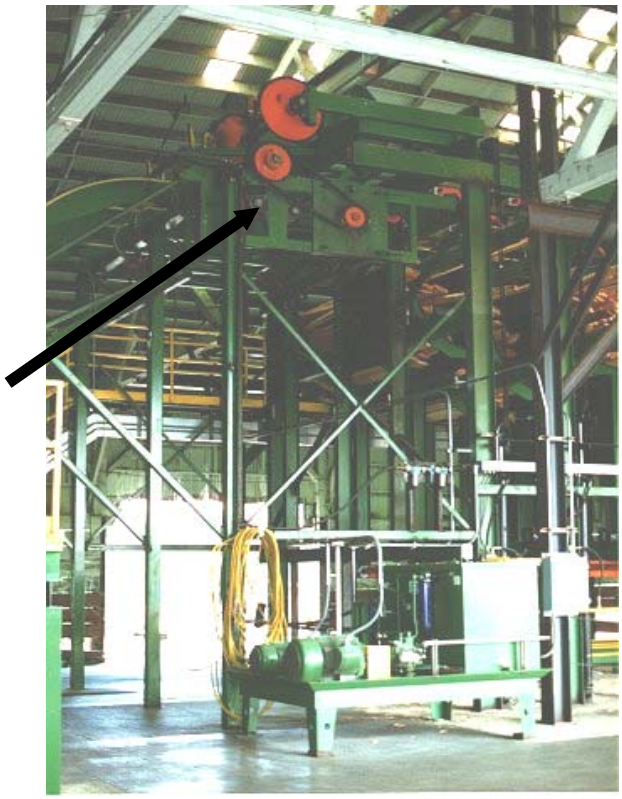
A gate is a movable barrier which protects the operator at the point of operation before the machine cycle can be started. They are usually designed to operate with each machine cycle.

Two types: Type A & Type B

Third Safeguarding Strategy: Location & Distance

The machine or its dangerous moving parts are positioned so that the hazardous areas are not accessible or do not present a hazard during normal operation

- Walls
- Barriers/Fences
- Height above worker
- Size of stock (single end feed, punching)
- Controls (positioned at a safe distance)



What are some concerns when considering guarding by location and/or distance?

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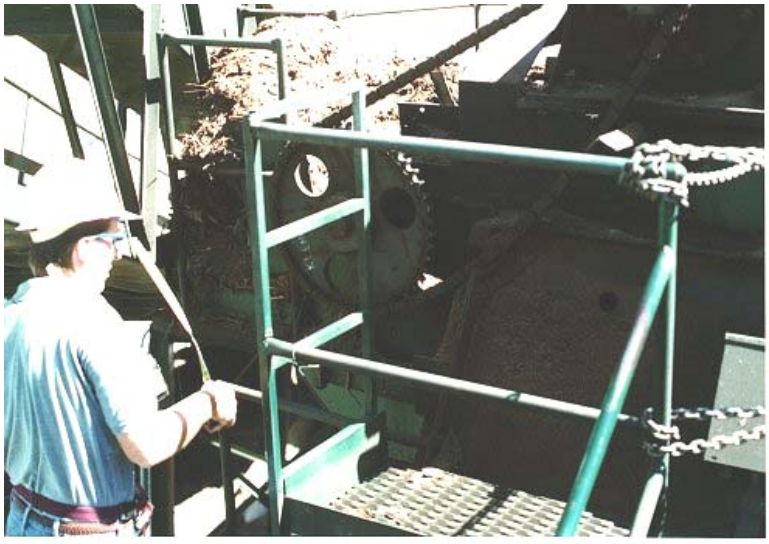
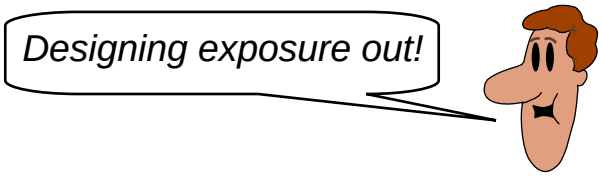
_____
_____
_____
_____

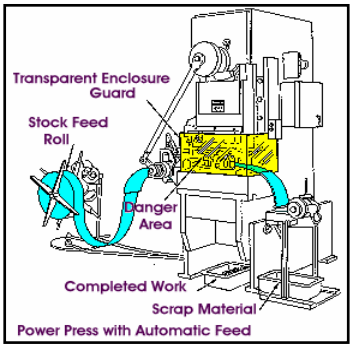


Fourth Safeguarding Strategy: Feeding & Injection



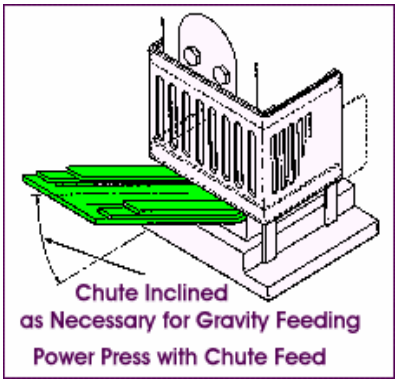
Automatic Feeding

Operator involvement is not necessary after the machine is set up



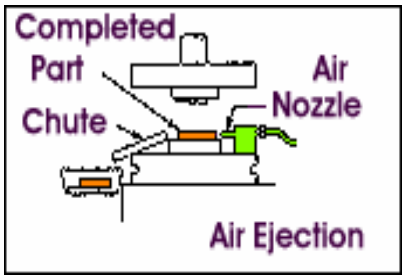
Semi-Automatic Feeding

Manually feed without reaching into the point of operation or other danger zones

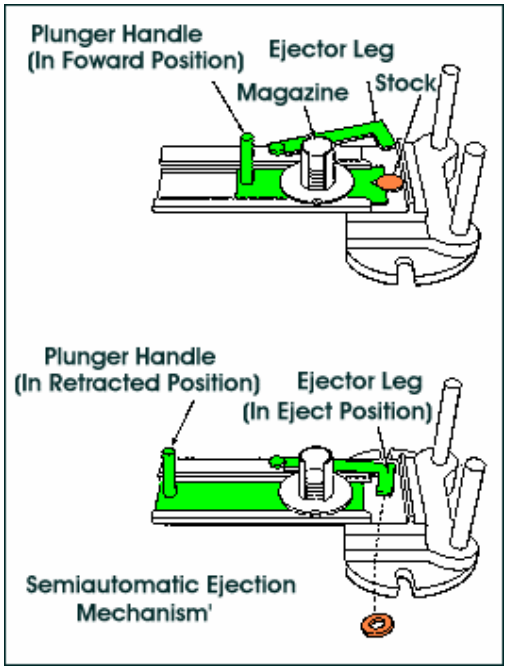


Automatic Ejection

Require no operator involvement



Semiautomatic Ejection



What are some concerns when considering feeding/ejection methods?

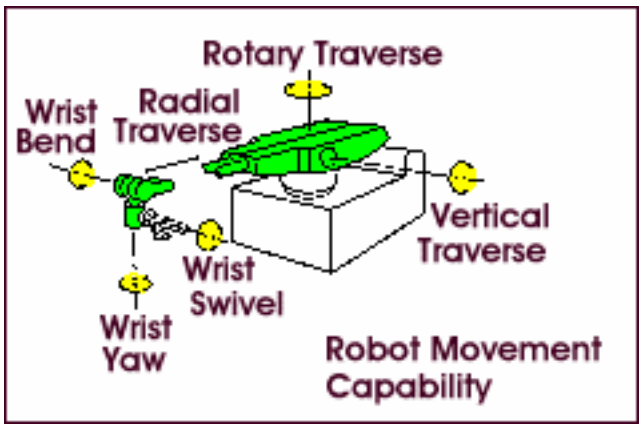
_____

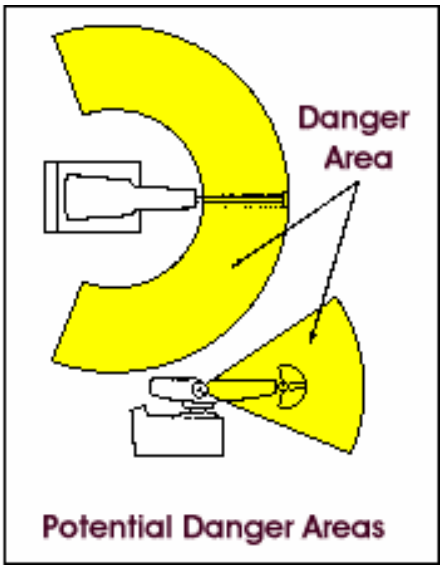
_____

_____

Robots

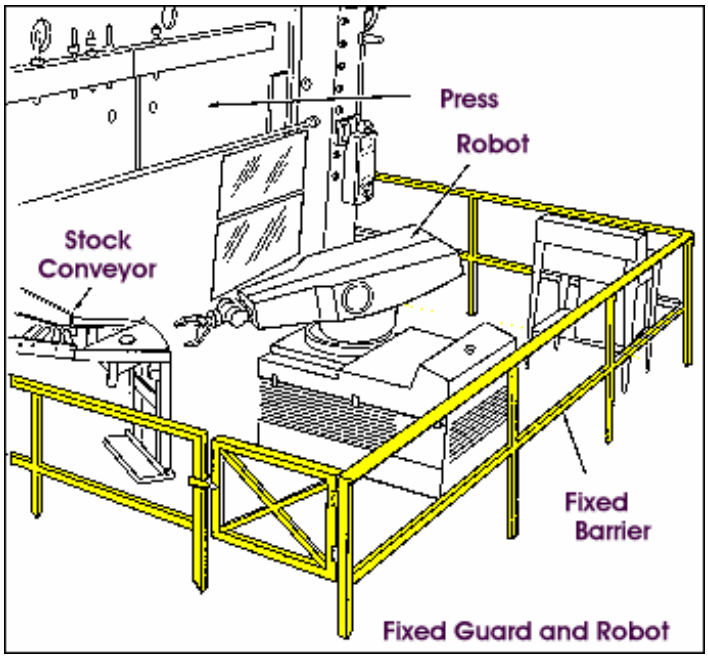
Machines that load and unload stock, assemble parts, transfer objects, and perform other tasks - otherwise done by the operator.





What are some concerns when considering robotics?

_____
_____
_____
_____

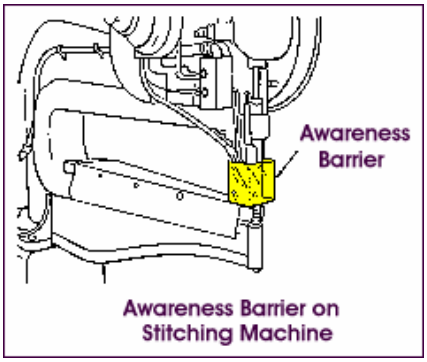


Fifth safeguard strategy: Miscellaneous Aids

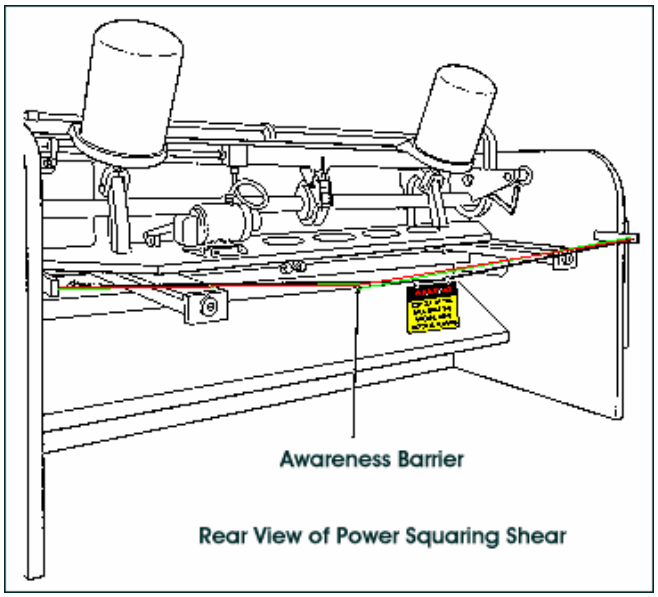
May not give complete protection from machine hazards, but may provide the operator with an extra margin of safety.

Examples:

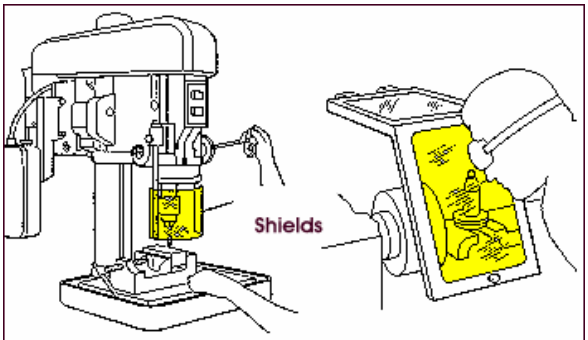
- Awareness barriers
- Ropes
- Shields
- Holding tools
- Push sticks or blocks



Awareness Barrier on Stitching Machine



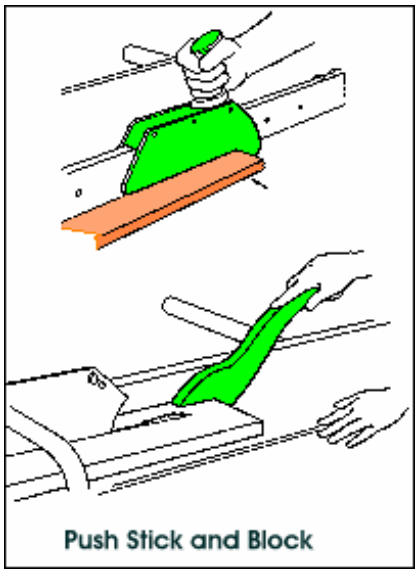
Rear View of Power Squaring Shear

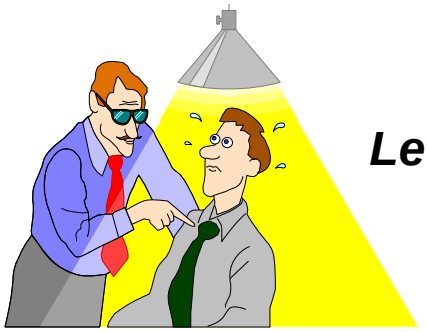


Transparent Shields on Drill and Lathe

What are some concerns when using miscellaneous aids?

_____
_____
_____
_____


Push Stick and Block



Let's review!

1. Machine guarding protects operators and prevents injury from……

   P____ __ _____ F_____ C_____

   R_____ P_____ S_____ N___ P_____

2. Three basic area require machine safeguarding. Circle the three:

   Other danger areas Point of operation Power transmission apparatus

3. What are the three types of equipment/machine motions that present hazards to the worker?

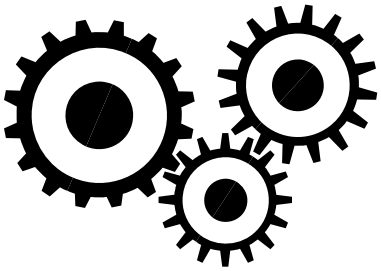
   R_____ R_____ T_____

4. What are the three types of in-running nip points?

   Parts rotating in o_____ direction

   Rotating and t_____ moving parts

   Rotating and f_____ parts



5. What are the four types of equipment/machine actions that can injure the worker?

   A. Cutting B. Shearing C. Punching D. Bending E. All of the above

6. List the four general types of guards.

   F_____ I_____ A_____ S____ A_____

6. List at least two types of safeguard devices.

7. What are the requirements for effective guards?

Appendix

Placing guards at a safe distance

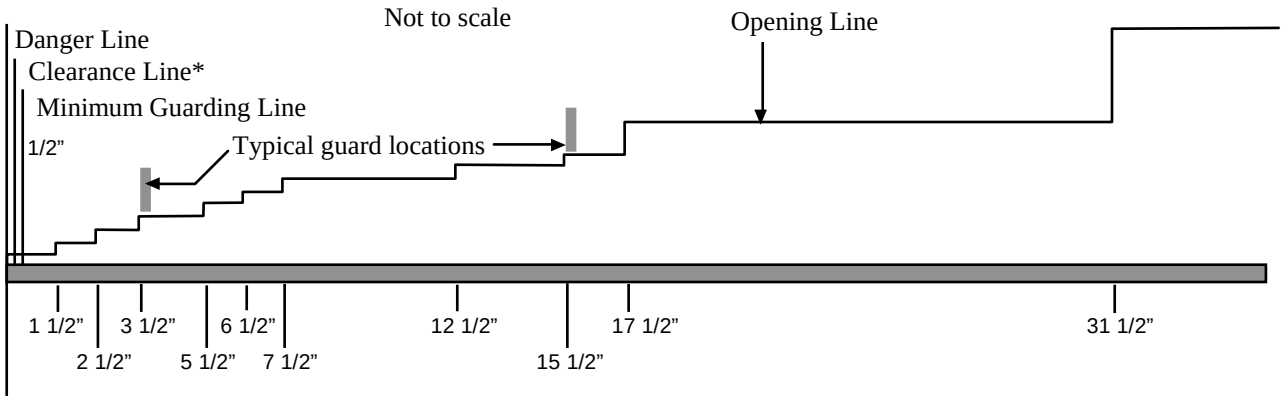
This diagram shows the accepted safe openings between the bottom edge of a guard and feed table at various distances from the **danger line** or point of operation.

The **clearance line** marks the distance required to prevent contact between guard and moving parts.

The **minimum guarding** line is the distance between the infeed side of the guard and the danger line which is one-half inch from the danger line.

The various openings are such that for average size hands, an operator's fingers won't reach the point of operation.

After installation of point of operation guards and before a job is released for operation a check should be made to verify that the guard will prevent the operator's hands from reaching the point of operation.



*Guard must extend from some point on the clearance line to some point on opening line

Distance of opening from point of operation hazard (inches)	Maximum width of opening (inches)
1/2 to 1 1/2	1/4
1 1/2 to 2/12	3/8
2 1/2 to 3 1/2	1/2
3 1/2 to 5 1/2	5/8
5 1/2 to 6 1/2	3/4
6 1/2 to 7 1/2	7/8
7 1/2 to 12 1/2	1 1/4
12 1/2 to 15 1/2	1 1/2
15 1/2 to 17 1/2	1 7/8
17 1/2 to 31 1/2	2 1/8
Over 31 1/2	6

Machine Guarding Checklist

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

____ ____ 1. Do the safeguards provided meet the minimum OSHA requirements?

____ ____ 2. Do the safeguards prevent workers' hands, arms, and other body parts for making contact with dangerous moving parts?

____ ____ 3. Are the safeguards firmly secured and not easily removable?

____ ____ 4. Do the safeguards ensure that no object will fall into the moving parts?

____ ____ 5. Do the safeguards permit safe, comfortable, and relatively easy operation of the machine?

____ ____ 6. Can the machine be oiled without removing the safeguard?

____ ____ 7. Is there a system for shutting down the machinery before safeguards are removed?

____ ____ 8. Can the existing safeguards be improved?

Mechanical Hazards

Y N

The point of operation:

____ ____ 1. Is there a point-of-operation safeguard provided for the machine?

____ ____ 2. Does it keep the operator's hands, fingers, body out of the danger area?

____ ____ 3. Is there evidence that the safeguards have been tampered with or removed?

____ ____ 4. Could you suggest a more practical, effective safeguard?

____ ____ 5. Could changes be made on the machine to eliminate the point-of-operation hazard entirely?

Requirements for all Safeguards (continued)

Yes No

Power transmission apparatus:

____ ____ 1. Are there any unguarded gears, sprockets, pulleys, or flywheels on the apparatus?

____ ____ 2. Are there any exposed belts or chain drives?

____ ____ 3. Are there any exposed set screws, key ways, collars, etc.?

____ ____ 4. Are starting and stopping controls within easy reach of the operator?

____ ____ 5. If there is more than one operator, are separate controls provided?

Other moving parts:

____ ____ 1. Are safeguards provided for all hazardous moving parts of the machine including auxiliary parts?

Nonmechanical Hazards

____ ____ 1. Have appropriate measures been taken to safeguard workers against noise hazards?

____ ____ 2. Have special guards, enclosures, or personal protective equipment been provided, where necessary, to protect workers from exposure to harmful substances used in machine operation?

Electric Hazards

____ ____ 1. Is the machine installed in accordance with National Fire Protection Association and National Electrical Code requirements?

____ ____ 2. Are there loose conduit fittings?

____ ____ 3. Is the machine properly grounded?

____ ____ 4. Is the power supply correctly fused and protected?

____ ____ 5. Do workers occasionally receive minor shocks while operating any of the machines?

Requirements for all Safeguards (continued)

Yes No

Training

____ ____ 1. Do operators and maintenance workers have the necessary training in how to use the safeguards and why?

____ ____ 2. Have operators and maintenance workers been trained in where the safeguards are located, how they provide protection, and what hazards they protect against?

____ ____ 3. Have operators and maintenance workers been trained in how and under what circumstances guards can be removed?

____ ____ 4. Have workers been trained in the procedures to follow if they notice guards that are damaged, missing, or inadequate?

Protective Equipment and Proper Clothing

____ ____ 1. Is protective equipment required?

____ ____ 2. 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?

____ ____ 3. Is the operator dressed safely for the job (i.e., no loose-fitting clothing or jewelry)?

Machinery Maintenance and Repair

____ ____ 1. Have maintenance workers received up-to-date instruction on the machines they service?

____ ____ 2. Do maintenance workers lock out the machine from its power sources before beginning repairs?

____ ____ 3. Where several maintenance persons work on the same machine, are multiple lockout devices used?

____ ____ 4. Do maintenance persons use appropriate and safe equipment in their repair work?

____ ____ 5. Is the maintenance equipment itself properly guarded?

____ ____ 6. Are maintenance and servicing workers trained in the requirements of 29 CFR 1910.147, lockout/tagout hazard, and do the procedures for lockout/tagout exist **before** they attempt their tasks?

Managing a Machine Guarding Program

When it comes to machine guarding a good rule-of-thumb to follow is, "if you can touch a moving part, guard it." Where the operation of a machine or accidental contact with it can injure the operator or others in the vicinity, the hazard must be either controlled or eliminated. This section describes some of the hazards of mechanical motion and action and presents some techniques for protecting workers from these hazards.

If appropriate, the safety committee may want to assign a member to monitor machine guarding throughout the workplace to make sure all machines are properly guarded.

Where Mechanical Hazards Occur

Dangerous moving parts in these three areas need safeguarding:

- The point of operation: that point where work is performed on the material, such as cutting, shaping, boring, or forming stock.
- Power transmission apparatus: all components of the mechanical system which transmit energy to the part of the machine performing the work. These components include flywheels, pulleys, belts, connecting rods, couplings, cams, spindles, chains, cranks, and gears.
- Other moving parts: all parts of the machine which move while the machine is working. These can include reciprocating, rotating, and transverse moving parts, as well as feed mechanisms and auxiliary parts of the machine.

Hazardous Mechanical Motions and Actions

A wide variety of mechanical motions and actions may present hazards to the worker. These can include 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.

Requirements for Safeguards

What must a safeguard to protect workers against mechanical hazards? Safeguards must meet these minimum general requirements:

- *Prevent contact*: The safeguard must prevent hands, arms, or any other part of a worker's body from making contact with dangerous moving parts. A good safeguarding system eliminates the possibility of the operator or another worker placing their hands near hazardous moving parts.
- *Secure:* 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. Guards and safety devices should be made of durable material that will withstand the conditions of normal use. They must be firmly secured to the machine.
- *Protect from falling objects*: 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 injury someone.
- *Create no new hazards*: A safeguard defeats its own purpose if it creates a hazard of its own such as shear point, a jagged edge, or an unfinished surface which can cause a laceration. The edges of guards, for instance, should be rolled or bolted in such a way that they eliminate sharp edges.
- *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.
- *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.

Training

Even the most elaborate safeguarding system cannot offer effective protection unless the worker knows how to use it and why. Specific training is a crucial part of any effort to provide safeguarding against machine-related hazards. Thorough operator training should:

1. Identify and describe the hazards associated with particular machines.
2. Discuss the safeguards and how they provide protection.
3. Discuss how to use the safeguards and why.
4. Discuss how and under what circumstances safeguards can be removed.
5. Discuss under what circumstances a safeguard can be removed, and by whom.
6. Describe what to do if a safeguard is damaged, missing, or unable to provide adequate protection.