MACHINE SAFEGUARDING

BASICS OF MACHINE SAFEGUARDING

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.

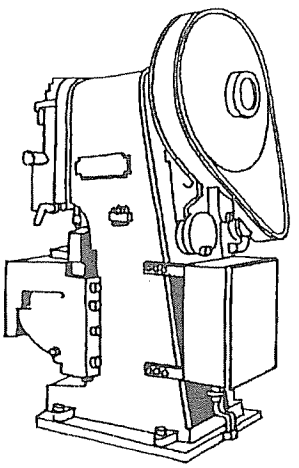


Figure 1

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 hazard must be either controlled or eliminated.

Where Mechanical Hazards Occur

Dangerous moving parts in these three basic areas need safeguarding:

The point of operation: that point where work is performed on the material, such as cutting, shaping, boring, or forming of 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 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

- rotating (including in-running nip points)
- reciprocating
- transverse

Actions

- cutting
- punching
- shearing
- bending

We will briefly examine each of these basic types in turn.

Motions

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, and horizontal or vertical shafting are some examples of common rotating mechanisms which may be hazardous. There is added danger when bolts, nicks, abrasions, and projecting keys or set screws are exposed on rotating parts on machinery, as shown in Figure 2.

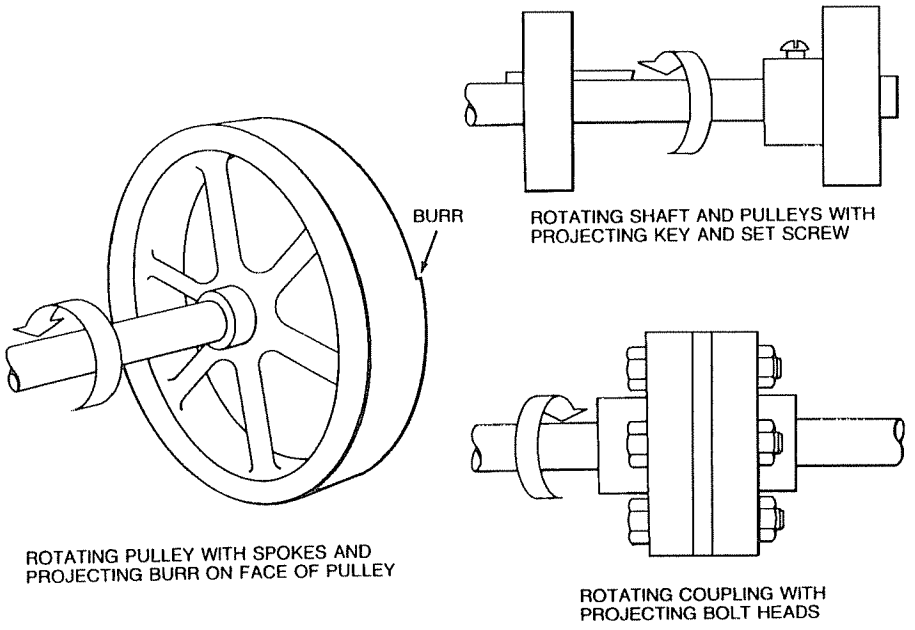


Figure 2

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

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 to each other. In the latter case, the *stock* fed between the rolls produces the nip points. This danger is common on machinery with intermeshing gears, rolling mills, and calenders as shown in Figure 3 below.

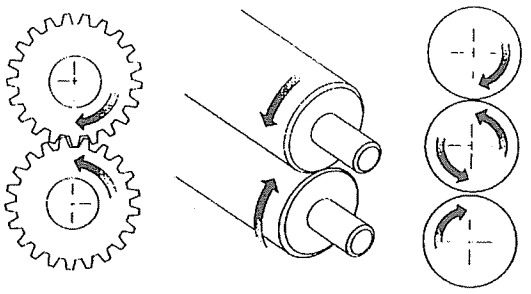


Figure 3

Another type of nip point is 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, or a rack and pinion, as shown in Figure 4.

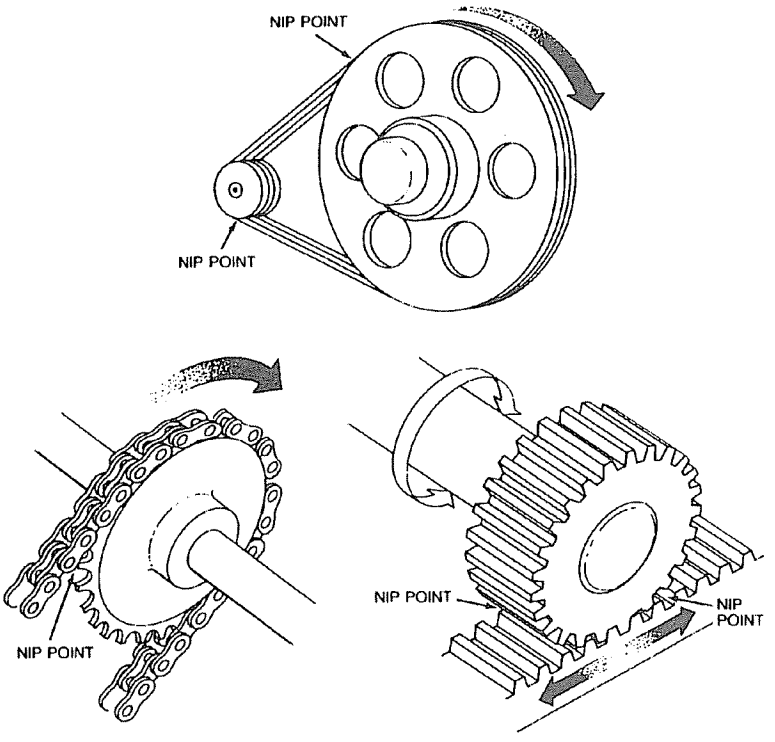


Figure 4

Nip points can also 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 as shown in Figure 5.

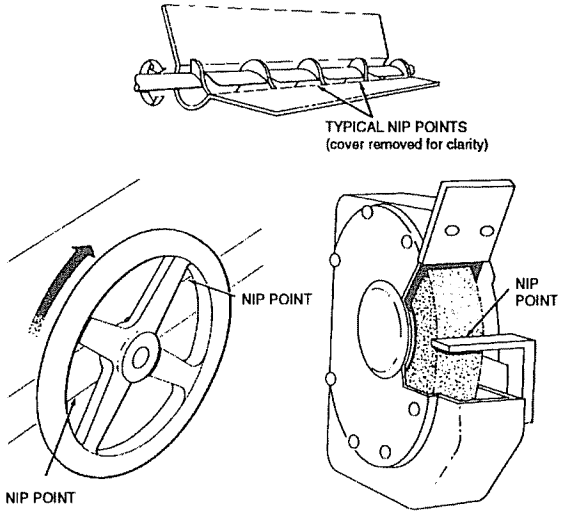


Figure 5

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. An example is shown in Figure 6.

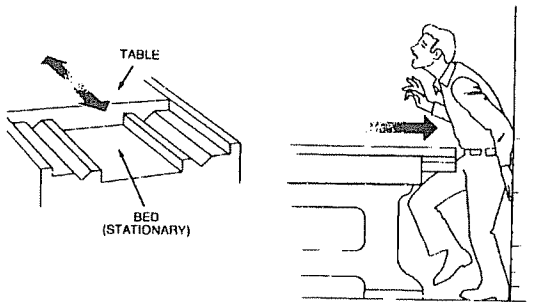
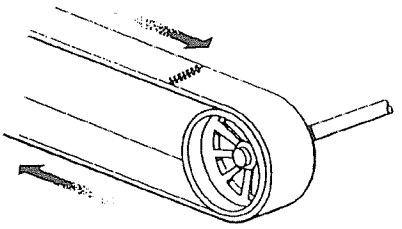


Figure 6

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 a moving part. An example of transverse motion is shown in Figure 7.



TRANSVERSE MOTION OF BELT

Figure 7

Actions

Cutting action involves rotating, reciprocating, or transverse motion. The danger of cutting action exists at the point of operation where finger, head, and arm injuries can occur and where flying chips or scrap material can strike the eyes or face. Such hazards are present at the point of operation in cutting wood, metal, or other materials. Typical examples of mechanisms involving cutting hazards include bandsaws, circular saws, boring or drilling machines, turning machines (lathes), or milling machines. See Figure 8.

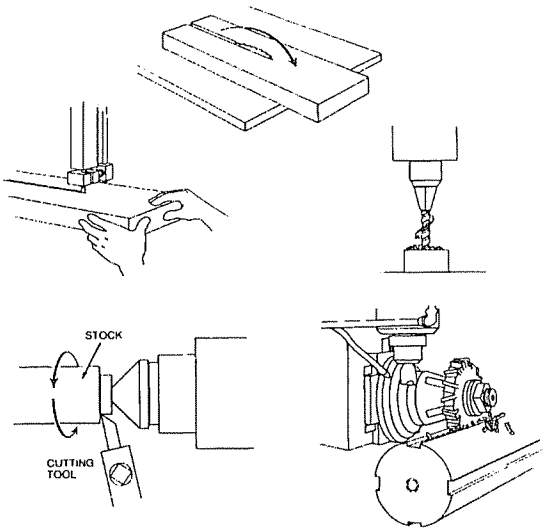


Figure 8

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

Typical machinery used for punching operations are power presses and iron workers. See Figure 9.

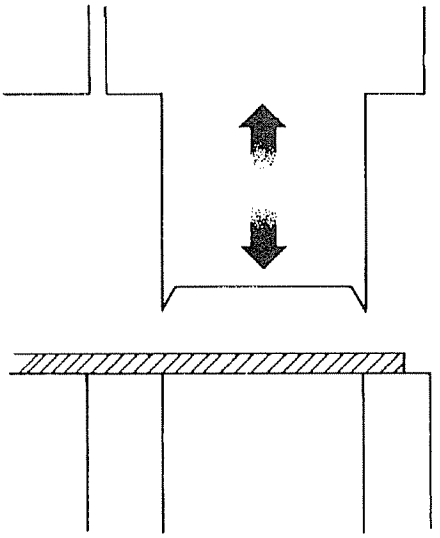


Figure 9

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.

Typical examples of machinery used for shearing operations are mechanically, hydraulically, or pneumatically powered shears. See Figure 10 below.

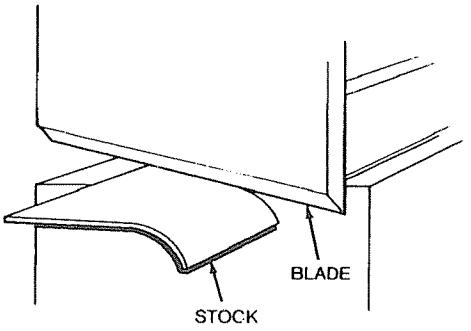


Figure 10

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. See Figure 11.

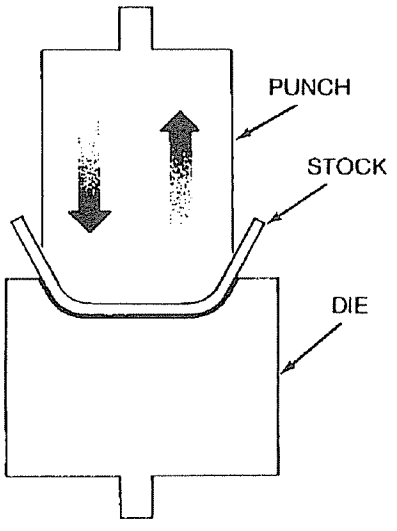


Figure 11

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, 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 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.

Training

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:

(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); and
(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.

METHODS OF MACHINE SAFEGUARDING

There are many ways to safeguard machinery. 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 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.

We can group safeguards 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
       - o Pressure-sensitive body bar

- Safety triprod
- 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

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.

In Figure 12, a fixed guard on a power press completely encloses the point of operation. The stock is fed through the side of the guard into the die area, with the scrap stock exiting on the opposite side.

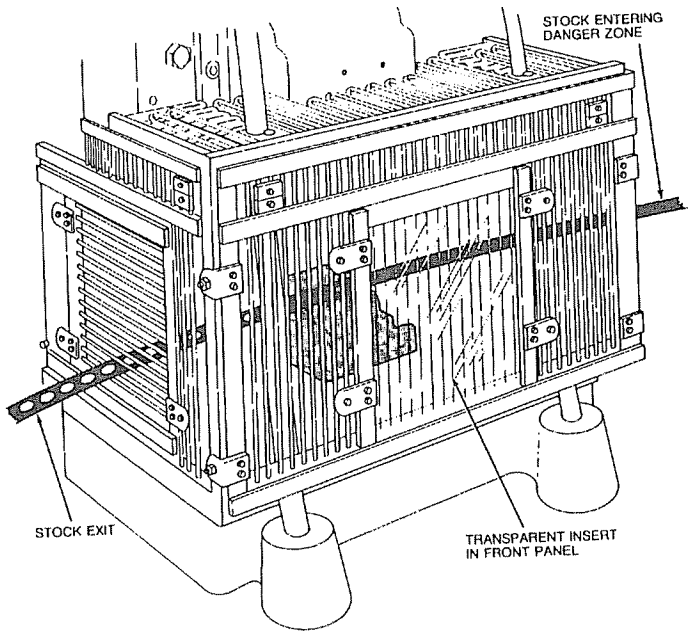


Figure 12

Figure 13 shows a fixed enclosure guard shielding the belt and pulley of a power transmission unit. An inspection panel is provided on top in order to minimize the need for removing the guard.

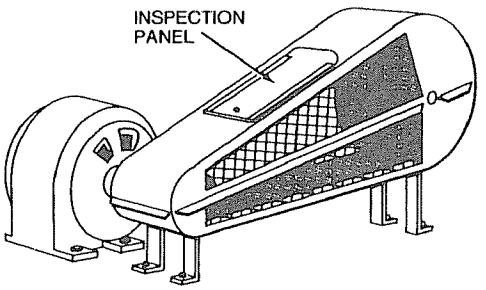


Figure 13

In Figure 14, fixed enclosure guards are shown on a bandsaw. These guards protect the operator from the turning wheels and moving saw blade. Normally, the only time for the guards to be opened or removed would be for a blade change or maintenance. It is very important that they be securely fastened while the saw is in use.

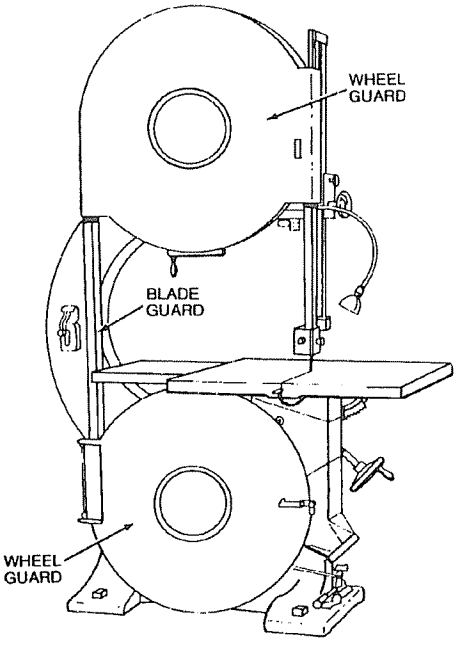


Figure 14

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.

An example of an interlocking guard is shown below in Figure 15. As shown in this figure, the beater mechanism of a picker machine (used in the textile industry) is covered by an interlocked barrier guard. This guard cannot be raised while the machine is running, nor can the machine be restarted with the guard in the raised position.

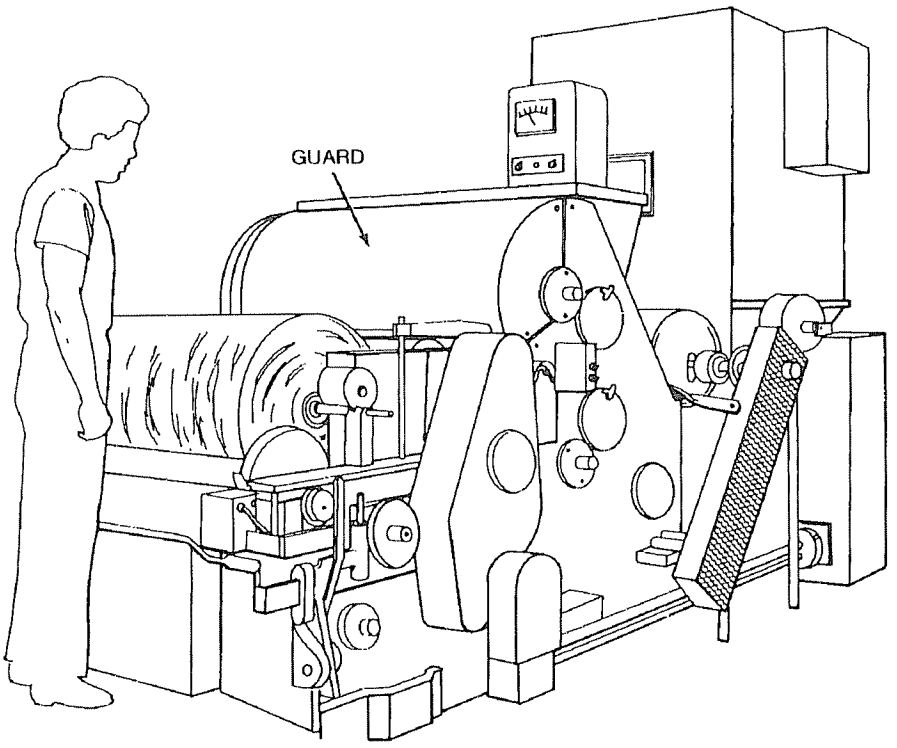


Figure 15

Adjustable: Adjustable guards are useful because they allow flexibility in accommodating various sizes of stock. Figure 16 shows an adjustable enclosure guard on a bandsaw.

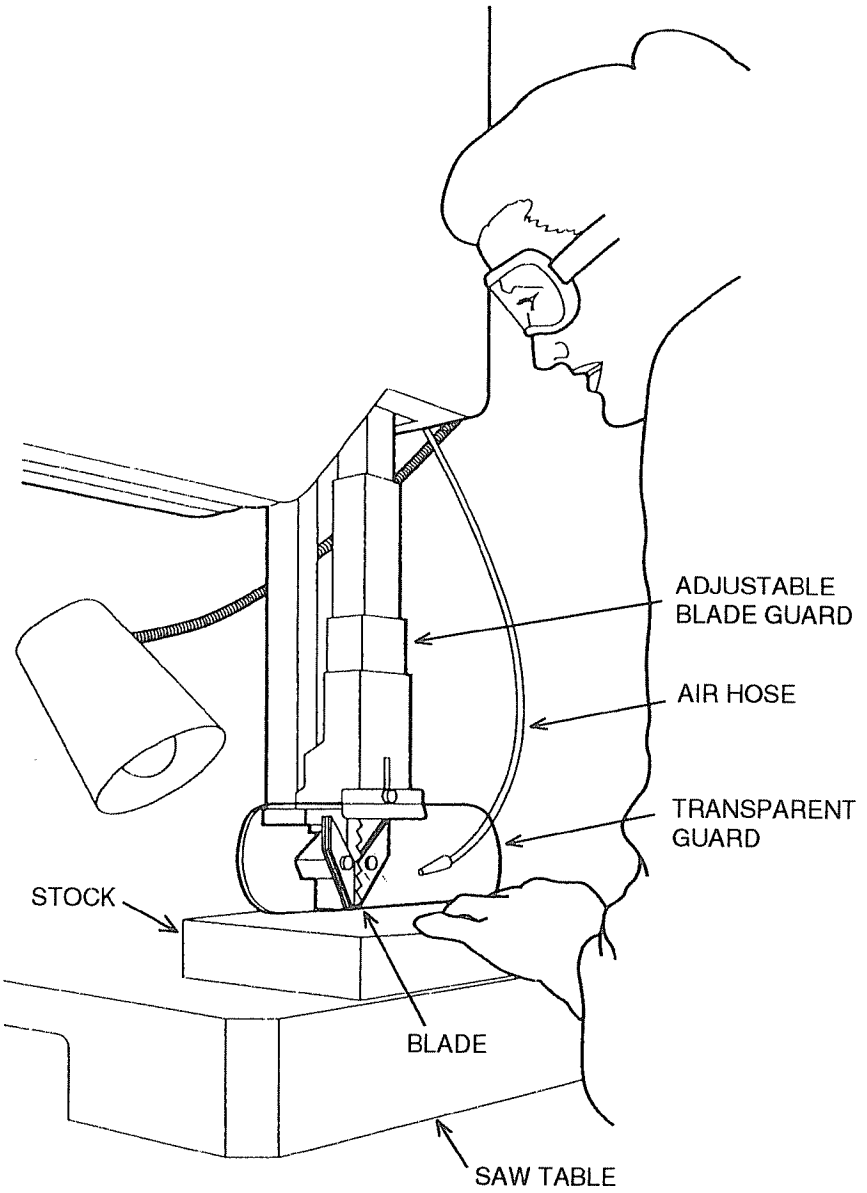


Figure 16

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.

Figure 17 shows 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.

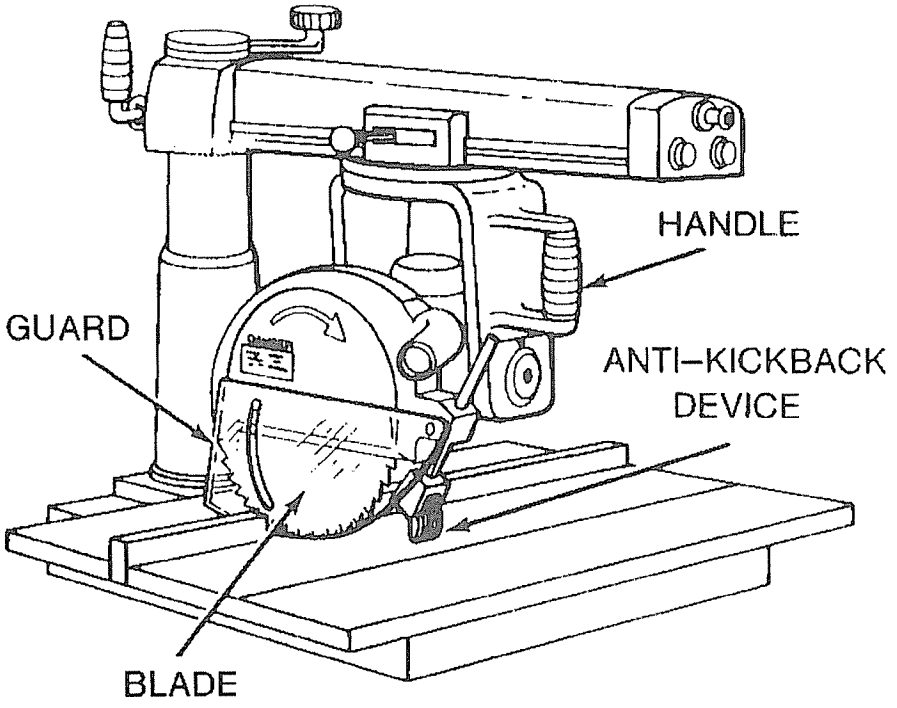


Figure 17

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.

Figure 18 shows a photoelectric presence-sensing device used with a press brake. The device may be swung up or down to accommodate different production requirements.

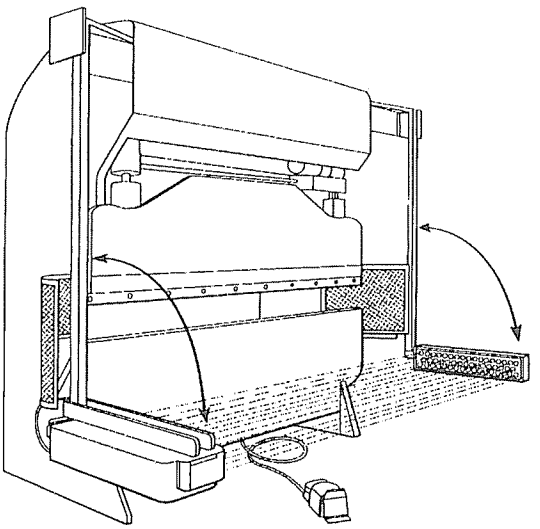


Figure 18

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 shall 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.

Figure 19 shows a radiofrequency presence-sensing device mounted on a part-revolution power press.

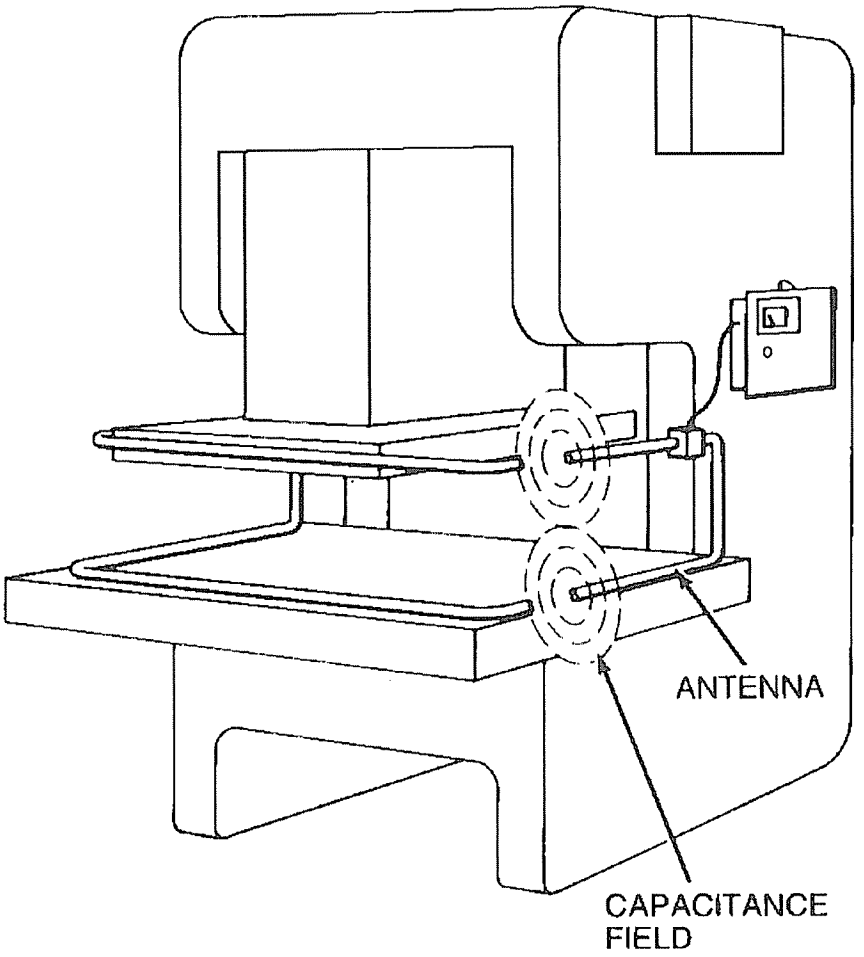


Figure 19

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.

Figure 20 shows an electromechanical sensing device on an eyeletter. The sensing probe in contact with the operator's finger is also shown.

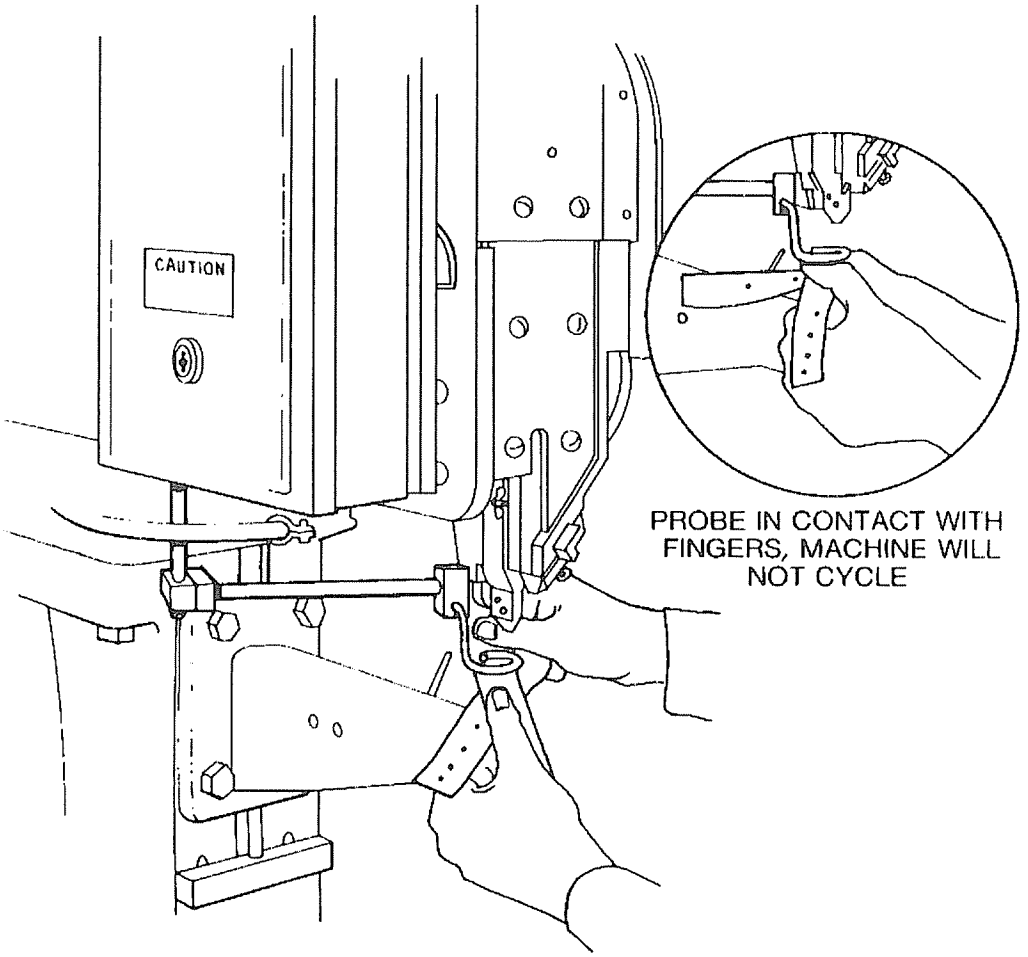


Figure 20

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, 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.

Figure 21 shows a pullback device on a small press.

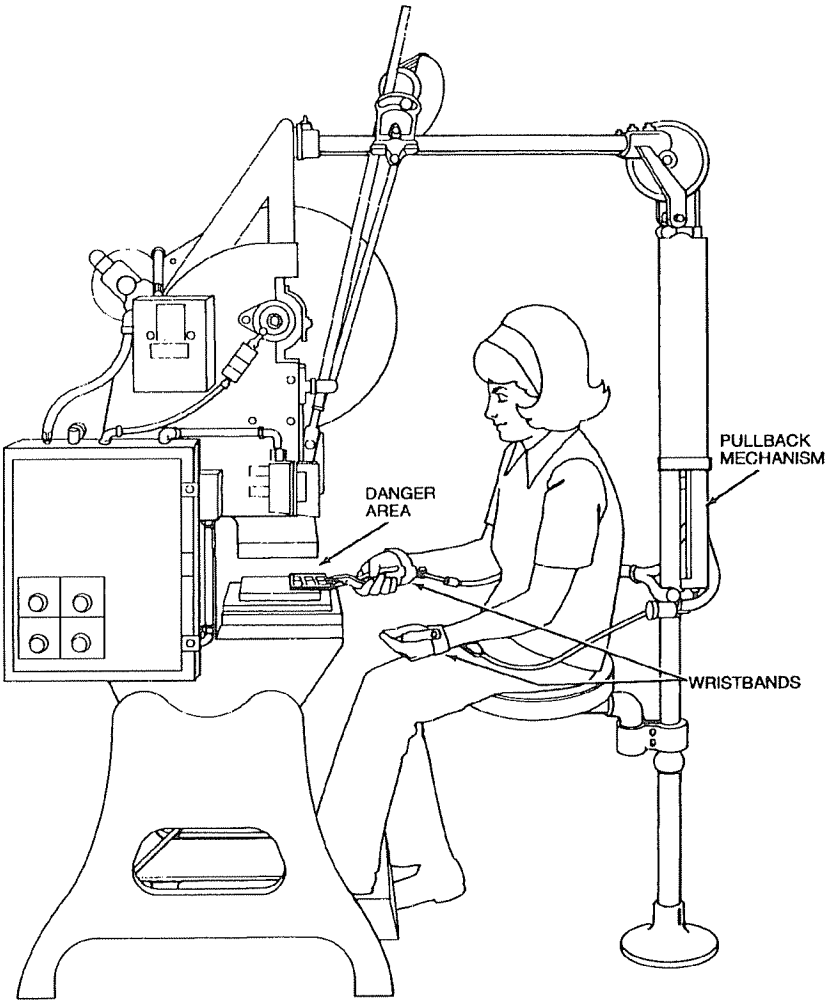
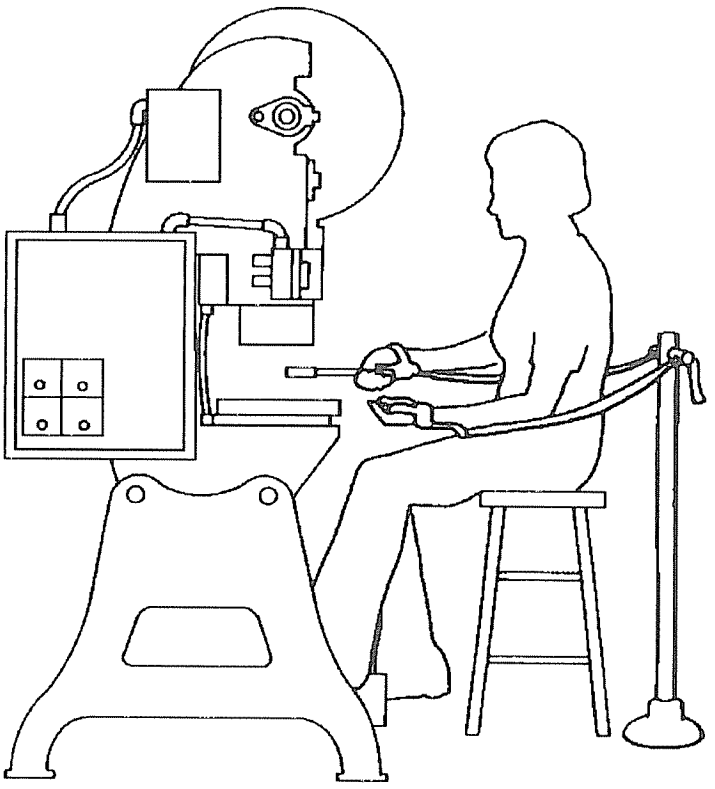


Figure 21



Restraint

The restraint (holdout) device in Figure 22 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.

Figure 22

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. Figure 23 shows a pressure-sensitive body bar located on the front of a rubber mill.

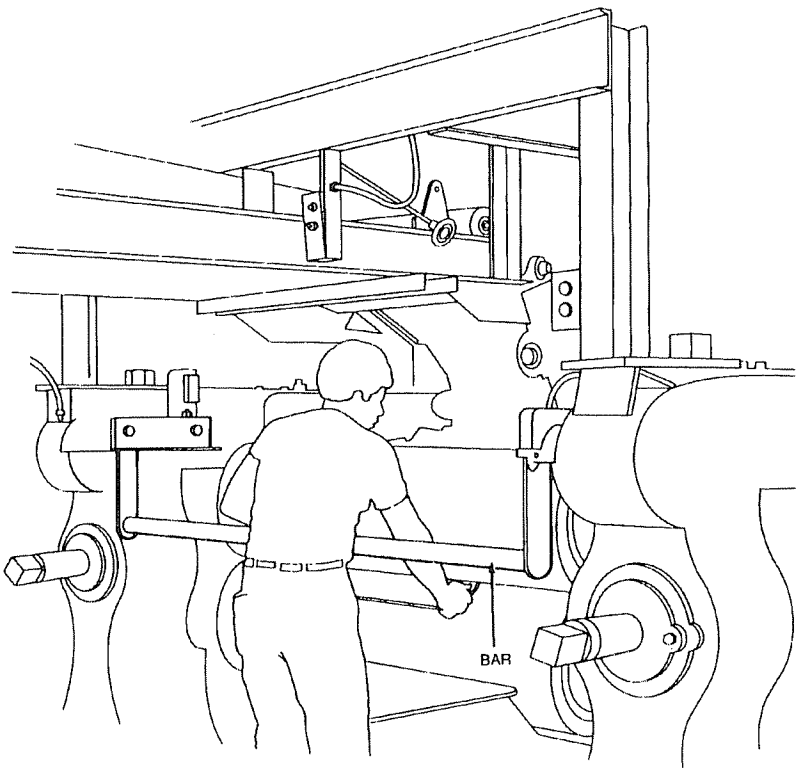


Figure 23

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. Figure 24 shows a triprod located above the rubber mill.

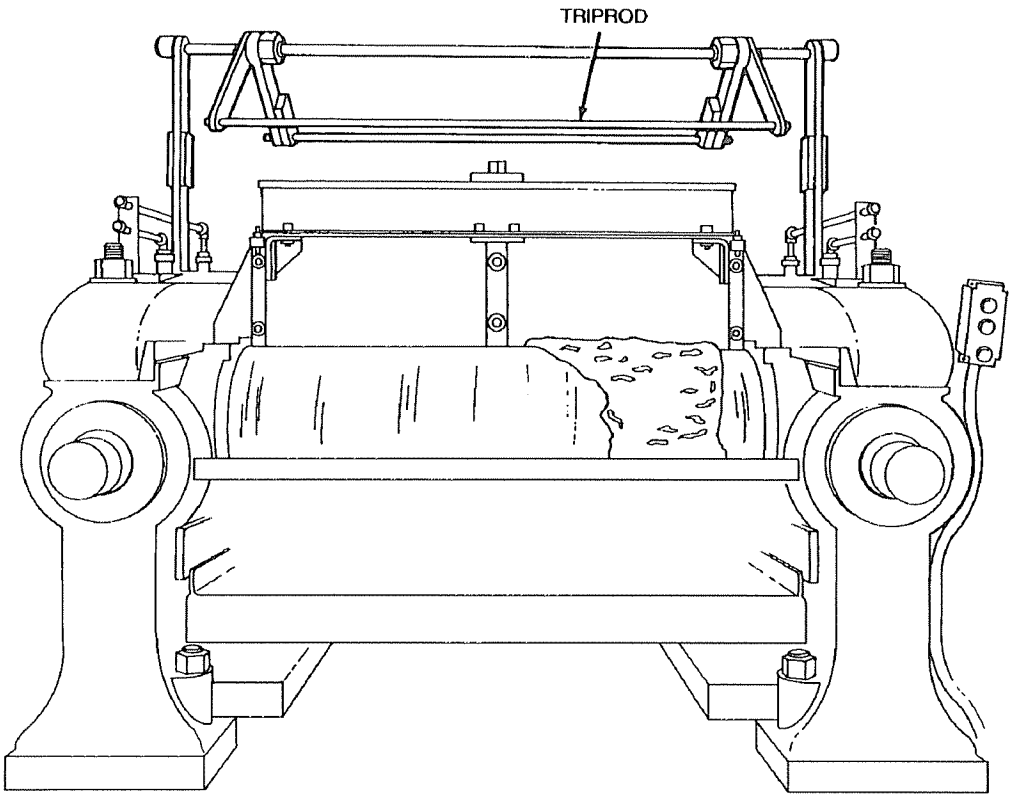


Figure 24

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. Figure 25 shows a calender equipped with this type of control.

All of these tripwires, rods or other safety devices must be manually reset to restart the machine.

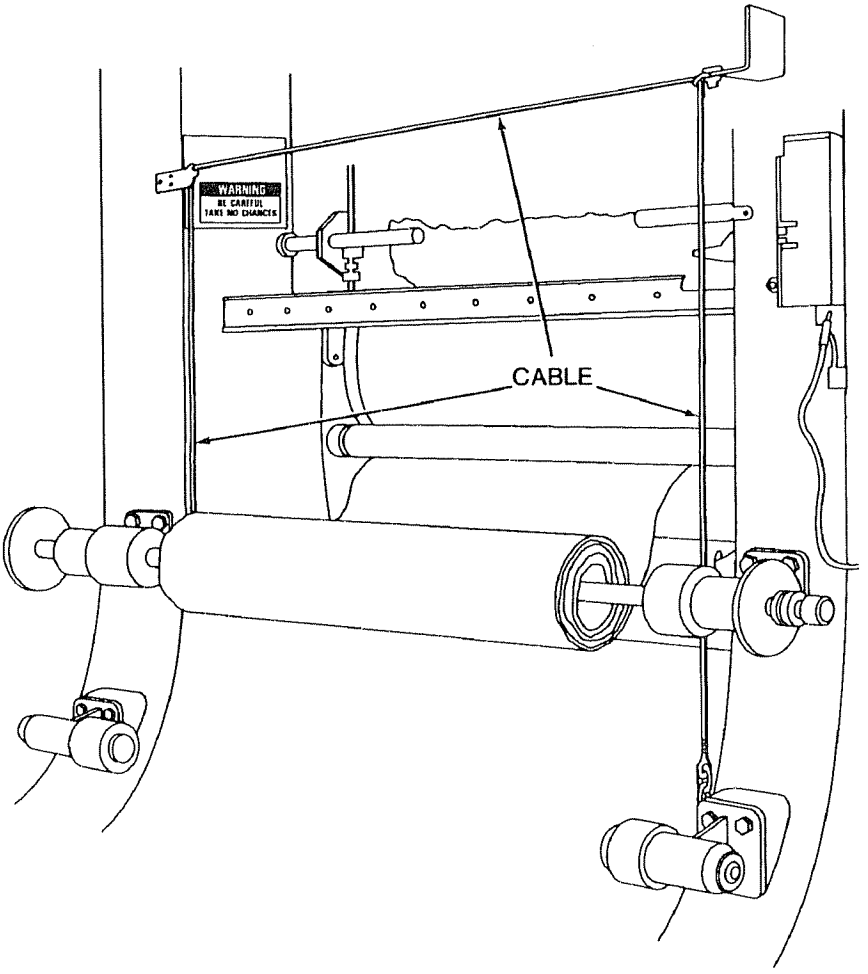


Figure 25

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 brake monitor if used on a power press as shown below in Figure 26. 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.

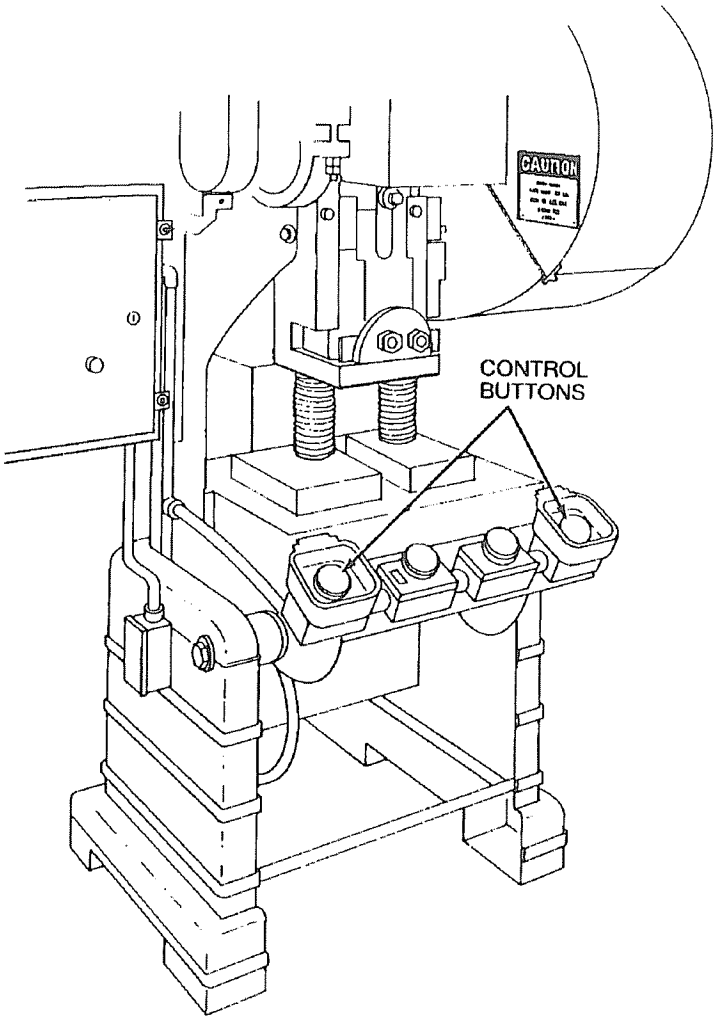


Figure 26

Two-Hand Trip

The two-hand trip in Figure 27 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.

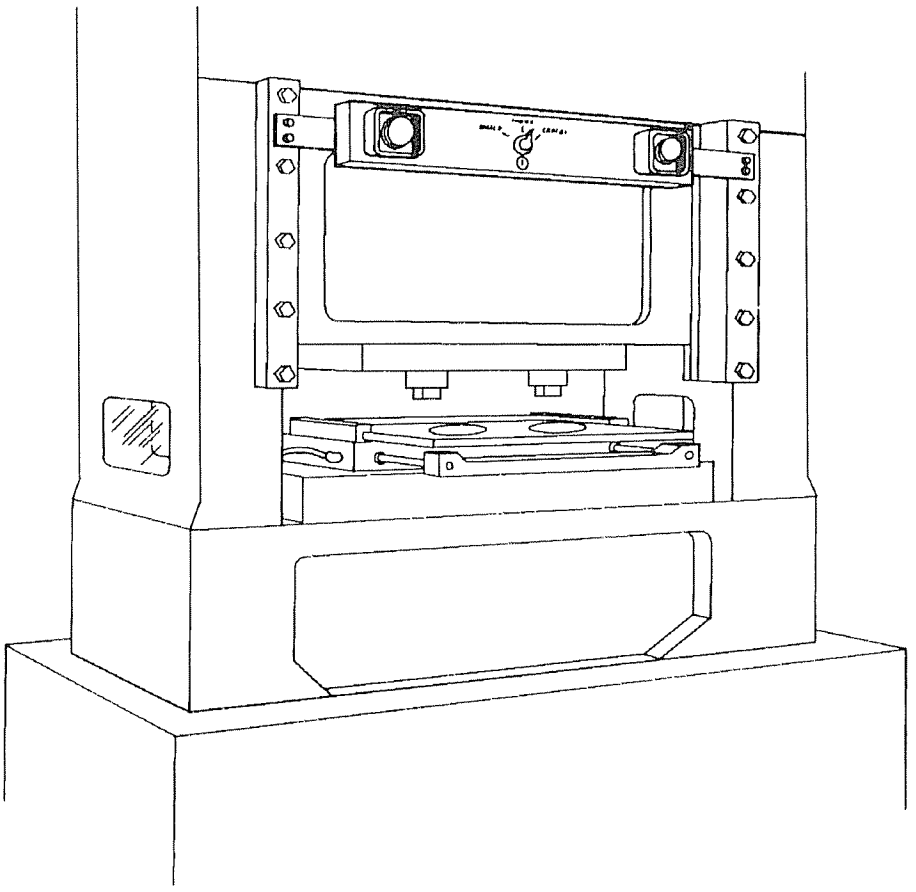


Figure 27

Gate

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.

Figure 28 shows a gate on a power press. 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.

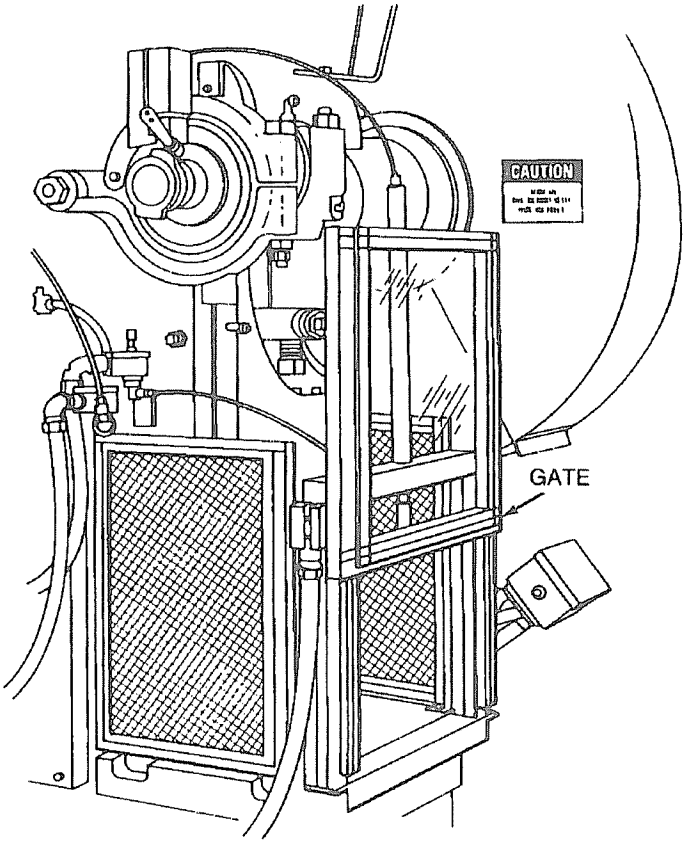


Figure 28

Safeguarding by Location/Distance

The examples mentioned below 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 safeguard a machine by location, the machine or its dangerous moving parts must be so positioned that hazardous 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 a plant design feature, such as a wall, protects the worker and other personnel. 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 no 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, no 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 feed

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.

In Figure 29 below, the power press has an automatic feeding mechanism. Notice the transparent fixed enclosure guard at the danger area.

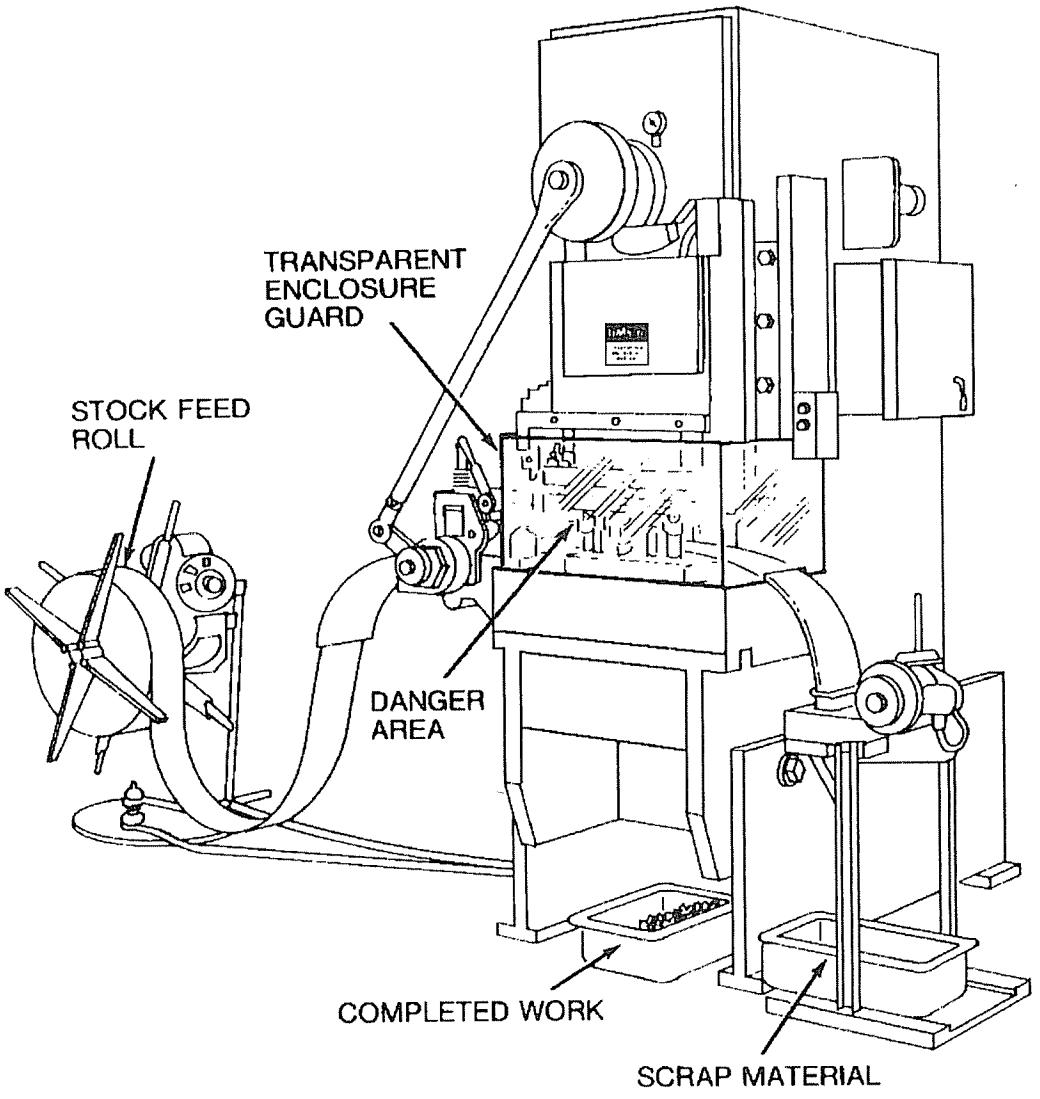

TRANSPARENT
ENCLOSURE
GUARD
STOCK FEED
ROLL
DANGER
AREA
COMPLETED WORK
SCRAP MATERIAL

Figure 29

Semi-automatic feed

With *semiautomatic 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. Figure 30 shows a chute feed. It may be either a horizontal or an inclined chute into which each piece is placed by hand. Using a chute feed on an inclined press not only helps center the piece as it slides into the die, but may also simplify the problem of ejection.

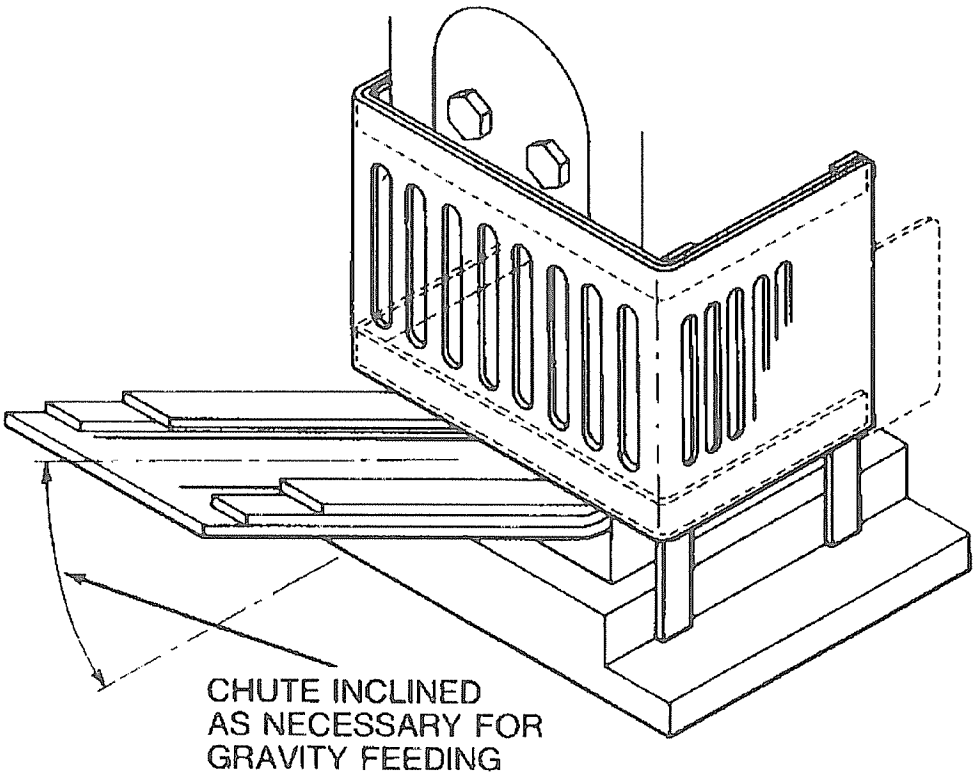


Figure 30

Automatic Ejection

Automatic ejection may employ either an air-pressure or a mechanical apparatus to remove the completed part from a press. It may be interlocked with the operating controls to prevent operation until part ejection is completed. This method requires additional safeguards for full protection of the operator.

As shown in Figure 31, the pan shuttle mechanism moves under the finished part as the slide moves toward the "up" position. The shuttle then catches the part stripped from the slide by the knockout pins and deflects it into a chute. When the ram moves down toward the next blank, the pan shuttle moves away from the die area.

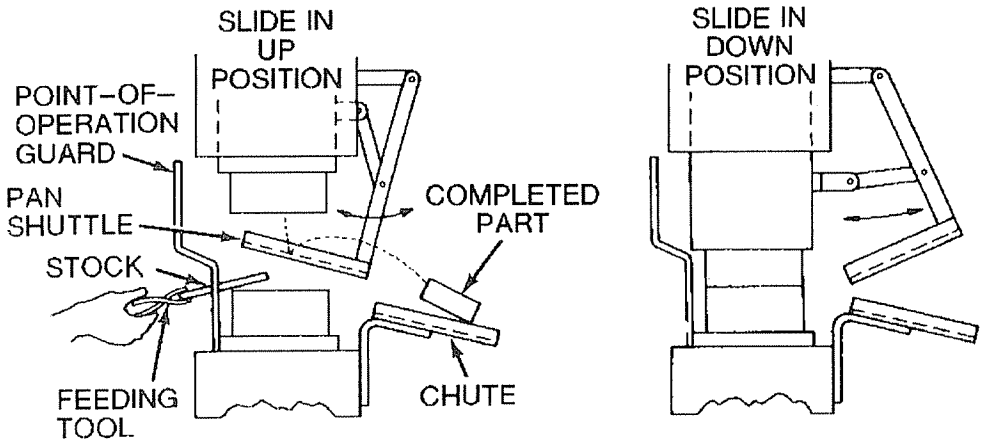


Figure 31

Semiautomatic Ejection

Figure 32 shows a semiautomatic ejection mechanism used on a power press. When the plunger is withdrawn from the die area, the ejector leg, which is mechanically coupled to the plunger, kicks the completed work out.

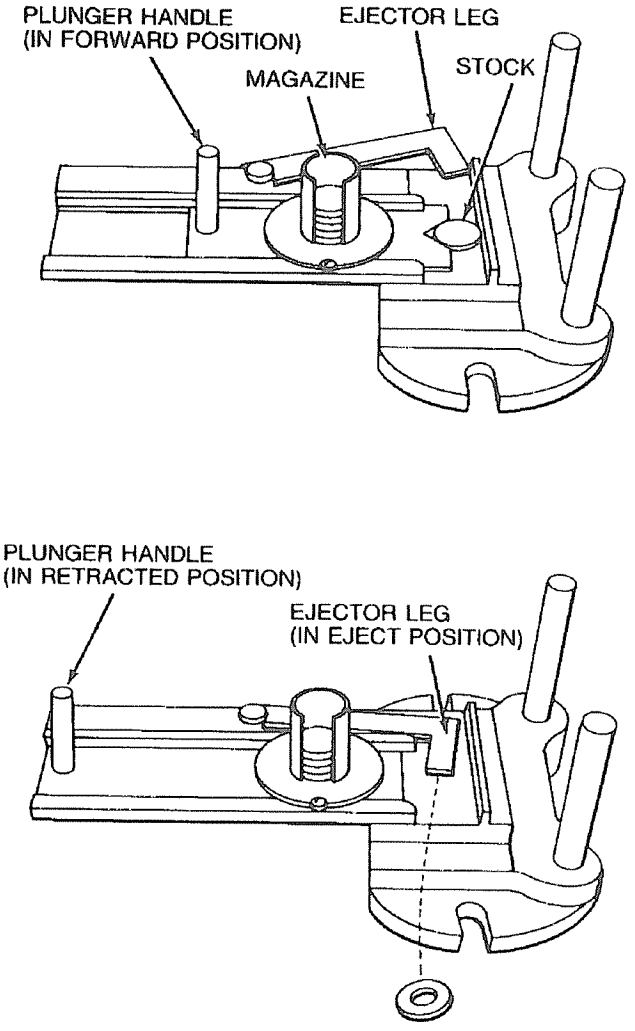


Figure 32

Robots

Robots are machines that load and unload stock, assemble parts, transfer objects, or perform other tasks. Essentially, they perform work otherwise done by an operator. They are best used in high-production processes requiring repeated routines where they prevent other hazards to employees. However, they may create hazards themselves, and, if they do, appropriate guards must be used.

Figure 33 shows an example of a robot feeding a press.

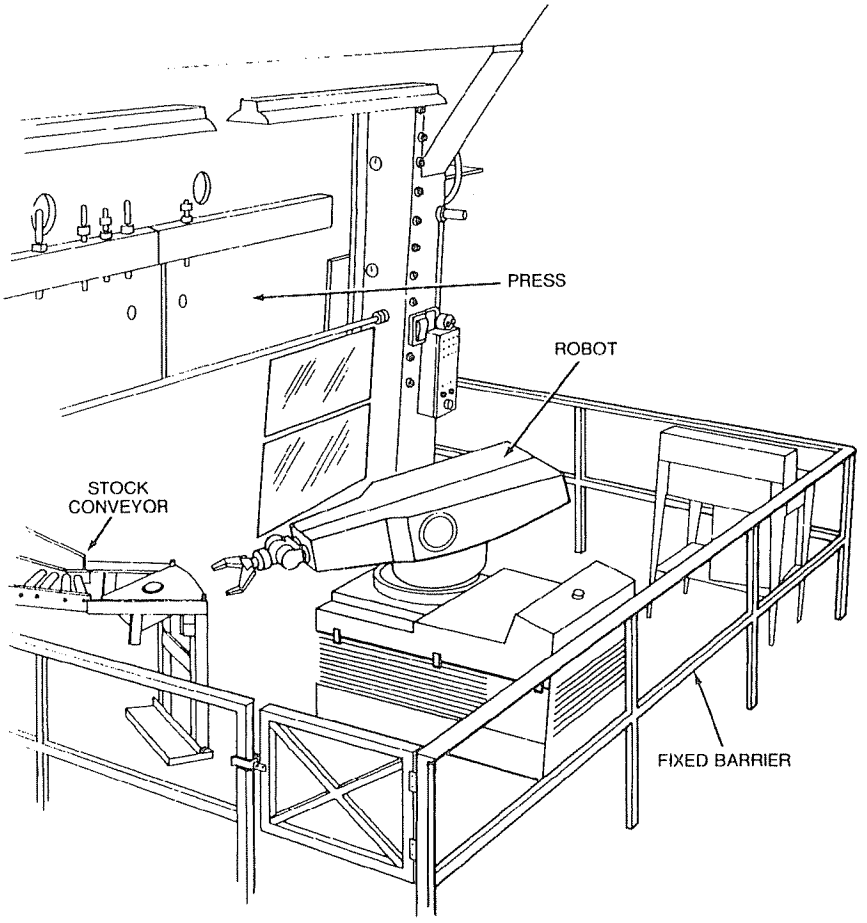


Figure 33

Various techniques are available to prevent employee exposure to the hazards which can be imposed by robots. The most common technique is through the installation of perimeter guarding with interlocked gates. A critical parameter relates to the manner in which the interlocks function. Of major concern is whether the computer program, control circuit, or the primary power circuit, is interrupted when an interlock is activated. The various industry standards should be investigated for guidance, however, it is generally accepted that the primary motive power to the robot should be interrupted by the interlock.

The American National Standards Institute (ANSI) safety standard for industrial robots, ANSI/RIA R15.06-1986, is very informative and presents certain basic requirements for protecting the worker. However, when a robot is to be used in a workplace, the employer should accomplish a comprehensive operational safety/health hazard analysis and then devise and implement an effective safeguarding system which is fully responsive to the situation. (Various effective safeguarding techniques are described in ANSI B11.19-1990.)

Studies in Sweden and Japan indicate that many robot accidents have not occurred under normal operating conditions but rather during programming, program touch-up, maintenance, repair, testing, setup, or adjustment. During many of these operations, the operator, programmer or corrective maintenance worker may temporarily be within the robot's working envelope where unintended operations could result in injuries.

All industrial robots are either servo or non-servo controlled. Servo robots are controlled through the use of sensors which are employed to continually monitor the robot's axes for positional and velocity feedback information. This feedback information is compared on an on-going basis to pre-taught information which has been programmed and stored in the robot's memory.

Non-servo robots do not have the feedback capability of monitoring the robot's

axes and velocity and comparing with a pre-taught program. Their axes are controlled through a system of mechanical stops and limit switches to the control the robot's movement.

Types of hazards associated with robots include:

- **Impact or collision hazards.** Impact with the robot's arm or peripheral equipment as a result of unpredicted movements, component malfunctions, or unpredicted program changes.

- **Crushing or trapping hazards.** A hazard resulting in some part of a person's body being trapped between the robot's arm and other peripheral equipment or being crushed by peripheral equipment as a result of being impacted by the robot into this equipment.

- **Mechanical components hazards.** Mechanical hazards result from the mechanical failure of components associated with the robot or its power source, drive components, tooling or end-effector, and/or peripheral equipment. The failure of gripper mechanisms with resultant release of parts, or the failure of end-effector power tools such as grinding wheels, buffing wheels, de-burring tools, power screwdrivers, and nut runners to name a few.

- **Human errors.** Human errors result in hazards both to personnel and equipment. Errors in programming, interfacing peripheral equipment, connecting inputs/output sensors, can all result in unpredicted movement or action by the robot which can result in personnel injury or equipment breakage. Human errors in judgment result frequently from incorrectly activating the teach pendant or control panel. The greatest human judgement error results from becoming so familiar with the robot's redundant motions that personnel are too trusting in assuming the nature of these motions and place themselves in hazardous positions while programming or performing maintenance within the robot's work envelope.

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.

One example is an *awareness barrier.* 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.

Figure 34 shows a rope used as an awareness barrier on the rear of a power squaring shear. Although the barrier does not physically prevent a person from entering the danger area, it calls attention to it.

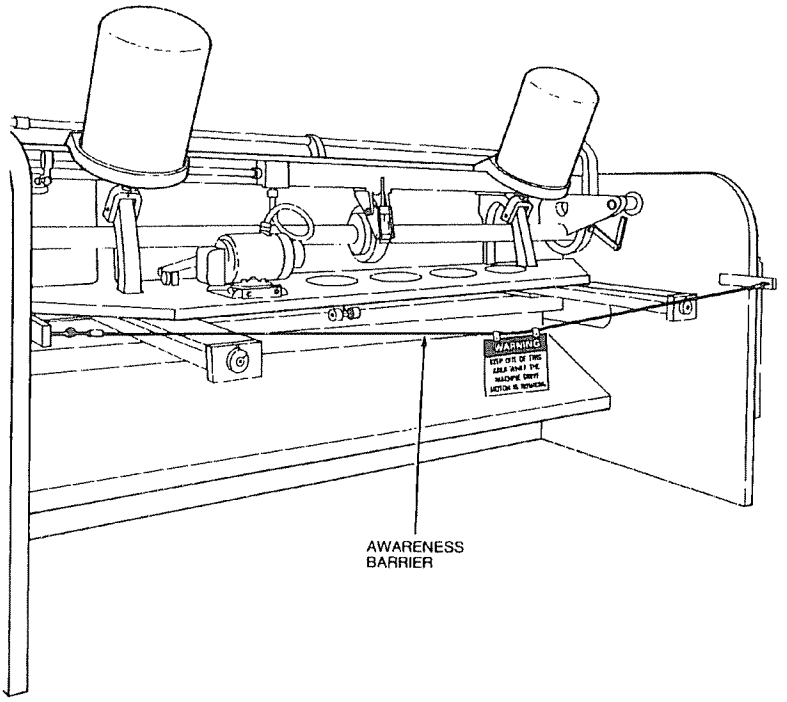


Figure 34

Shields, another aid, may be used to provide protection from flying particles, splashing cutting oils, or coolants. Figure 35 shows two potential applications.

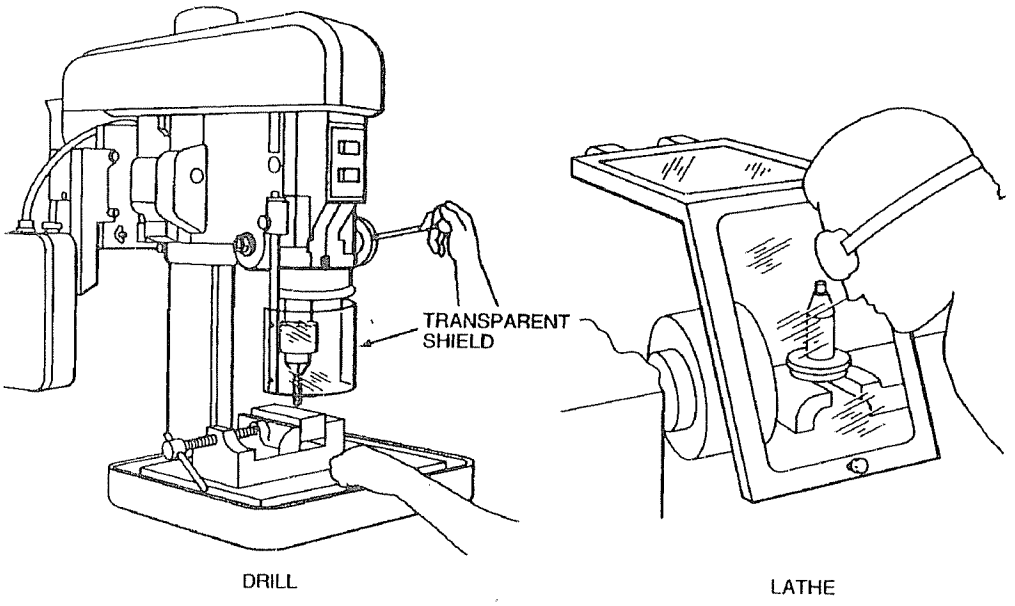


Figure 35

Holding tools can place and remove stock. A typical use would be for reaching into the danger area of a press or press brake. Figure 36 shows an assortment of tools for this purpose. Holding tools should not be used *instead* of other machine safeguards; they are merely a supplement to the protection that other guards provide.

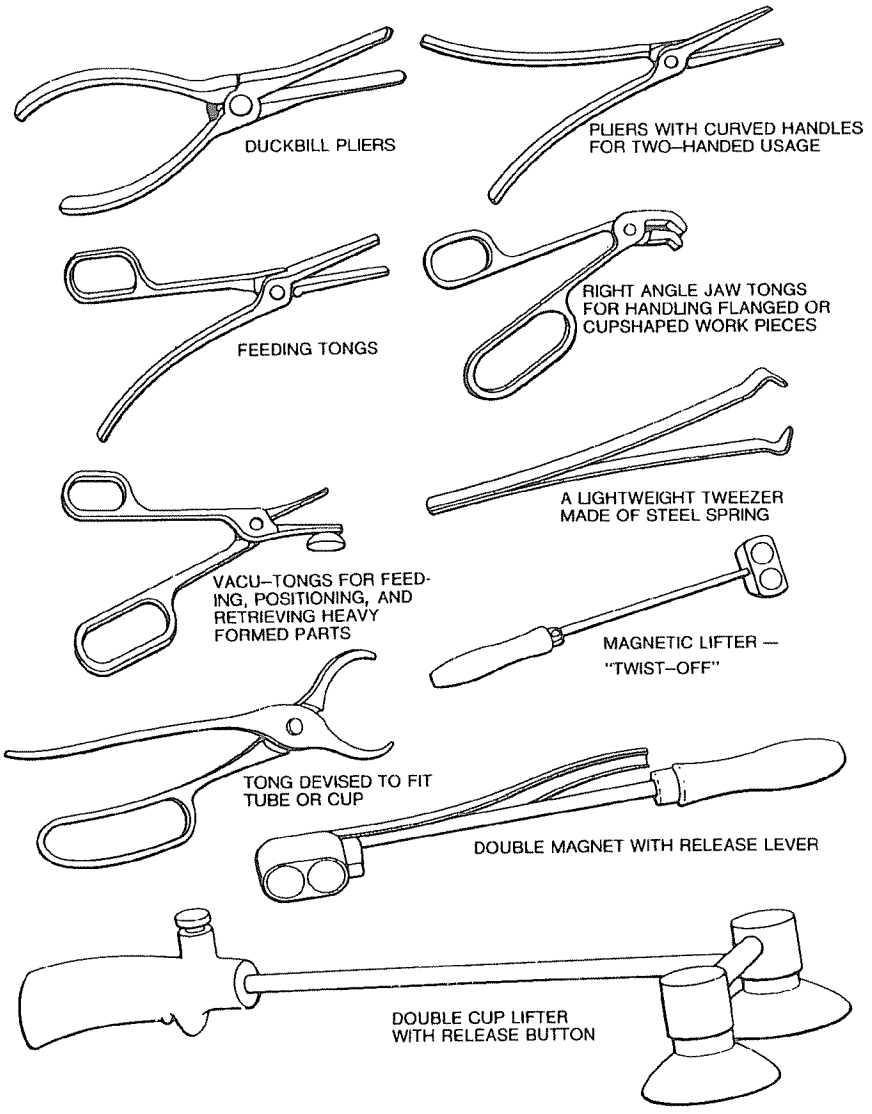


Figure 36

A *push stick or block*, such as shown in Figure 37, 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. In the illustration, the push block fits over the fence.

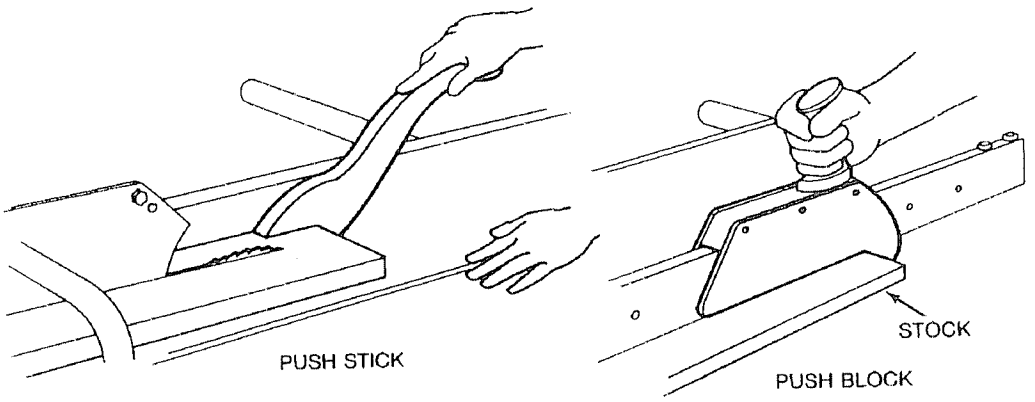


Figure 37

MACHINERY AND MACHINE GUARDING
SUBPART O

It is important to understand how Subpart O applies to machinery in the workplace. Section 212 is a general (or a horizontal) standard that applies to all machines not specifically mentioned elsewhere in other sections of Subpart O. The other sections are specific (vertical) standards that apply to particular types of machines; e.g., Section 213 applies only to woodworking machinery.

DEFINITIONS - 1910.211

In order to properly apply these standards, it is essential to understand the meaning of the machinery terms as prescribed in this section.

GENERAL REQUIREMENTS FOR ALL MACHINES - 1910.212

Machine Guarding

One or more methods of machine guarding shall be provided to protect employees in the machine area from hazards such as those created by point of operation, ingoing nip points, rotating parts, flying chips and sparks.

Guards shall be affixed to the machine where possible and secured elsewhere if not possible.

A guard shall not offer an accident hazard in itself.

The point of operation of machines whose operation exposes an employee to injury shall be guarded.

Revolving drums, barrels and containers shall be guarded by an enclosure which is interlocked with the drive mechanism.

When the periphery of the blades of a fan is less than 7 feet above the floor or working level, the blades shall be guarded with a guard having openings no larger than ½ inch.

Anchoring Fixed Machinery

Machines designed for a fixed location shall be securely anchored to prevent walking or moving.

WOODWORKING MACHINERY REQUIREMENTS - 1910.213

Machine Construction, General

Each machine shall be so constructed as to be free from sensible (able to be felt) vibration when the largest size tool is mounted and run idle (no cutting load) at full speed.

Machine Controls and Equipment

A mechanical or electrical power control shall be provided on each machine to make it possible for operators to cut off the power from each machine without leaving their position at the point of operation.

On applications where injury to the operator might result if motors were to restart after power failures, provision shall be made to prevent machines from automatically restarting upon restoration of power.

Power controls and operating controls should be located within easy reach of the operators while they are at their regular work location, making it unnecessary for them to reach over the cutter to make adjustments. This does not apply to constant pressure controls used only for setup purposes.

Specific Machine Requirements

The remaining paragraphs of Section 213 contain guarding requirements for specific woodworking machines. A discussion of some of these requirements follows.

All woodworking machinery such as table saws, swing saws, radial saws, band saws, jointers, tenoning machines, boring and mortising machines, shapers,

planers, lathes, sanders, veneer cutters, and other miscellaneous woodworking machinery shall be effectively guarded to protect the operator and other employees from hazards inherent to their operation.

Table Saws

Circular table saws shall have a hood over the portion of the saw above the table, so mounted that the hood will automatically adjust itself to the thickness of and remain in contact with the material being cut.

Circular table saws shall have a spreader aligned with the blade, spaced no more than one-half inch behind the largest blade mounted in the saw. The provision of a spreader in connection with grooving, dadoing, or rabbiting is not required.

Circular table saws used for ripping shall have nonkickback fingers or dogs.

Feed rolls and blades of self-feed circular saws shall be protected by a hood or guard to prevent the hand of the operator from coming into contact with the in-running rolls at any point.

Swing or Sliding Cut-Off Saws

All swing or sliding cut-off saws shall be provided with a hood that will completely enclose the upper half of the saw.

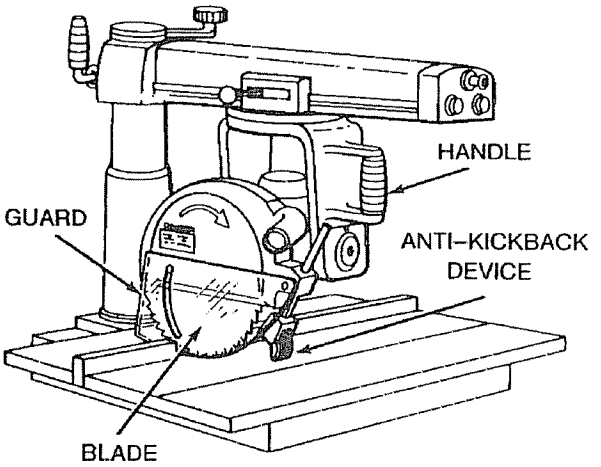
Limit stops shall be provided to prevent swing or sliding type cut-off saws from extending beyond the front or back edges of the table.

Each swing or sliding cut-off saw shall be provided with an effective device to return the saw automatically to the back of the table when released at any point of its travel.

Inverted sawing or swing cut-off saws shall be provided with a hood that will cover the part of the saw that protrudes above the top of the table or material being cut.

Radial Saws

The upper hood shall completely enclose the upper portion of the blade down to a point that will include the end of the saw arbor.



The sides of the lower exposed portion of the blade shall be guarded to the full diameter of the blade by a device that will automatically adjust itself to the thickness of the stock and remain in contact with stock being cut.

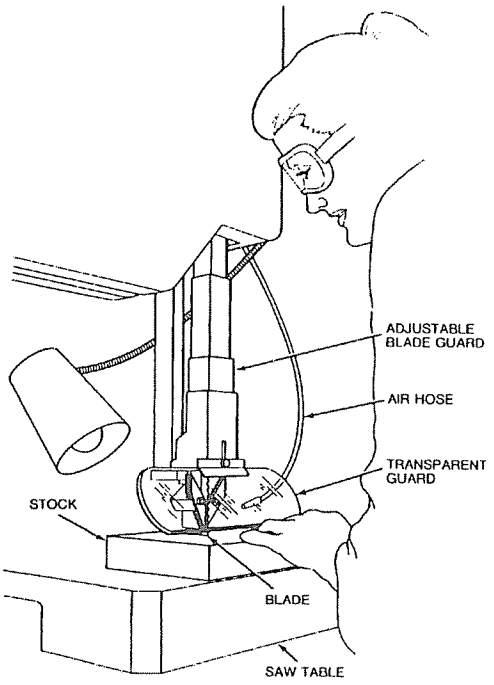
Radial saws used for ripping shall have nonkickback fingers or dogs.

An adjustable stop shall be provided to prevent the forward travel of the blade beyond the position necessary to complete the cut in repetitive operations.

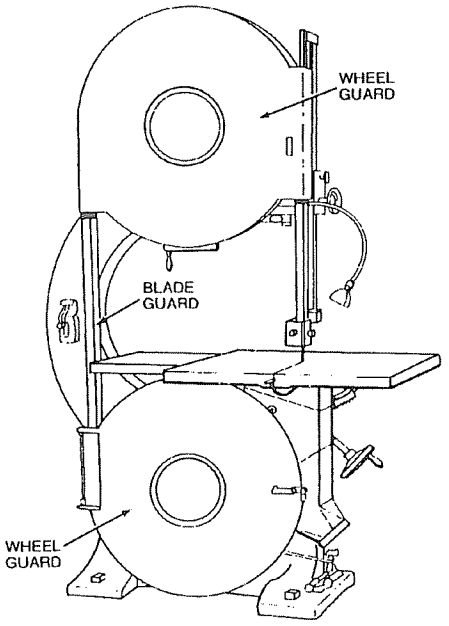
Installation shall be in such a manner that the front end of the unit will be slightly higher than the rear, so as to cause the cutting head to return gently to the starting position when released by the operator.

Bandsaws and Band Resaws

All portions of the saw blade shall be enclosed or guarded, except for the working portion of the blade between the bottom of the guide rolls and the table. See figure below.

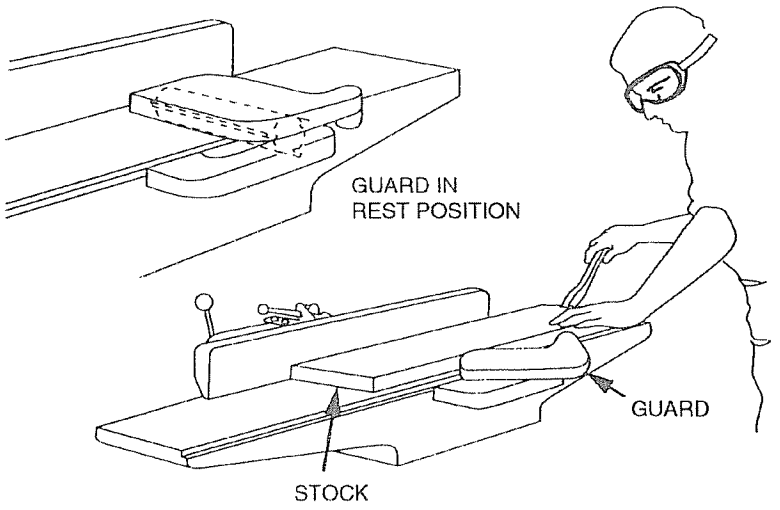


Bandsaw wheels shall be fully encased. The outside periphery of the enclosure shall be solid. The front and back shall be either solid or wire mesh or perforated metal.



Jointers

Each hand-fed jointer with horizontal cutting head shall be equipped with an automatic guard which will cover all the section of the head on the working side of the fence or gage.



Miscellaneous Woodworking Machines

This paragraph states that the mention of specific machines in previous paragraphs "is not intended to exclude other woodworking machines from the requirement that suitable guards and exhaust hoods be provided to reduce to a minimum the hazard due to the point of operation of such machines."

ABRASIVE WHEEL MACHINERY - 1910.215

This section regulates only abrasive wheel machinery. It does not cover wire wheels, buffing wheels or the like. An abrasive wheel is made up of individual particles that are bonded together to form a wheel. The hazard here, of course, is that if not properly mounted and used, the wheel can literally explode! Sections of the wheel may fly out at high speeds and can strike the operator causing death or serious injury.

General Requirements

Machine Guarding

Abrasive wheels shall be used only on machines provided with safety guards with the following exceptions:

- Wheels used for internal work while within the work being ground;
- Mounted wheels, used in portable operations, 2 inches and smaller in diameter; and
- Type 16, 17, 18, 18R, and 19 cones, plugs, and threaded hole pot balls where the work offers protection.

Guard Design

Abrasive wheel safety guards shall cover the spindle end, nut, and flange projections, except:

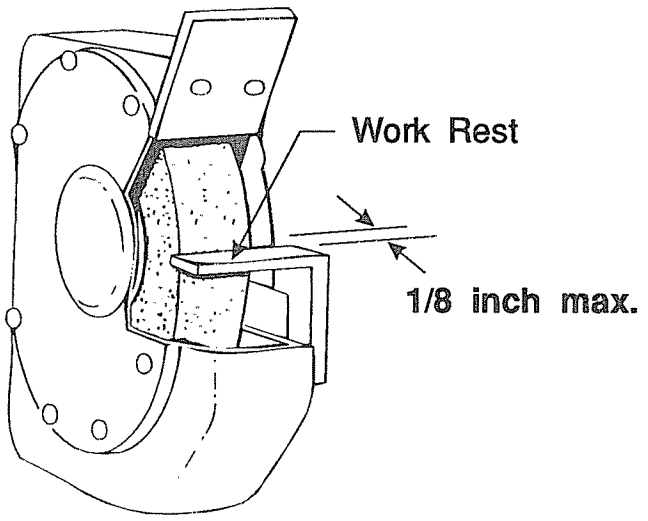
- Safety guards on all operations where the work provides a suitable measure of protection to the operator may be so constructed that the spindle end, nut, and outer flange are exposed;

- Where the nature of the work is such as to entirely cover the side of the wheel, the side covers of the guard may be omitted; and

- The spindle end, nut, and outer flange may be exposed on machines designed as portable saws.

Work Rests

On offhand grinding machines, adjustable work rests of rigid construction shall be used to support the work. Work rests shall be kept adjusted closely to the wheel with a maximum opening of ⅛ inch to prevent the work from being jammed between the wheel and the rest, which may cause breakage.

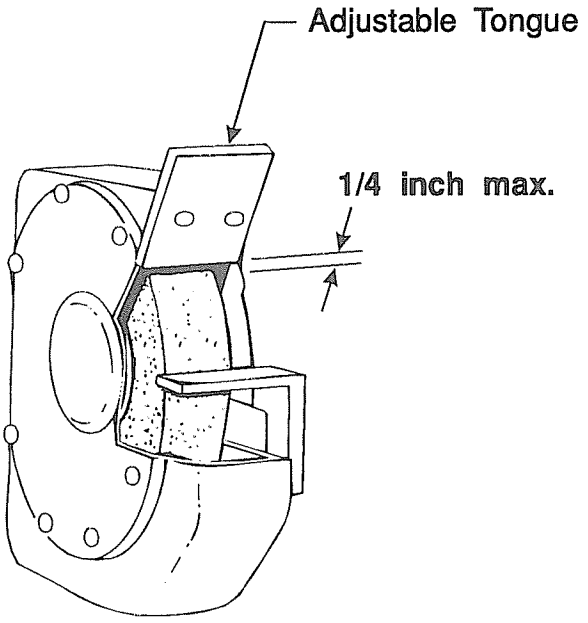


Angular Exposure

Abrasive wheel safety guards for bench and floor stands, and for cylindrical grinders shall not expose the grinding wheel periphery for more than 65 degrees above the horizontal plane of the wheel spindle.

Exposure Adjustment

The protecting member of the abrasive wheel safety guard shall be adjustable for variations in wheel size so that the distance between the wheel periphery and the adjustable tongue or the end of the peripheral member at the top shall never exceed ¼ inch.



Mounting

Immediately before mounting, all wheels shall be closely inspected and sounded by the user (ring test) to make sure they have not been damaged.

The spindle speed of the machine shall be checked before mounting of the wheel to be certain that it does not exceed the maximum operating speed marked on the wheel.

MILLS AND CALENDERS - 1910.216

This section regulates mills and calenders in the rubber and plastics industries. Due to the specialized nature of these rules, they are beyond the scope of this discussion.

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Machine Safeguarding Classifications

1. **Guards**
   - Fixed
   - Interlocked
   - Adjustable
   - Self-adjusting

2. **Devices**
   - Presence Sensing
     - — Photoelectrical (optical)
     - — Radiofrequency (capacitance)
     - — Electromechanical
   - Pullback
   - Restraint
   - Safety Controls
     - — Safety trip control
       - o Pressure-sensitive body bar
       - o Safety triprod
       - o 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