

MACHINE GUARDING & EQUIPMENT SAFETY

29 CFR-§1910.211-.219 - Machine Guarding

Basics of Machine Safeguarding

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. When 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 information describes the various hazards of mechanical motion and describes some techniques for protecting workers from these hazards. General information 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 of non-mechanical hazards.

Principles

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

- Point of operation
- In-running nip points
- Rotating parts
- Flying chips
- Sparks

Where Mechanical Hazards Occur

Dangerous moving parts in three basic areas require safeguarding:

1. Point of Operation

- Cutting
- Shaping
- Grinding
- Boring
- Forming
- Turning
- Shearing
- Punching
- Bending
- Drilling

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 moves while the machine is working:

- Reciprocating
- Rotating
- Transverse
- Feed mechanisms
- Auxiliary parts

Hazardous Mechanical Motions

A wide variety of mechanical ***motions*** and actions may present hazards to the worker. These can include the movement of rotating members (*belts, sprockets, fan blades, etc.*), reciprocating arms (*shaker screens, tables, etc.*), moving belts (*transverse motion conveyors, transfer chains/belts, etc.*), meshing gears, cutting teeth, and any parts that impact or shear.

There are three basic categories of hazardous machine and equipment motions:

1. Rotating

2. Reciprocating

3. Transverse

Rotating motion can be dangerous; even smooth, slowly rotating shafts can grip clothing, and through mere skin contact force an arm or hand into a dangerous position. Injuries due to contact with rotating parts can be severe.

Collars, couplings, cams, clutches, flywheels, shaft ends, spindles, meshing gears, and horizontal or vertical shafting are some examples of common rotating mechanisms which may be hazardous. The danger increases when projections such as set screws, bolts, nocks, abrasions, and projecting keys or set screws are exposed on rotating parts.

In-running nip point hazards are caused by the rotating parts on machinery. There are three main types of in-running nips.

Parts can rotate in opposite directions while their axes are parallel to each other. These parts may be in contact (producing a nip point) or in close proximity. In the latter case the stock fed between the rolls produces the nip points. This danger is common on machines with intermeshing gears, rolling mills, and calendars.

Nip points are also created between rotating and tangentially moving parts. Some examples would be: The point of contact between a power transmission belt and its pulley, a chain and a sprocket, and a rack and pinion.

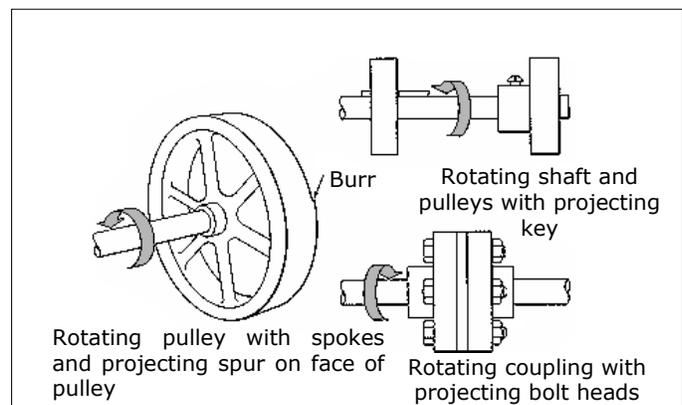
Nip points can occur between rotating and fixed parts which create a shearing, crushing, or abrading action. Examples are: Spoked handwheels or flywheels, screw conveyors, or the periphery of an abrasive wheel and an incorrectly adjusted work rest.

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

All Rotating-Motion including:

- Cams
- Sprockets
- Couplings
- Clutches
- Flywheels
- Shafts
- Pulleys
- Meshing Gears
- Fans



In-Running Nip Point Hazards

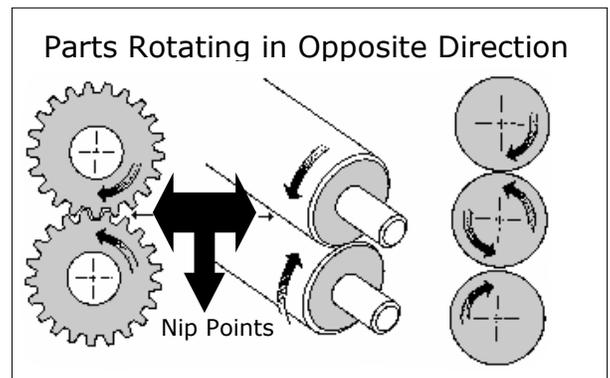
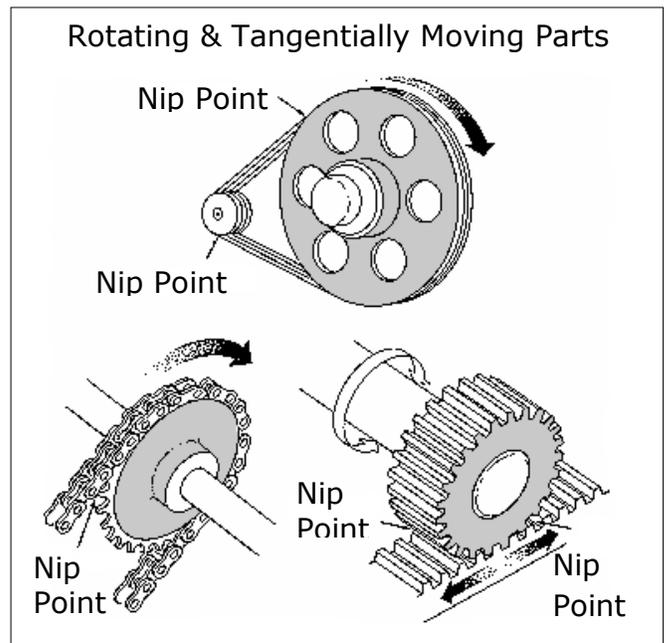
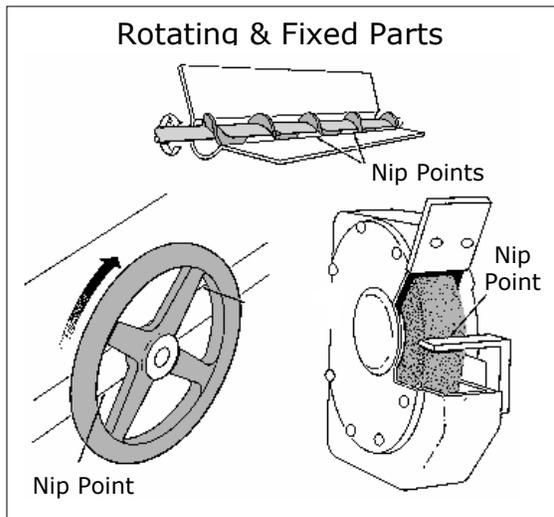
There are three main types of running nips:

1. Parts rotating in opposite direction
2. Rotating and Tangentially-moving parts
3. Rotating and Fixed parts

Reciprocating Motion

- Back & Forth; Up & Down
- May be struck by or caught between a moving or stationary part

Do you have reciprocating motion in your facility? e.g. Scissor lifts, shaker screens, feed tables, slicers, feeding/ejection parts, etc.



Transverse Motion

- Straight & Continuous Line
 - Conveyor Lines
 - Lengthy Belts

May be struck or caught in a pinch or shear point by the moving part

Hazardous Mechanical Actions

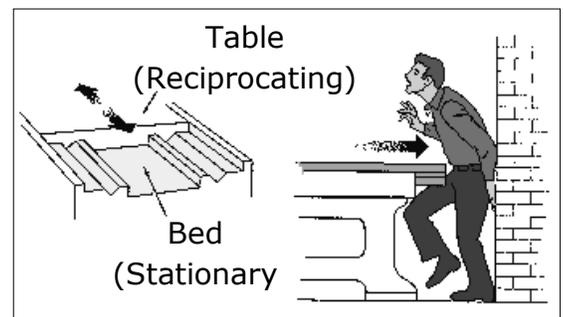
A wide variety of mechanical actions may present hazards to the worker. These can include:

Stamping/Punching (impact) action

- Cutting teeth
- Shearing blades
- Meshing gears
- Movement of rotating members
- Reciprocating arms
- Moving belts
- Rollers and brakes

There are four basic categories of hazardous machine and equipment actions:

- Cutting
- Shearing
- Bending
- Punching



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 work, metal, or other materials.

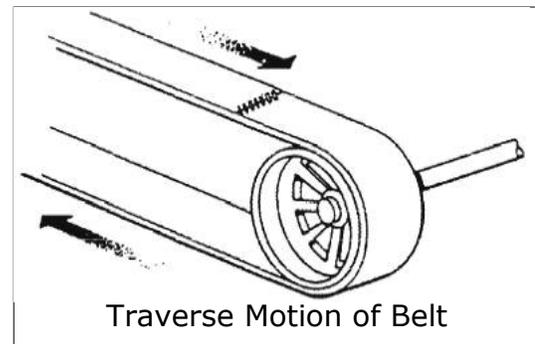
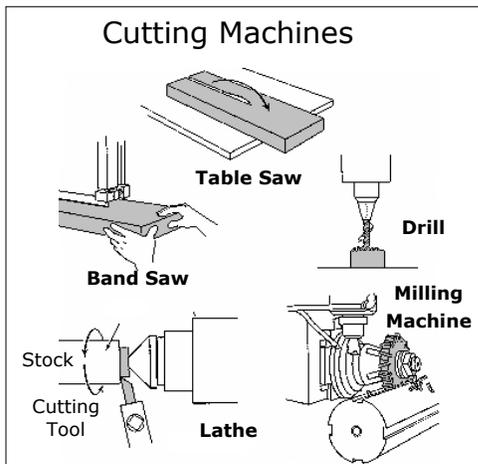
Examples of mechanisms involving cutting hazards include band saws, circular saws, boring or drilling machines, turning machines (lathes), or milling machines.

A punching action results when power is applied to a slide (ram) for the purpose of blanking, drawing, or stamping metal and 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 and iron workers.

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.

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.

These different types of hazardous mechanical 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.



Requirements for Safeguards

What must a safeguard do to protect workers against mechanical hazards?

Safeguards must meet these minimum general requirements:

Prevent contact: The safeguard must prevent hands, arms, and 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 parts of their bodies 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 injure someone.

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. 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.

Non-Mechanical Hazards

Machines obviously present a variety of other hazards which cannot be ignored. Remember that things other than safeguarding moving parts can affect the safe operation of machines.

All power sources for machines are potential sources of danger. When using electrically powered or controlled machines, for instance, the equipment as well as the electrical system itself must be properly grounded. Replacing frayed, exposed, or old wiring will also help to protect the operator and others from electrical shocks or electrocution. High pressure systems also need careful inspection and maintenance to prevent possible failure from pulsation, vibration, or leaks. Such a failure could cause, among other things, explosions or flying objects.

Machines often produce noise (unwanted sound) which can result in a number of hazards to workers. Noise can startle and disrupt concentration, and can interfere with communications, thus hindering the worker's safe job performance.

Engineering controls such as the use of sound-dampening materials, and personal protective equipment, such as ear plugs and muffs, can help control the harmful effects of noise. Also, administrative controls that involve removing the worker from the noise source can be an effective measure when feasible.

Because some machines require the use of cutting fluids, coolant, and other potentially harmful substances, operators, maintenance workers, and others in the vicinity may need protection. These substances can cause ailments ranging from dermatitis to

serious illnesses and disease. Specially constructed safeguards, ventilation, and protective equipment and clothing are possible temporary solutions to the problem of machinery-related chemical hazards until these hazards can be better controlled or eliminated from the workplace.

Training

Specific and detailed training is 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:

1. A description and identification of the hazards associated with particular machines.
2. The safeguards themselves, how they provide protection, and the hazards for which they are intended.
3. How to use the safeguards and why.
4. How and under what circumstances safeguards can be removed, and by whom (in most cases, repair or maintenance personnel only).
5. What to do (e.g., contact the supervisor) if a safeguard is damaged, missing, or unable to provide adequate protection.

This kind of safety 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.

Protective Clothing and Personal Protective Equipment

Engineering controls, which eliminate the hazard at the source and do not rely on the worker's behavior for their effectiveness, offer the best and most reliable means of machine safeguarding. Therefore, engineering controls must be the employer's first choice for eliminating machine hazards. But whenever engineering controls are not available or are not fully capable of protecting the employee (and extra measure of protection is necessary), operators must wear protective clothing or personal protective equipment.

If it is to provide adequate protection, the protective clothing and equipment selected must always be:

1. Appropriate for the particular hazards.
2. Maintained in good condition.
3. Properly stored when not in use, to prevent damage or loss.
4. Kept clean, fully functional, and sanitary.

Protective clothing is, of course, available for different parts of the body.

Hard hats can protect the head from the impact of bumps and falling objects when the worker is handling stock, caps and hair nets can help keep the worker's hair from being caught in machinery.

If machine coolants could splash, or particles could fly into the operator's eyes or face, then face shields, safety goggles, glasses, or similar kinds of protection might be necessary. Hearing protection may be needed when workers operate noisy machines. To guard the trunk of the body from cuts or impacts from heavy or rough-edged stock, there are certain protective coveralls, jackets, vests, aprons, and full-body suits. Workers can protect their hands and arms from the same kinds of injury with special sleeves and gloves. Safety shoes and boots, or other acceptable foot guards, can shield the feet against injury in case the worker needs to handle heavy stock which might drop.

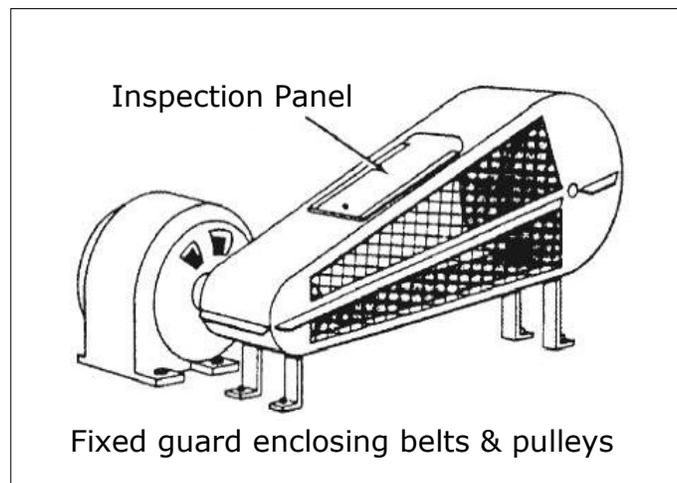
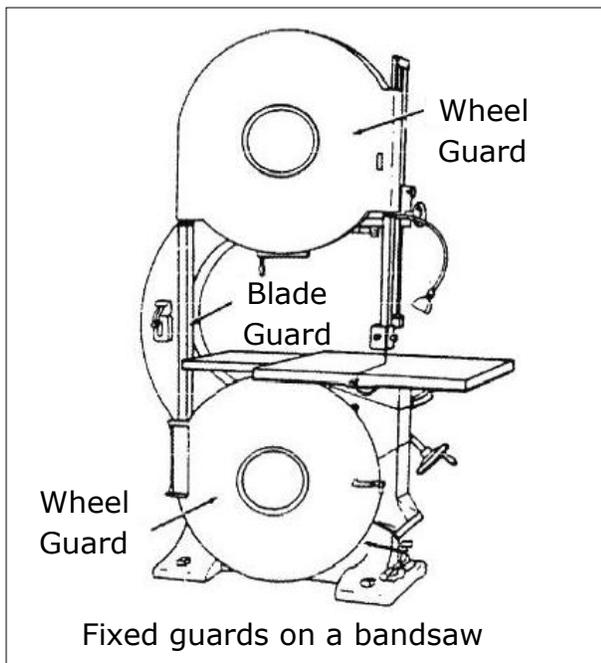
It is important to note that protective clothing and equipment can create hazards. A protective glove which can become caught between rotating parts, or a respirator face-piece which hinders the wearer's vision, for example, require alertness and continued attentiveness whenever they are used.

Other parts of the worker's clothing may present additional safety hazards. For example, loose-fitting shirts might possibly become entangled in rotating spindles or other kinds of moving machinery. Jewelry, such as bracelets and rings, can catch on machine parts or stock and lead to serious injury by pulling a hand into the danger area.

Methods of Machine Safeguarding

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 to 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.



Machine safeguards can be grouped under five general classifications:

1. **Guards**

- Fixed
- Interlocked
- Adjustable
- Self-adjusting

2. **Devices**

- Presence Sensing
 - Photoelectrical (optical)
 - Radiofrequency (capacitance)
 - Electromechanical
- Pullback
- Restraint
- Safety Controls
 - Safety trip control
 - Pressure-sensitive body bar
 - Safety trip-rod
 - Safety tripwire cable
 - Two-hand control
 - Two-hand trip
- Gates
 - Interlocked
 - Other

3. **Location/Distance**

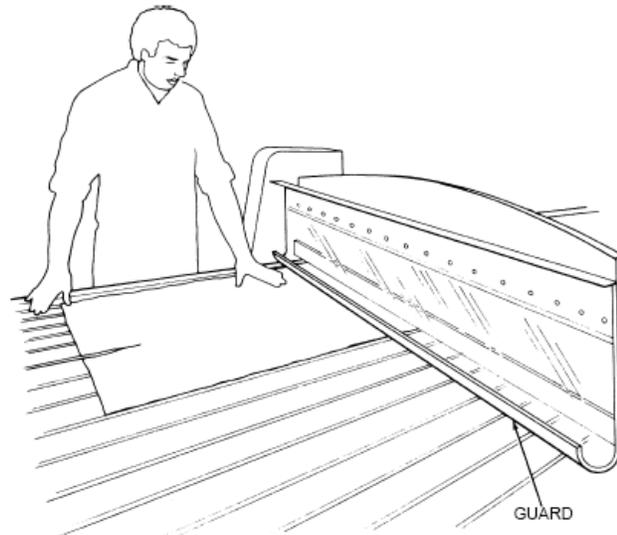
4. **Potential Feeding and Ejection Methods to Improve Safety for the Operator**

- Automatic feed
- Semi-automatic feed
- Automatic ejection
- Semi-automatic ejection
- Robot

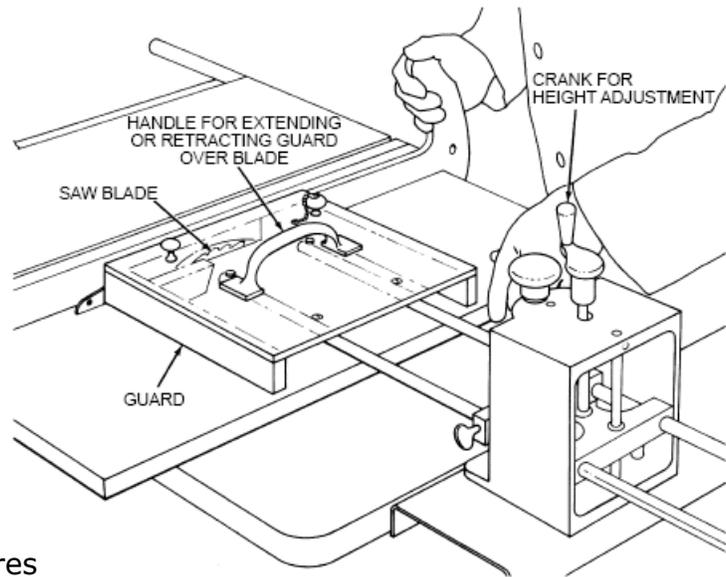
5. **Miscellaneous Aids**

- Awareness barriers
- Miscellaneous protective shields
- Hand-feeding tools and holding fixtures

Fixed guard on a veneer clipper



Adjustable guard on a table saw



Guards

Guards are barriers which prevent access to danger areas. There are four general types of guards:

Fixed: As its name implies, a fixed guard is a permanent part of the machine. It is not dependent upon moving parts to perform its intended function. It 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. This guard is usually preferable to all other types because of its relative simplicity and permanence.

Types of Machine Guards			
Method	Safeguarding Action	Advantages	Limitations
Fixed	Provides a barrier	Can be constructed to suit many specific applications. In-plant construction is often possible. Can provide maximum protection. Usually requires minimum maintenance. Can be suitable to high production, repetitive operations.	May interfere with visibility. Can be limited to specific operations. Machine adjustment and repair often require its removal, thereby necessitating other means of protection for maintenance personnel.
Interlocked	Shuts off or disengages power and prevents starting of machine when guard is open; should require the machine to be stopped before the worker can reach into the danger area.	Can provide maximum protection. Allows access to machine for removing jams without time consuming removal of fixed guards.	Requires careful adjustment and maintenance. May be easy to disengage jams.
Adjustable	Provides a barrier that may be adjusted to facilitate a variety of production operations.	Can be constructed to suit many specific applications. Can be adjusted to admit varying sizes of stock.	Hands may enter danger area – protection may not be complete at all times. May require frequent maintenance and/or adjustment. The guard may be made ineffective by the operator. May interfere with visibility.
Self-Adjusting	Provides a barrier that moves according to the size of the stock entering the danger area.	Off-the-shelf guards are often commercially available.	Does not always provide maximum protection. May interfere with visibility. May require frequent maintenance and adjustment.

Interlocked: 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.

An interlocked guard may use electrical, mechanical, hydraulic, or pneumatic power or any combination of these. Interlocks should not prevent "inching" by remote control if required. Replacing the guard should not automatically restart the machine. To be effective, all movable guards should be interlocked to prevent occupational hazards.

Adjustable: Adjustable guards are useful because they allow flexibility in accommodating various sizes of stock.

Self-Adjusting: 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.

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, thus keeping both hands and body out of danger; 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.

Presence-Sensing

The photoelectric (optical) presence-sensing device uses a system of light sources and controls which 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 design and placement of the guard depends upon the time it takes to stop the mechanism and the speed at which the employee's hand can reach across the distance from the guard to the danger zone.

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 photoelectric device, this device will only be used on machines which can be stopped before the worker can reach the danger area. This requires the machine to have a friction clutch or other reliable means for stopping.

The electromechanical 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.

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. When the slide/ram begins to cycle by starting its descent, a mechanical linkage automatically assures withdrawal of the hands from the point of operation.

Restraint

The restraint (holdout) device generally utilizes 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.

Safety Trip Controls

Safety trip controls 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 deactivates the machine. Because the trip-rod 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.

Types of Devices			
Method	Safeguarding Action	Advantages	Limitations
Photoelectric	Machine will not start cycling when the light field is interrupted. When the light field is broken by any part of the operator's body during the cycling process, immediate machine braking is activated.	Can allow freer movement for operator. Simplicity of use. Used by multiple operators. Provide passerby protection. No adjustment required.	Does not protect against mechanical failure. Limited to machines that can be stopped.
Radiofrequency (optical)	Machine cycling will not start when the capacitance field is interrupted. When the capacitance field is disturbed by any part of the operator's body during the cycling process, immediate machine braking is activated.	Can allow freer movement for operator.	Does not protect against mechanical failure. Antennae sensitivity must be properly adjusted; this adjustment must be maintained properly. Limited to machines that can be stopped.
Electromechanical	Contact bar or probe travels a predetermined distance between the operator and the danger area. Interruption of this movement prevents the starting of machine cycle.	Can allow access at the point of operation.	Contact bar or probe must be properly adjusted for each application; this adjustment must be maintained properly.

Types of Devices			
Method	Safeguarding Action	Advantages	Limitations
Pullback Restraint (holdback)	As the machine begins to cycle, the operator's hands are pulled out of the danger area. Prevents the operator from reaching into the danger area.	Eliminates the need for auxiliary barriers or other interference at the danger area. Little risk of mechanical failure.	Limits movement of operator. May obstruct work space around operator. Adjustments must be made for specific operations and for each individual. Requires frequent inspections and regular maintenance. Requires close supervision of the operator's use of the equipment.

Two-Hand Control

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 a brake monitor if used on a power press. With this type of device, the operator's hands are required to be at a safe location (on control buttons) and at a safe distance from the danger area while the machine completes its closing cycle.

Types of Devices			
Method	Safeguarding Action	Advantages	Limitations
Safety trip controls: Pressure-sensitive body bar Safety trip-rod Safety tripwire	Stops the machine when tripped.	Simplicity of use.	All controls must be manually activated. May be difficult to activate controls because of their location. Only protects the operator. May require special fixtures to hold work. May require a machine brake.
Two-hand Control	Concurrent use of both hands is required, preventing the operator from entering the danger area.	Operator's hands are at a pre-determined location. Operator's hands are free to pick up a new after first half of cycle is completed.	Requires a partial cycle machine with a brake. Some two-hand controls can be rendered unsafe by holding with arm or blocking, thereby permitting one-hand operation. Protects only the operator.

<p>Two-hand Trip</p>	<p>Concurrent use of two hands on separate controls prevents hands from being in danger area when machine cycle starts.</p>	<p>Operator's hands are away from danger area. Can be adapted to multiple operations. No obstruction to hand feeding. Does not require adjustment for each operation.</p>	<p>Operator may try to reach into danger area after tripping machine. Some trips can be rendered unsafe by holding with arm or blocking, thereby permitting one-hand operation. Protects only the operator. May require special fixtures.</p>
<p>Gate</p>	<p>Provides a barrier between danger area and operator or other personnel</p>	<p>Can prevent reaching into or walking into the danger area.</p>	<p>May require frequent inspection and regular maintenance. May interfere with operator's ability to see the work.</p>

Two-Hand Trip

The two-hand trip requires concurrent application of both 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. The distance from the trip button depends upon the speed of the cycle and the band speed constant.

Thus the operator's hands are kept far enough away to prevent them from being placed in the danger area prior to the slide/ram or blade reaching the full "down" position.

To be effective, both two-hand controls and trips must be located so that the operator cannot use two hands or one hand and another part of his/her body to trip the machine.

Gate

A gate is a moveable barrier that 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.

To be effective, the gate must be interlocked so that the machine will not begin a cycle unless the gate guard is in place. It must be in the closed position before the machine can 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.

Safeguarding by Location/Distance

The examples mentioned are a few of the numerous applications of the principle of safeguarding by location/distance. A thorough hazard analysis of each machine and particular situation is absolutely essential before attempting this safeguarding technique.

To consider a part of a machine to be safeguarded by location, the dangerous moving part of a machine must be so positioned that those areas are not accessible or do not present a hazard to a worker during the normal operation of the machine.

This may be accomplished by locating a machine so that the hazardous parts of the machine are located away from operator work stations or other areas where employees walk or work. This can be accomplished by positioning a machine with its power transmission apparatus against a wall and leaving all routine operations conducted on the other side of the machine. Additionally, enclosure walls or fences can restrict access to machines. Another possible solution is to have dangerous parts located high enough to be out of the normal reach of any worker.

The feeding process can be safeguarded by location if a safe distance can be maintained to protect the worker's hands. The dimensions of the stock being worked on may provide adequate safety.

For instance, if the stock is several feet long and only one end of the stock is being worked on, the operator may be able to hold the opposite end while the work is being performed. An example would be a single-end punching machine. However, depending upon the machine, protection might still be required for other personnel.

The positioning of the operator's control station provides another potential approach to safeguarding by location. Operator controls may be located at a safe distance from the machine if there is not a reason for the operator to tend it.

Feeding and Ejection Methods to Improve Operator Safety:

Many feeding and ejection methods do not require the operator to place his or her hands in the danger area. In some cases, not operator involvement is necessary after the machine is set up. In other situations, operators can manually feed the stock with the assistance of a feeding mechanism. Properly designed ejection methods do not require any operator involvement after the machine starts to function.

Some feeding and ejection methods may even create hazards themselves. For instance, a robot may eliminate the need for an operator to be near the machine but may create a new hazard itself by the movement of its arm.

Using these feeding and ejection methods does not eliminate the need for guards and devices. Guards and devices must be used wherever they are necessary and possible in order to provide protection from exposure to hazards.

Types of feeding and ejection methods:

Automatic feeds reduce the exposure of the operator during the work process, and sometimes do not require any effort by the operator after the machine is set up and running.

With semi-automatic feeding, as in the case of a power press, the operator uses a mechanism to place the piece being processed under the ram at each stroke. The operator does not need to reach into the danger area, and the danger area is completely enclosed.

Types of Feeding and Ejection Methods			
Method	Safeguarding Action	Advantages	Limitations
Automatic Feed	Stock is fed from rolls, indexed by machine mechanism, etc.	Eliminates the need for operator involvement in the danger area.	Other guards are also required for operator protection – usually fixed barrier guards.
Semi-Automatic Feed	Stock is fed by chutes, movable dies, dial feed, plungers, or sliding bolster.		Requires frequent maintenance. May not be adaptable to stock variation.
Automatic Ejection	Work pieces are ejected by air or mechanical means.	Operator does not have to enter danger area to remove finished work.	May create a hazard of blowing chips or debris. Size of stock limits the use of this method. Air ejection may present a noise hazard.
Semi-Automatic Ejection	Work pieces are ejected by mechanical means which are initiated by the operator.		Other guards are required for operator protection. May not be adaptable to stock variation
Robots	They perform work usually done by operator.	Operator does not have to enter danger area. Are suitable for operations where high stress factors are present, such as heat and noise.	Can create hazards themselves. Require maximum maintenance. Are suitable only to specific operations.

Miscellaneous Aids

While these aids do not give complete protection from machine hazards, they may provide the operator with an extra margin of safety. Sound judgment is needed in their application and usage. Following are several examples of possible applications.

An awareness barrier does not provide physical protection, but serves only to remind a person that he or she is approaching the danger area. Generally, awareness barriers are not considered adequate when continual exposure to the hazard exists.

Although the barrier does not physically prevent a person from entering the danger area, it calls attention to it. For an employee to enter the danger area, an overt act must take place, that is, the employee must either reach or step over, under or through the barrier.

Shields, another aid, may be used to provide protection from flying particles, splashing cutting oils, or coolants.

Special hand tools may be used to place or remove stock, particularly from or into the point of operation of a machine. A typical use would be for reaching into the danger area of a press or press brake.

Holding tools should not be used instead of other machine safeguards; they are merely a supplement to the protection that other guards provide.

A push stick or block may be used when feeding stock into a saw blade. When it becomes necessary for hands to be in close proximity to the blade, the push stick or block may provide a few inches of safety and prevent a severe injury.

Guard Construction

Today, many builders of single-purpose machines provide point-of-operation and power transmission safeguards as standard equipment. However, not all machines in use have built-in safeguards provided by the manufacturer.

Guards designed and installed by the builder offer two main advantages:

1. They usually conform to the design and function of the machine.
2. They can be designed to strengthen the machine in some way or to serve some additional functional purposes.

User-built guards are sometimes necessary for a variety of reasons.

They have these advantages:

- Often, with older machinery, they are the only practical safeguarding solution.
- They may be the only choice for mechanical power transmission apparatus in older plants, where machinery is not powered by individual motor drives.
- They permit options for point-of-operation safeguards when skilled personnel design and make them.
- They can be designed and built to fit unique and even changing situations.
- They can be installed on individual dies and feeding mechanisms.
- Design and installation of machine safeguards by plant personnel can help to promote safety consciousness in the workplace.

However, they also have disadvantages:

- User-built guards may not conform well to the configuration and function of the machine.
- There is a risk that user-built guards may be poorly designed or built.

Point-of-Operation Guards

Point-of-operation safeguarding is complicated by the number and complexity of machines and also by the different uses for individual machines. For these reasons, not all machine builders provide point-of-operation guards on their products.

In many cases, a point-of-operation guard can only be made and installed by the user after a thorough hazard analysis of the work requirements. Poorly designed, built, or installed guards may create a hazard rather than eliminate one. To be effective, they must safeguard the employee while allowing the work to continue with minimum disruption to the production process.

Mechanical Power Transmission Apparatus Guarding

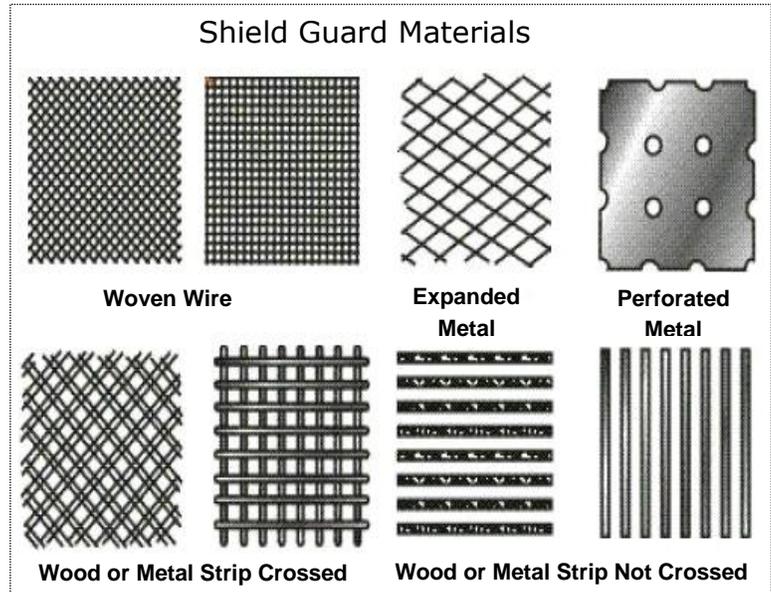
A significant difference between power transmission guards and point-of-operation guards is that the former type needs no opening for feeding stock. The only openings necessary for power transmission guards are those for lubrication, adjustment, repair, and inspection. These openings should be provided with interlocked covers that cannot be removed except by using tools for service or adjustment.

To be effective, power transmission guards should cover all moving parts in such a manner that no part of the operator's body can come in contact with them.

Guard Material

Under many circumstances, metal is the best material for guards. Guard framework is usually made from structural shapes, pipe, bar, or rod stock. Filler material generally is expanded or perforated or solid sheet metal or wire mesh. It may be feasible to use plastic or safety glass where visibility is required.

Guards made of wood generally are not recommended because of their flammability and lack of durability and strength. However, in areas where corrosive materials are present, wooden guards may be the better choice.



Machinery Maintenance and Repair

Good maintenance and repair procedures contribute significantly to the safety of the maintenance crew as well as that of machine operators. The variety and complexity of machines to be serviced, the hazards associated with their power sources, the special dangers that may be present during machine breakdown, and the severe time constraints often placed on maintenance personnel all make safe maintenance and repair work difficult.

Training and aptitude of people assigned to these jobs should make them alert for the intermittent electrical failure, the worn part, the inappropriate noise, the cracks or other signs that warn of impending breakage or that a safeguard has been damaged, altered, or removed. By observing machine operators at their tasks and listening to their comment, maintenance personnel may learn where potential trouble spots are and give them early attention before they develop into sources of accidents and injury. Sometimes, all that is needed to keep things running smoothly and safely is machine lubrication or adjustment.

Any damage observed or suspected should be reported to the supervisor; if the condition impairs safe operation, the machine should be taken out of service for repair. Safeguards that are missing, altered, or damaged also should be reported so appropriate action can be taken to insure against worker injury.

If possible, machine design should permit routine lubrication and adjustment without removal of safeguards. However, when safeguards must be removed, and the machine serviced, the OSHA lockout procedure must be adhered to. The maintenance and repair crew must never fail to replace the guards before the job is considered finished and the machine released from lockout.

Is it necessary to oil machine parts while a machine is running? If so, special safeguarding equipment may be needed solely to protect the oiler from exposure to hazardous moving parts. Maintenance personnel must know which machines can be serviced while running and which cannot.

"If in doubt, lock it out." Obviously, the danger of accident or injury is reduced by shutting off and locking out all sources of energy.

In situations where the maintenance or repair worker would necessarily be exposed to electrical elements or hazardous moving machine parts in the performance of the job, there is no question that all power sources must be shut off and locked out before work begins. Warning signs or tags are inadequate insurance against the untimely energizing of mechanical equipment.

Thus, one of the first procedures for the maintenance person is to disconnect and lock out the machine from all of its power sources, whether the source is electrical, mechanical, pneumatic, hydraulic, or a combination of these. Energy accumulation devices must be "bled down."

Electrical: Unexpected energizing of any electrical equipment that can be started by automatic or manual remote control may cause electric shock or other serious injuries to the machine operator, the maintenance worker, or others operating adjacent machines controlled by the same circuit. For this reason, when maintenance personnel must repair electrically powered equipment, they should open the circuit at the switch box and padlock the switch (lock it out) in the "OFF" position. This switch should be tagged with a description of the work being done, the name of the maintenance person, and the department involved. When more than one worker is to be engaged in the servicing/maintenance function, a typical lockout hasp to which each may affix a personal lock must be used.

Mechanical: Safety blocks should be used as an additional safeguard on equipment such as a mechanical power press, even though the machine has been locked out. The safety blocks prevent the ram from coming down under its own weight.

Pneumatic and hydraulic: Valves used during repair or shutdown to keep a pneumatic-powered machine or its components from operating can be locked open or shut. Before the valve can be opened, everyone working on the machine must use his or her own key to release the lockout. A sliding-sleeve valve exhausts line pressure at the same time it cuts off the air supply. Valves used to lock out pneumatic or hydraulic-powered machines should be designed to accept locks or lockout adapters and should be capable of "bleeding off" pressure residues that could cause any part of the machine to move.

In shops where several maintenance persons might be working on the same machine, multiple lockout devices accommodating several padlocks are used. The machine cannot be reactivated until each person removes his or her lock. As a matter of general policy, lockout control is gained by the procedure of issuing personal padlocks to each maintenance or repair person; no one but that person can remove the padlock, thereby each worker controls the power systems.

Whenever machines or equipment are serviced, there are hazards encountered by the employees performing the servicing or maintenance which are unique to the repair or maintenance procedures being conducted. These hazards may exist due to the failure of the employees doing the servicing or maintenance to stop the machine being worked on. Even if the machine has been stopped, the machine can still be hazardous due to the possibility of the machine becoming re-energized or restarting.

In order to prevent these hazards, each machine or piece of equipment should be safeguarded during the conduct of servicing or maintenance by:

1. Notifying all affected employees (usually machine or equipment operators or users) that the machine or equipment must be shut down to perform some maintenance or servicing.
2. Stopping the machine.
3. Isolating the machine or piece of equipment from its energy source.
4. Locking out or tagging out the energy source.
5. Relieving any stored or residual energy.
6. Verifying that the machine or equipment is isolated from the energy source.

Although this is the general rule, there are exceptions when the servicing or maintenance is not hazardous for an employee, when the servicing which is conducted is minor in nature, done as an integral part of production, and the employer utilizes alternative safeguards which provide effective protection as is required by specific OSHA Regulations.

When the servicing or maintenance is completed, there are specific steps which must be taken to return the machine or piece of equipment to service. These steps include:

1. Inspection of the machine or equipment to ensure that all guards and other safety devices are in place and functional.
2. Checking the area to ensure that energizing and start up of the machine or equipment will not endanger employees.
3. Removal of the lockout devices.
4. Re-energizing of the machine or equipment.
5. Notification of affected employees that the machine or equipment may be returned to service.

The steps to lockout described here are only a part of the total energy control program which must exist in the workplace. In addition, the employee should have written procedures for all machines and equipment, employees must be trained in their duties and responsibilities under the energy control program, and periodic inspections must be conducted to maintain the effectiveness of the program.

The maintenance and repair facility in the company deserves consideration here. Are all the right tools on hand and in good repair? Are lubricating oils and other common supplies readily available and safely stored?

Are commonly used machine parts and hardware kept in stock so that the crews are not encouraged (even obliged) to improvise, at the risk of doing an unsafe repair, or to postpone a repair job? And do not overlook the possibility that maintenance equipment itself may need guarding of some sort. The same precaution applies to tools and machines used in the repair shop. Certainly, the maintenance and repair crew are entitled to the same protection that their service provides to the machine operators in the company.

Ergonomic Considerations of Machine Safeguarding

The ergonomic considerations of machine safeguarding are as significant to the Health and Safety of the worker as are the multitude of techniques to accomplish Health and Safety in the workplace. Worker stress and fatigue can be averted by creditable work setups and well integrated safeguarding.

The various industry consensus standards are only now beginning to address this issue. Future evaluations of safeguarding are likely to devote more attention to this aspect.

Cooperation and Assistance

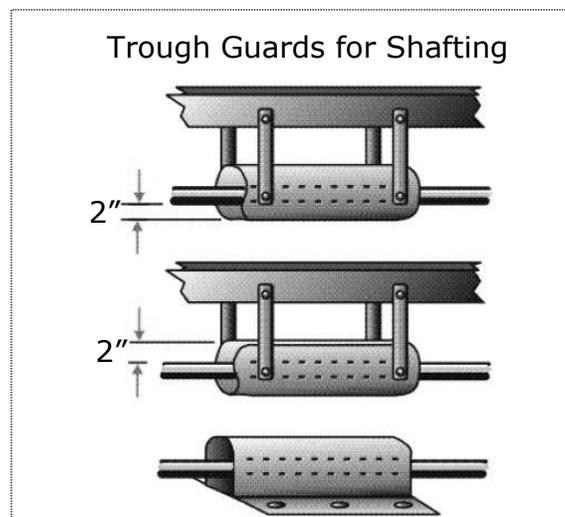
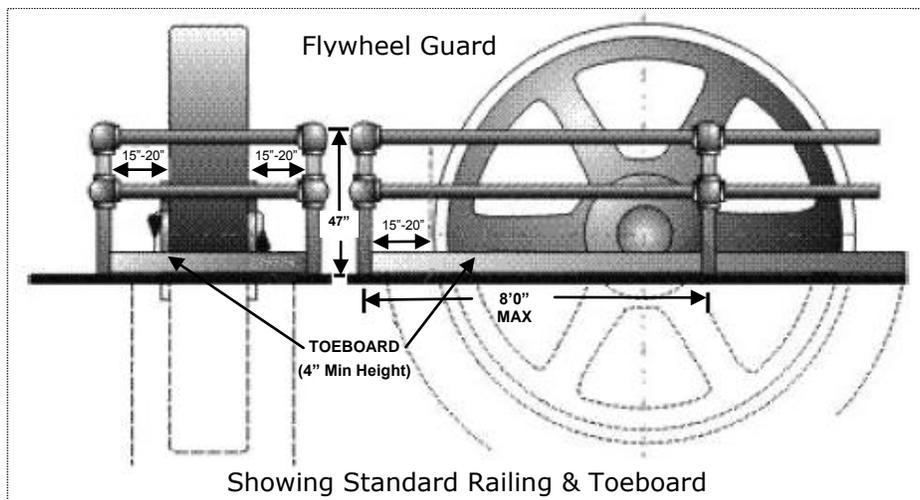
Safety in the workplace demands cooperation and alertness on everyone's part. Supervisors, operators and other workers who notice hazards in need of safeguarding, or existing systems that need repair or improvement, should notify the proper authority immediately.

Supervisors have these additional, special responsibilities with regard to safety in the workplace; explaining to the worker all the potential hazards associated with the machines and processes in the work area; and being responsive to employer requests for action or information regarding machine hazards.

The first-line supervisor plays a pivotal role in communicating the safety needs of the worker to management and the employer's safety rules and policies to the worker.

Sometimes, the solution to a machine safeguarding problem may require expertise that is not available in a given establishment. Employers are encouraged to find out where help is available and, when necessary, to request it.

The machine's manufacturer is often a good place to start when looking for assistance with a safeguarding problem. Manufacturers can often supply the necessary literature or advice, insurance carriers, too, will often make their safety specialists available to the establishments whose assets they insure. Union safety specialists can also lend significant assistance.



Machine Guarding Checklist

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

Yes	No	Requirements for All Safeguards
		Do the safeguards provided meet the minimum OSHA 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 The point of operation:		
		Is there a point-of-operation safeguard provided for the machine?
		Does it keep the operator's hands, fingers, and body out of the danger area?
		Is there evidence that the safeguards have been tampered with or removed?
		Could you suggest a more practical, effective safeguard?
		Could changes be made on the machine to eliminate the point-of-hazard entirely?
Power transmission apparatus:		
		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, key ways, collars, etc.?
		Are starting and stopping controls within easy reach of the operator?
		If there is more than one operator, are separate controls provided?
Other moving parts:		
		Are safeguards provided for all hazardous moving parts of the machine, including auxiliary parts?
Non-mechanical Hazards		
		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?

Yes	No	Electrical Hazards			
		Is the machine installed in accordance with National Electrical Code requirements?			
		Are there loose conduit fittings?			
		Is the machine properly grounded?			
		Is the power supply correctly fused and protected?			
		Do workers occasionally receive minor shocks while operating any of the machines?			
Training					
		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 Proper Clothing					
		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					
		Have maintenance workers received up-to-date instruction 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?			
		Is the maintenance equipment itself properly guarded?			
		Are maintenance and servicing workers trained in the requirements of lockout/tagout hazard, and do the procedures for lockout/tagout exist before they attempt their tasks?			
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