CHAPTER 13

# TOOLS AND MACHINES

## 13-1 TOOL AND MACHINE HAZARDS

Since the early days humans have always used tools to extend human capabilities, and tools have gradually become more sophisticated. The industrial revolution combined different tools into machines, and a variety of power sources have improved the efficiency of tools and machines. Tools and machines using manual and other sources of power are more common than ever. There are many special kinds of tools that are often similar in function or action.

Tools and machines are a major source of injuries. Hand tools cause approximately 8% of lost-time occupational accidents; machines cause an even greater share. Because powered tools and machines involve much greater energy and power, injuries from them are likely to be more severe than for hand-operated ones.

### Hazards

There are a variety of hazards associated with tools and machines. Some hazards are unique to particular tools and machines; others are related to the material acted on or the use environment. Certain hazards are common for many kinds of tools and machines.

One hazard is being struck by a tool, moving machine, or machine part. For example, most everyone has struck a finger or thumb when learning to drive a nail with a hammer. Motor vehicles, one type of machine, strike people every day.

Another hazard of certain tools and machines is being struck by materials acted on. When using a cold chisel or star drill and hammer to break a hole in concrete, particles of concrete fly from the tip of the tool with each blow. Particles fly from the cutting tool as a lathe removes material. The particles may strike the tool or machine user or someone else. Some parts of the body, such as the eyes, have a greater risk of injury than others when struck by flying materials.

Another kind of hazard is getting caught in a machine or tool. Many people have experienced the pinching action of a pair of pliers. One can get caught in many ways: in power transmission elements, such as belts, chains, gears, linkages, and other components, and in the portions of the machine that act on something else.

Repeated motion by users in operating a tool or machine can lead to a group of injuries called cumulative trauma disorders or repeated motion disorders.

The power source may add to the inherent hazards of a tool or machine itself. For example, electrical power brings certain hazards (discussed in Chapter 12). Combustible fuels, explosives, hydraulics, and pneumatics each bring an additional hazard to the tools

*Safety and Health for Engineers, Second Edition*, by Roger L. Brauer

and machines they power. Machines and tools may create noise hazards, produce air contaminants, become hot, or create other hazards.

## Injuries

There are many kinds of injuries related to tools and machines. Tools and machines designed to cut materials also will cut people. Knives, hatchets, and axes are examples of hand tools. Hedge trimmers, paper cutting machines, and shears are examples of powered tools and machines.

Abrasion injuries result from contact with machines that use friction or abrasion, such as grinding and sanding equipment. Puncture wounds can result from contact with pointed tools, like drills, punches, and awls. Tissue tears may result from contact with sharp edges on equipment.

A variety of crushing injuries, fractures, and other injuries can result from getting caught in the compression action of a tool or machine.

Flying particles may cause injuries to surface tissue on impact. The likelihood of injury depends on the tissue struck, the strength of the tissue, and the ability of the tissue to absorb and distribute forces. The larger the material in motion, the greater the chances of injury. Initial impact may not be the only concern. The materials may have other hazards associated with them. For example, they may be caustic or they may be rough and cause injury if they contact skin or other tissue.

Objects may fall from machines and crush hands, feet, or bodies. Materials being operated on by tools and machines may be poorly anchored and subsequently may fall, producing crushing or related injuries.

## Cumulative Trauma or Repeated Motion Injuries

Cumulative trauma injuries, cumulative trauma disorders, or repeated motion injuries are a family of injuries that result from repeated motion or repeated use of a tool or other equipment. They are one form of musculoskeletal disorder. Most involve inflammation of or damage to various tissues. Several may occur at the same time. The appearance of symptoms will vary from person to person, with frequency of activity, forces, and movements involved in the activity and other factors. Factors other than repeated motion, such as age and personal differences, may contribute to the incidence of these disorders.

***Trigger Finger*** Trigger finger is characterized by irritation and soreness of the hand resulting from repeated use of individual fingers for operation of switches and buttons. Operation of spray guns, video games, power tools, or machine controls with one or more fingers may result in trigger finger.

***Carpal Tunnel Syndrome*** This is an affliction caused by the compression of the median nerve, median artery, and tendons passing through the carpal tunnel of the wrist (see Figure 13-1). The medial side of the wrist has a ligamentous band that serves as a "pulley" of sorts for the tendons extending from muscles in the forearm to the fingers. The size of the passage under this band may decrease as a result of inflammation, aging, and other factors. Extreme bending of the wrist, particularly ulnar deviation, causes tissues in and surrounding the carpal tunnel to become irritated and to swell. Symptoms of carpal tunnel syndrome include tingling, pain, or numbness in the thumb and first three fingers and reduced manipulative skills in the hand.

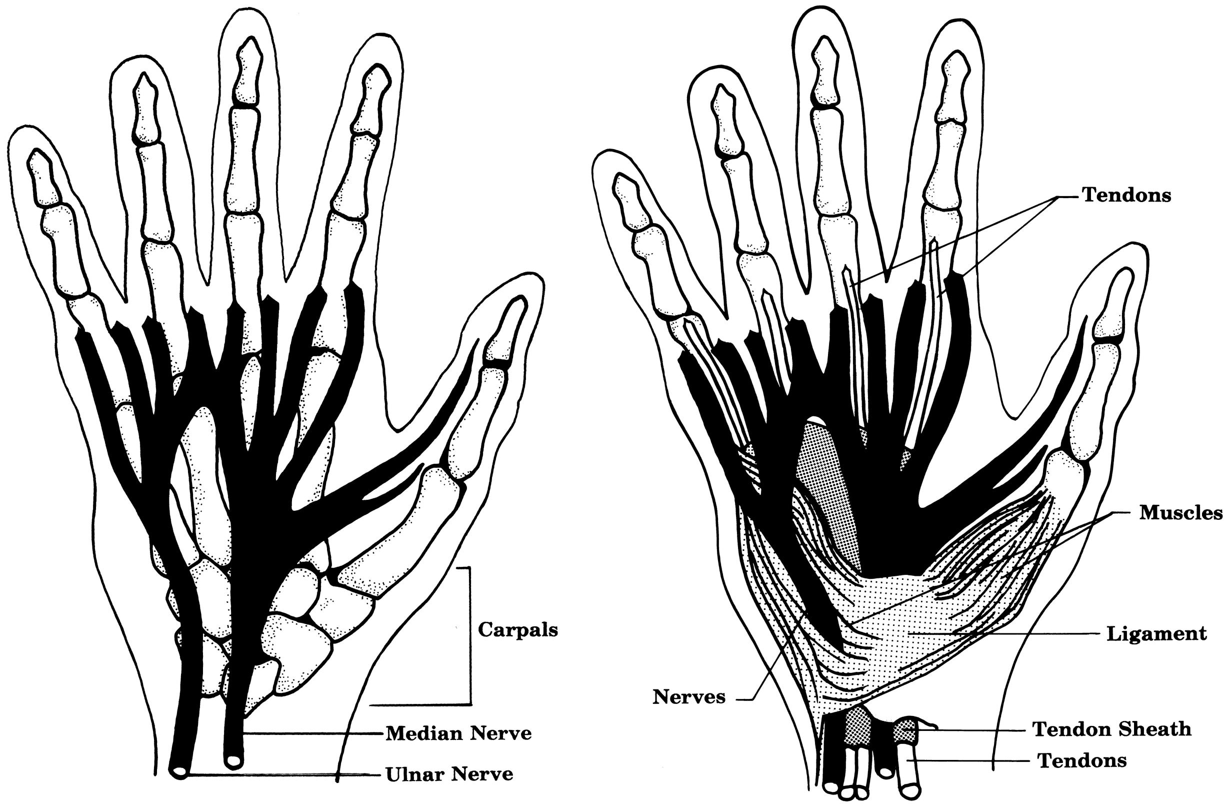



Figure 13-1. Pictorial representation of the anatomy related to carpal tunnel syndrome. Through the carpal region of the wrist pass nerves, blood vessels, tendons, and tendon sheaths. The large ligament over the carpal region helps keep tissues in place during wrist articulation. Various forms of inflammation and disorders result from repetitive motion.

***Raynaud's Syndrome*** This disorder, also called white finger, is caused by blood vessels in the hand constricting from cold temperature, vibration, emotion, or unknown causes. Signs and symptoms include both hands becoming simultaneously cold, blue, or white and numb and loss of manipulation of fine objects. On recovery, the hands become red, accompanied by a burning sensation. Of particular concern in design of tools and controls for machines is vibration that induces Raynaud's syndrome. The handles on some machines and tools may produce very high compression forces on the tissues of the palm and may lead to this disorder. Examples of activities that lead to Raynaud's syndrom are use of impact tools and vibrating sanders.

***Dequervain's Disease*** This disorder results from narrowing of the tendon sheath for both long and short abductor muscles of the thumb. This disease results from manual tasks involving radial or inward hand motions and firm grips.

***Bursitis*** Each joint of the body has an encapsulating tissue called the bursa. Bursitis is the inflammation of the bursa.

***Tendinitis*** Tendinitis is inflammation of a tendon.

***Perimyotendinitis*** This disorder is the inflammation of tissues surrounding a tendon or its sheath.

***Tenosynovitis, Stenosing Tenosynovitis, or Tenovaginitis*** These terms refer to inflammation involving the compression or narrowing of a tendon sheath.

***Epicondylitis*** This disorder is caused by the combined action of pronation of the hand and ulnar deviation. For example, swinging a hammer involves these combined motions. Symptoms include pain in the elbow, forearm, and hand. Epicondylitis also has activity-related names, such as carpenter's elbow or tennis elbow.

***Ganglion Cysts*** This disorder is the enlargement of a nerve cell or ganglion. The disorder is often manifested with other cumulative trauma disorders.

***Rotator Cuff*** This disorder stems from a tearing of a particular ligament in the shoulder joint. As a result, the mechanics of the shoulder change. One has difficulty beginning to raise the arms from its position along the side of the body or raising it above shoulder height.

***Thoracic Outlet Syndrome*** This disorder stems from restriction of the blood supply or compression of the nerves passing from the neck to the shoulder. Symptoms may include lateral arm pain, tingling of the ring and small finger, and hand swelling or weakness. Activities contributing to this disorder include pulling the shoulders back and down, carrying heavy loads in the hand (such as carrying suitcases or similar objects), working overhead with repeated arm abduction and adduction, and holding something between the shoulder and neck.

## 13-2 SAFEGUARDING MACHINES

### History

Machines became prominent during the industrial revolution. With the growth of machine use, injuries resulting from machines increased. Principles of guarding closely paralleled the industrial revolution. Whereas machines, designs, and materials have changed, the principles of guarding have been around for a long time. Over the years, guarding principles and standards have appeared in many publications on machines. New technologies have provided some new capabilities for machines, but the basic ideas for guarding have changed little.

The first interlock, a mechanical arrangement, was patented in 1868. The first electrical interlock on a power transmission guard was patented in 1923. In 1899, a patent was issued for a press guard that prevented the machine from acting if the guard was not fully closed. The earliest set of standards for machine guarding appeared in 1914. The current series of ANSI machine guarding standards (B11 series) began in 1922 with adoption of the first standard for power presses and foot and hand presses. The first edition of the standard for guarding power transmission apparatus (B15) appeared in 1927.

### Guarding Principles

Guards, one type of machine safeguard, are preferred over other types. Guards on machines are intended to keep people and their clothing from coming into contact with hazardous parts of machines and equipment. They also prevent flying particles from an operation and broken machine parts from coming into contact with or striking people. Guards may serve other functions, such as enclosing noise or dust and forming part of an exhaust system for contaminants.

Guards must have certain characteristics. They must be a permanent part of the machine or equipment, must prevent access to the danger zone during operation, and must be durable and constructed strongly enough to resist the wear and abuse expected in the environment where machines are used. Guards must not create hazards. They should not interfere with the operation of the machine. Even though some designers incorporated guards that protect machine users only during normal operations, where possible they should be designed so routine inspection, adjusting, lubricating, cleaning, and repairing can be performed without removing them. Because the equipment likely will pose the same hazards during setup, maintenance, and repair, guards should protect these activities as well.

***Guard Openings*** Guards may have openings for several reasons: to insert materials into a machine for processing; to allow access for inspection or lubrication; to monitor machine action. The larger an opening, the farther one can reach through it. In approximately 1950, the insurance industry studied the opening-reach distance relationship. Since then, people have used the resulting data, found in Table 13-1 and Figure 13-2, to define how far a barrier must be placed from a danger point for certain size openings. A danger point or line is where the dangerous action of a machine occurs or is a machine action location narrowing to $^3/_8$ in, which forms a pinch point. Three-eighths of an inch is the approximate thickness of a finger. Figure 13-3 illustrates the danger line for openings between rollers and the application of distance-opening data. For rollers that have openings larger than $^3/_8$ in, the fingers and hands may not sustain severe crushing. Not only are straight line distances important, but so is the potential of reaching around or over some

**TABLE 13-1 Distances a Guard Must Be from a Danger Line for Various Sizes of Openings**

| Distance of Opening from the Danger Line (in) | Maximum Width of Opening (in) |
|---|---|
| $^1/_2$–$1^1/_2$ | $^1/_4$ |
| $1^1/_2$–$2^1/_2$ | $^3/_8$ |
| $2^1/_2$–$3^1/_2$ | $^1/_2$ |
| $3^1/_2$–$5^1/_2$ | $^5/_8$ |
| $5^1/_2$–$6^1/_2$ | $^3/_4$ |
| $6^1/_2$–$7^1/_2$ | $^7/_8$ |
| $7^1/_2$–$12^1/_2$ | $1^1/_4$ |
| $12^1/_2$–$15^1/_2$ | $1^1/_2$ |
| $15^1/_2$–$17^1/_2$ | $1^7/_8$ |
| $17^1/_2$–$31^1/_2$ | $2^1/_8$ |

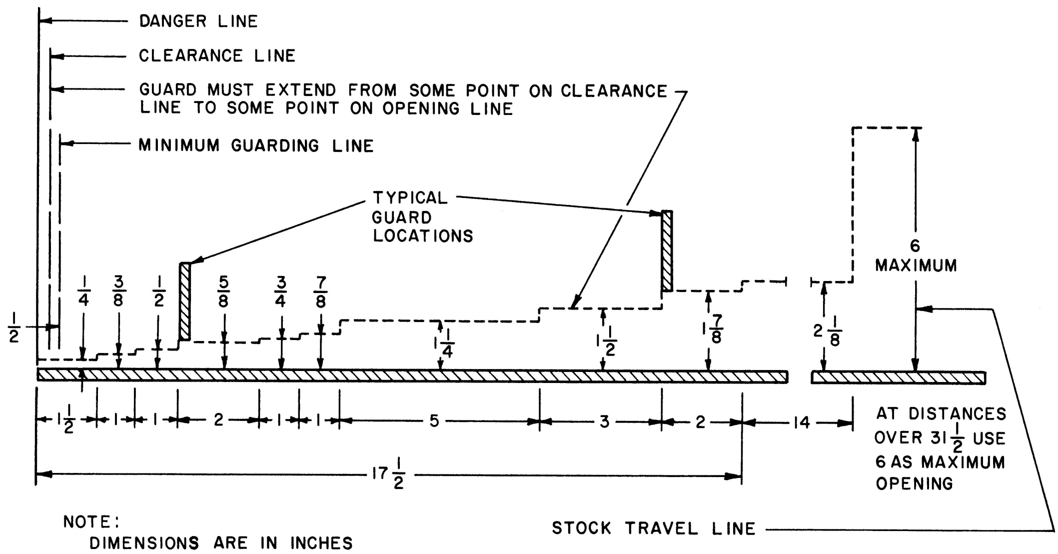



Figure 13-2. The distance guards must be located from a danger point depends on the size of the opening in the guard.

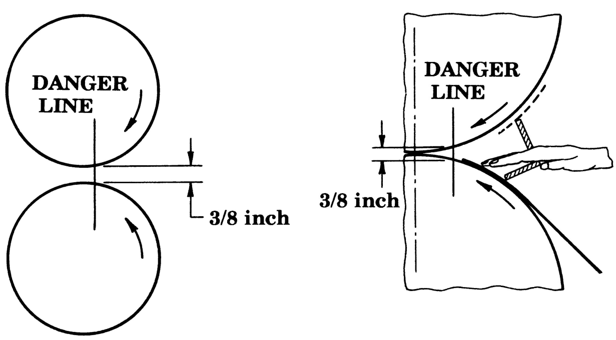



Figure 13-3. The danger line for in-running rolls. Guard placement is determined from the defined location.

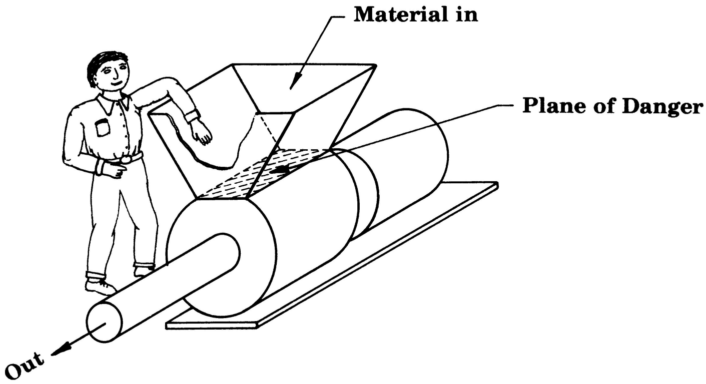



Figure 13-4. Example of using distance to keep someone from reaching into dangerous parts of a machine. The application and various standards determine whether the use of distance provides sufficient protection.

obstacle. Figure 13-4 gives an example. In some cases, one also must use human anthropometric data to determine if people can reach into the hazardous part of a machine.

***Guard Construction*** Guards must be substantial. To make them substantial, designers must consider the forces and events they are intended to protect and the use environment for the machines and guards. The environment may be dusty. Vehicles dumping material may strike guards. In some cases, the structural criterion is the force of a person leaning or falling on a guard. In other cases, the force and energy of flying machine parts or materials will establish what is substantial. Environmental factors, like a constant shower of particulates, a corrosive mist, or excessive heat, will determine what is substantial. Some standards give recommended materials of construction.

## Types of Machine Motion

There are five types of machine motion (see Figure 13-5) that create machine hazards: rotation, reciprocating or transverse motion, in-running nip points or pinch points, cutting actions, and punching, shearing, and bending.

***Rotation*** One example of rotating motion is the spindle, chuck, and bit of a drill. Others are shafts, splines, couplings, feed stock, flywheels, and handwheels. Burrs, set screws, keys, rough surfaces, and rotary or eccentric motion all tend to grab clothing or hair. Even smooth, rotating surfaces can catch clothing, hair, or other loose material and wind it up. After being caught, clothing or hair quickly pulls a person into a machine. Skin contact with these moving surfaces also can produce injury.

***Reciprocating or Transverse Motion*** Back-and-forth motion and motion in a straight line are dangerous because someone may be in the line of motion, resulting in their being struck by the moving part of the machine. Someone also may become sheared or pinched between fixed and moving parts of the machine or between the moving part of the machine and the surrounding fixed object. Even the body of a crawler-type backhoe can create a shear or pinch point when operated near a concrete wall. When the body is facing forward, the rear of the body may have clearance from a wall located along side. When the body

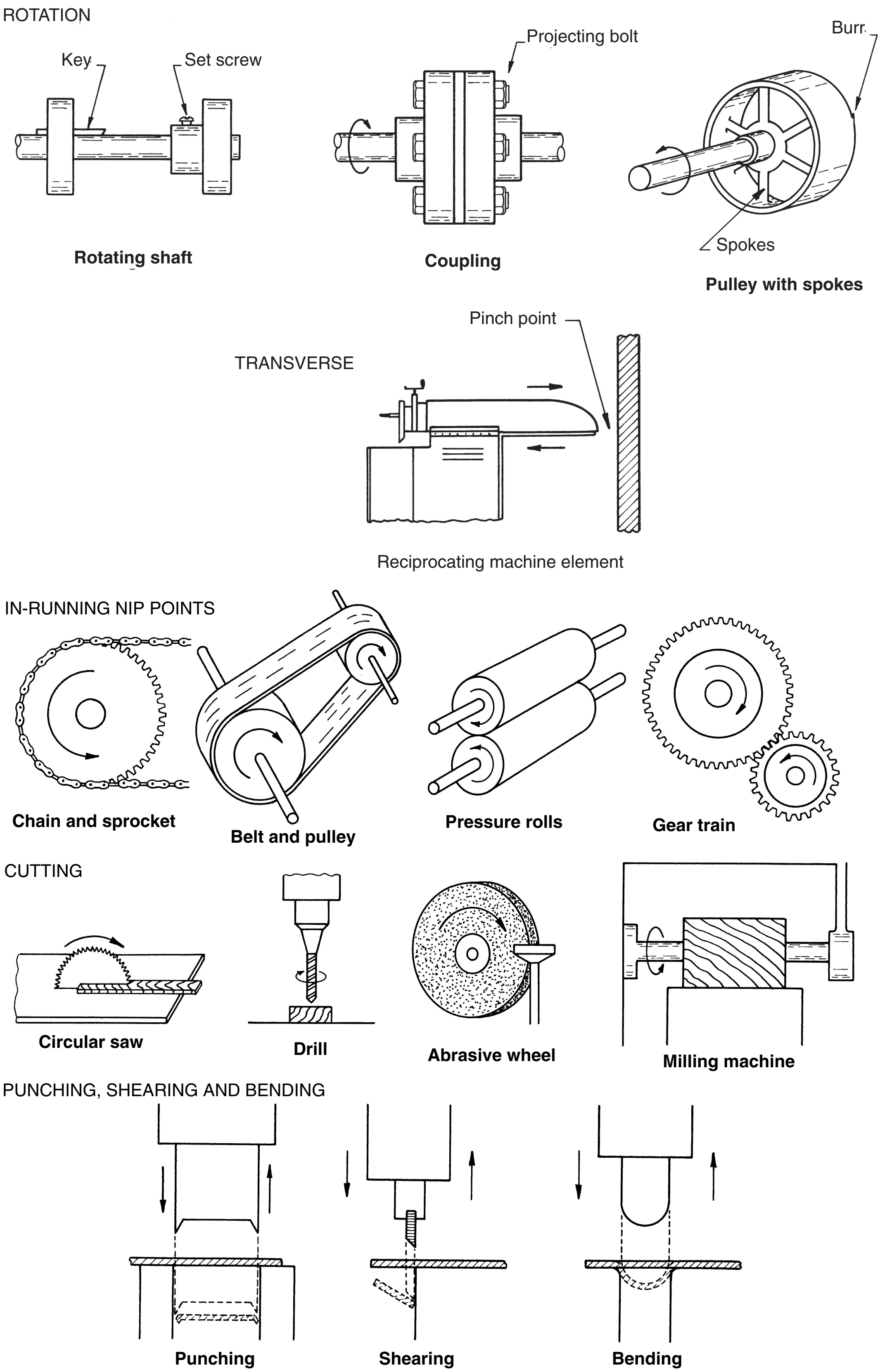



Figure 13-5. Five types of machine motions and examples of each.

rotates to the side, the rear of the body may extend over the top of the wall or may crush someone against the wall.

***In-Running Nip Points*** Machine parts that rotate toward each other or rotate toward a fixed component create in-running nip points or pinch points. If these pinch or nip points catch someone, severe injury can result. Examples of in-running nip points are belts and pulleys, chains and sprockets, gears, conveyor belts and rollers, and rolls used for various forming, mixing, and processing functions.

***Cutting Actions*** Machines that cut or remove material have cutting actions. Examples are saws, milling machines, shaping and planing machines, lathes, grinders, and boring mills. If the machine can cut wood, leather, metal, or paper, it can cut human tissue. The location of a machine's cutting action is the point of operation.

***Punching, Shearing, and Bending*** This type of motion describes two machine components that come together. Both may move or one may be fixed. Examples of this motion are punching, shearing, bending, stamping, drawing, and trimming. If the machine can perform these functions on metal, paper, wood, or other material fed into it, it can also damage human tissue. Again, the danger is at the point of operation.

### Types of Safeguards

Safeguards include guards, devices, distance, or location. Safeguards for machines fall into two major groups: mechanical power transmission safeguards and point-of-operation safeguards.

***Guards*** Guards are barriers that prevent the entry of a person's body and clothing into a hazardous part of a machine. They also prevent materials from striking and injuring someone.

***Devices*** Devices are controls or attachments that inhibit normal operation of a machine if any portion of a person's body is within a hazardous area.

***Distance*** Distance places the hazardous portion of a machine vertically or horizontally out of reach to prevent inadvertent contact with or access to a dangerous part on motion.

***Location*** Location means placing a hazardous machine or component where people will not normally be.

## 13-3 POWER TRANSMISSION SAFEGUARDS

Most machines use power transmission components to transfer power from a motor, engine, or other prime mover to an element of a machine where a useful function occurs. Some common power transmission components are belts, pulleys, ropes, sheaves, chains, sprockets, gears, and friction rollers. Pinch, nip, or shear points are created as these components come together.

Rotating shafts and couplings are also power transmission components that pose the danger of rotary motion. Some power transmissions include flywheels, which store energy during the power transmission process. At excessive speeds or after extended stress, they may fly apart. Unless these components are fully enclosed within the machine, people can come into contact with them.

### Guards

If possible, power transmission guards (see Figure 13-6) should totally enclose the hazardous components. They should prevent fingers, hands, or other parts of the body from coming into contact with them. Designs should prevent personnel from reaching around, over, under, or through the guard to the danger point.

Guards should be fastened to the machine to prevent access to the hazardous areas and they should have an interlock that will de-energize the machine when the guard is removed. When possible, guard designs should allow lubrication, adjustment, and inspection to be performed from outside the guard, without removing it.

### Devices

If the guard has an access panel, the panel should have an interlock or presence-sensing device that de-energizes the machine or enclosed power transmission equipment. There should be an emergency shutoff control within reach of the hazardous components for each and every operator. This is necessary in case someone does get caught when the guard is removed or a panel is opened while the machine is, for some reason, energized.

### Distance and Location

Mechanical power transmission equipment that is out of reach of people may not require guards. The minimum distance required from a floor or walking surface to mechanical power transmission apparatus varies with different standards, although 7 or 8 ft is often used. Most people would not be likely to contact or reach above this distance. Anthropometric reach data also can establish safe distances from people to danger points. Distances within reach require guarding, that is, enclosed screens, walls, or fences that provide safe locations and are permanent and substantial. They should be at least 8 ft high or have functionally equivalent features. Only trained workers should have access to the enclosed locations.

### Warnings

Guards and access points to hazardous areas of power transmission components should have warnings. The warnings should tell people to de-energize and lockout power before opening the access or removing the guard.

### Openings

Openings in power transmission guards, partitions, or screens must prevent people from coming into contact with hazardous elements. Such openings must comply with data in Table 13-1 and Figure 13-2.

## 13-4 POINT-OF-OPERATION SAFEGUARDS

A point of operation is the location where a machine performs work. Although there are many kinds of machines, each performing a different function, the basic kinds of machine

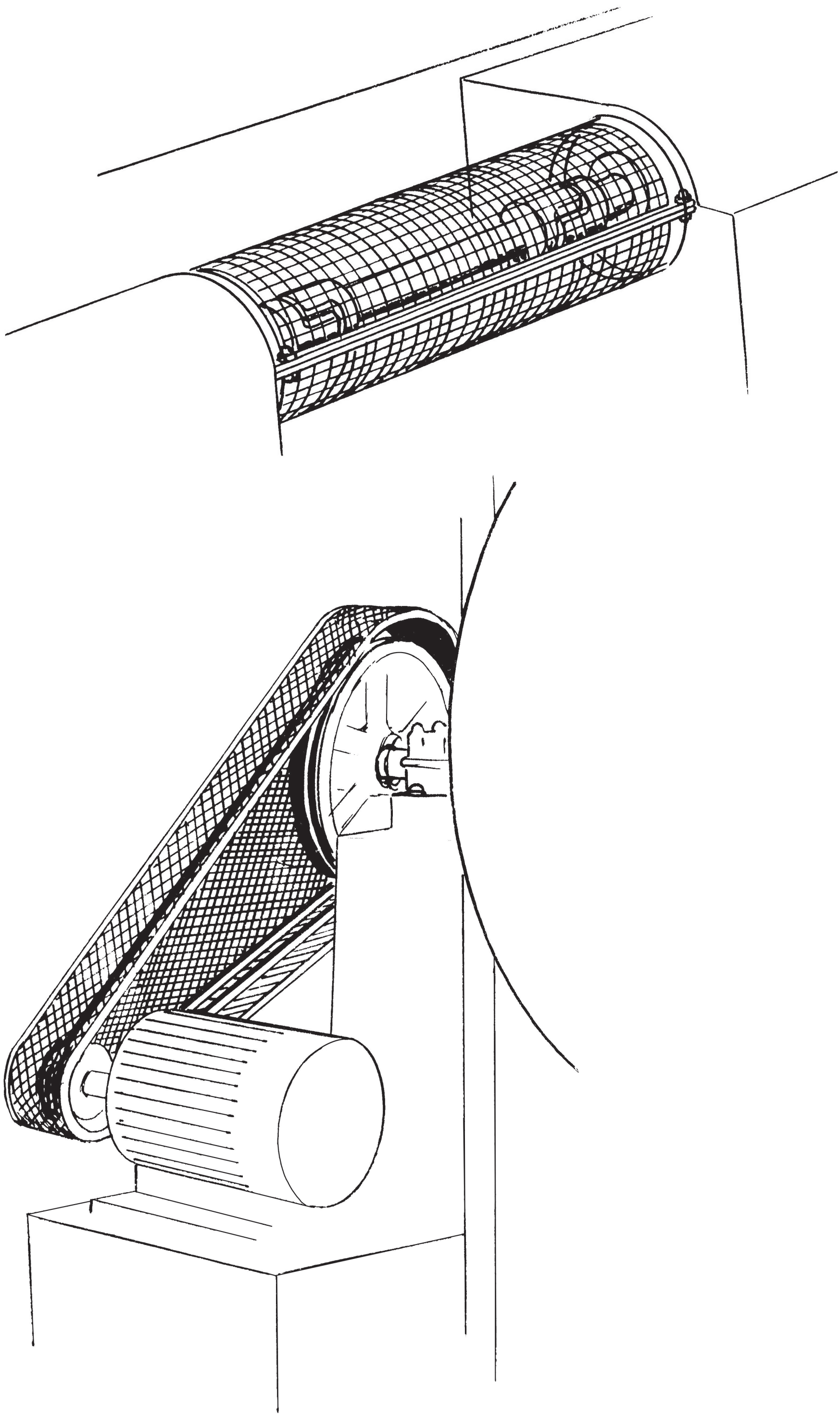


Figure 13-6. Examples of power transmission guards. (From *MSHA's Guide to Equipment Guarding*.)

motions previously described cover them all. The safeguards for points of operation are guards, devices, tools, awareness barriers and signals, and emergency stop controls. Not all of these safeguards apply to every machine; references about particular machines will give more details and will identify suitable safeguards.

## Guards

***Enclosure Guards*** Point-of-operation guards (see Figure 13-7) should prevent fingers, hands, other body parts, and clothing from reaching through, under, over, or around the guard to the point of operation. Criteria in Table 13-1 and Figure 13-2 apply. A guard should be fixed to the machine so that it does not create additional hazards, such as a pinch point. Construct and attach guards with fasteners that cannot be removed without tools to help prevent unauthorized removal. Most guards should permit viewing the point of operation.

***Interlocked Guards*** In some cases, a guard needs a hinged or moveable section for setup, adjustment, or maintenance, whereas in other cases, a guard is removed for such activities. The section or entire guard must be interlocked to the machine motion, so the machine will not operate while the section is open or the guard is removed. An example of a guard interlock is shown in Figure 13-8.

***Adjustable Guards*** Some guards must be adjusted for different operations (see Figure 13-9). If sections are adjustable, they should meet the preceding requirements.

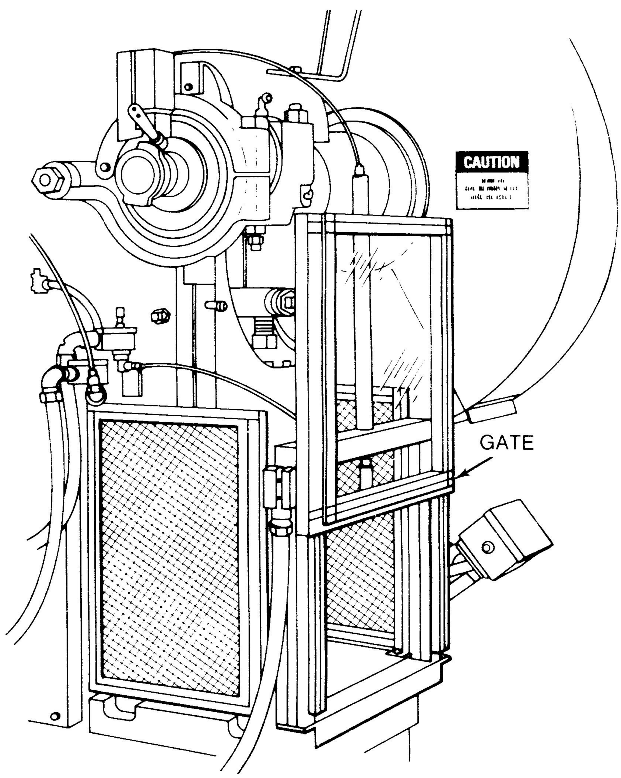



Figure 13-7. Example of an enclosure guard. (From OSHA 3067.)

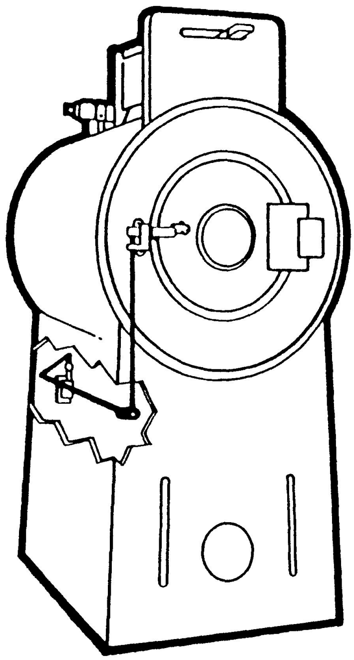



Figure 13-8. An example of an interlock.

***Special Guards*** There are many special guards (see Figure 13-10) that are unique to particular machines or machine actions. A few examples illustrate some of these special problems.

**Ring Guard** A rotating cutter on a shaper may be exposed on all sides. A ring guard adjusts to allow material to pass under it and to provide protection from the remaining exposed portion of the cutter.

**Leg of Mutton Guard** A leg of mutton guard covers the cutting head of a jointer. It gets its name from its shape. It swings horizontally out of the way when wood material moves across the jointer table. Its position varies with adjustments made in the fence that guides the material. The part of the cutting head behind the fence needs to be guarded as well. Because a leg of mutton guard can move only horizontally, it will not protect all jointer cuts. Other guards that float vertically give protection when material moves over the cutting head and extends over the side of the jointer table.

**Hood Guard** Circular table saws typically have a hood guard over the blade. The guard “floats” vertically as material is moved into the blade.

**Grinding Wheel Guards** Guards for grinding wheels perform several functions. They help keep operators from coming into contact with the wheel itself and they help contain fragments should a wheel fracture, disintegrate, and fly apart. As a result, grinding wheel guards are made of much heavier material than other guards and the opening provided for the grinding operation is held to a minimum. In addition, these guards often enclose the spindle end, nut, outer flange, and side of the abrasive wheel. The guard may

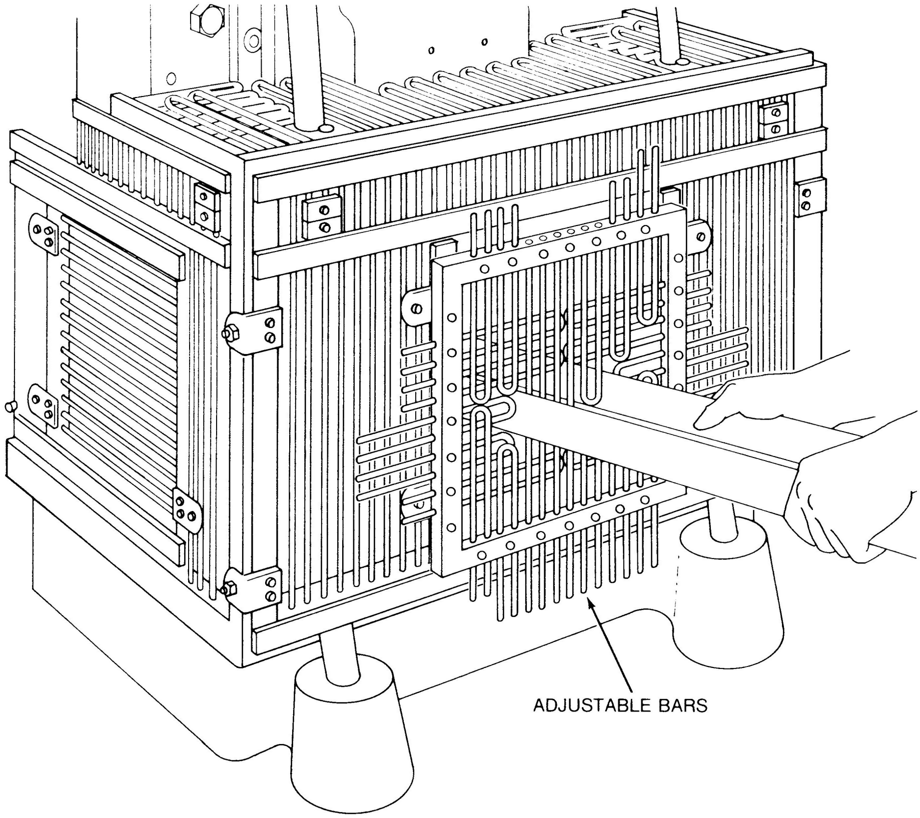



Figure 13-9. Example of an adjustable guard. (From OSHA 3067.)

form part of an exhaust system that collects particles from the operation. It may have a work rest attached to it and have enough structural strength for that purpose. Because there are many kinds of grinding operations and grinding wheels, there are many variations and additional design features to fit each variation.

## Devices

When it is not possible to provide an adequate guard, point-of-operation devices are used. Point-of-operation devices ensure that the machine cannot operate or create a hazard while an operator has fingers or hands in the point of operation. For example, it may be necessary to open a guard to insert or remove parts the machine must act on, and hands may reach the hazardous area of the machine through such openings.

There are many kinds of point-of-operation devices. They include gates or moveable barrier devices, presence sensing devices, pull-out devices, sweep devices, hold-out or restraint devices, two-hand controls, and hand-feed tools.

***Automatic or Semiautomatic Feed and Ejection*** One means for preventing the need to place fingers and hands on the point-of-operation is the use of automatic or semiautomatic feed and ejection equipment. Automatic devices require no action by an operator; semiautomatic devices require a control action by an operator. Material is fed and removed through openings in an enclosure guard (Figure 13-11). Mechanical actions, air pressure,

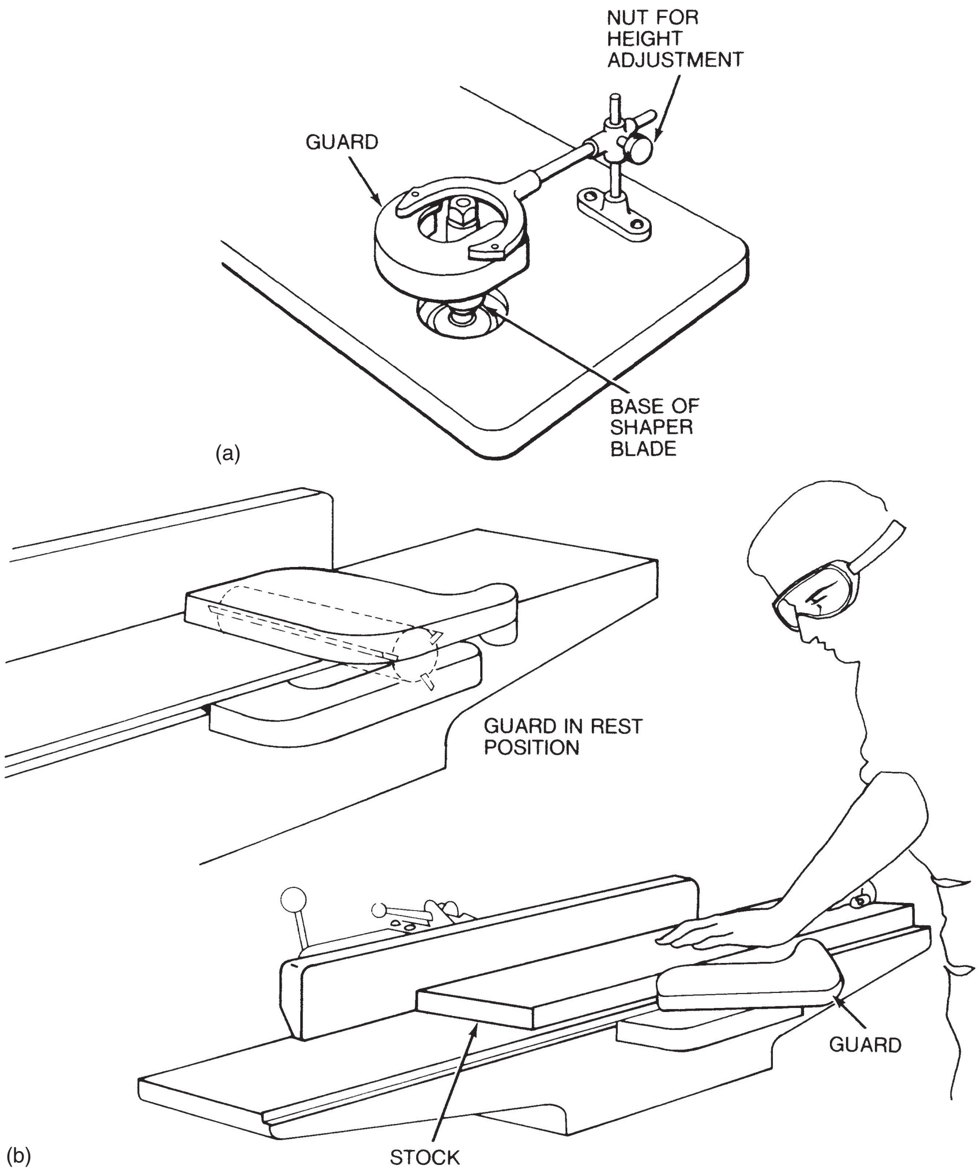



Figure 13-10. Examples of some special guards: (a) ring guard for a shaper; (b) leg of mutton guard for a jointer. (From OSHA 3067.)

and gravity are used for feeding and ejecting materials. The guard openings should meet the criteria in Table 13-1 and Figure 13-2. The means to accomplish this depend on the machine, its function, the material acted on, and other factors.

***Gates or Moveable Barrier Devices*** These are panels or barriers that open to allow materials to be inserted into or removed from a machine. These devices must enclose the point of operation before the machine can start and they stop the machine if the gate or barrier is opened.

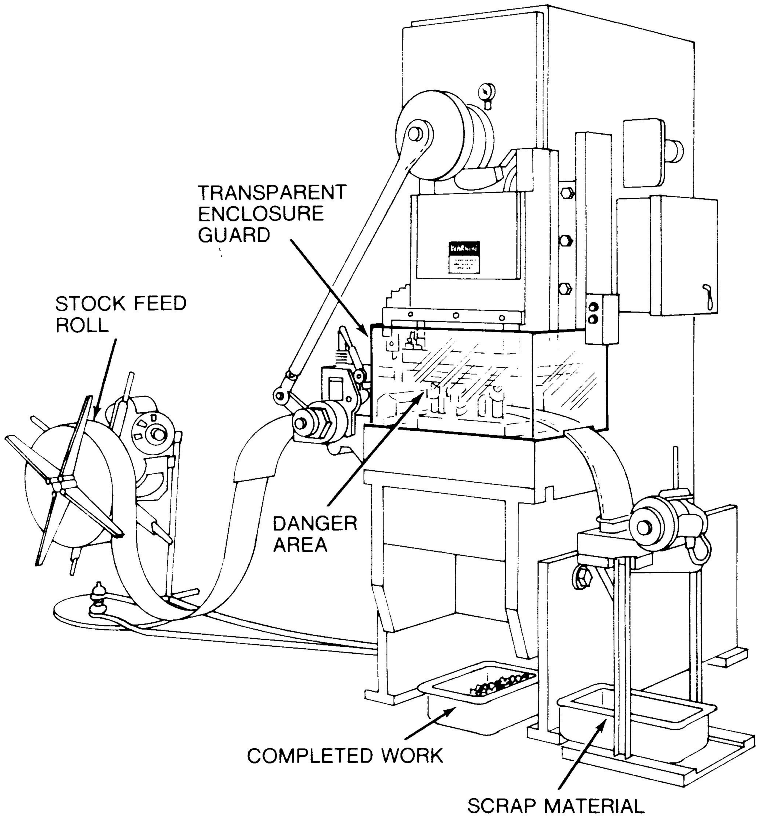



Figure 13-11. Example of a guard combined with automatic feed. (From OSHA 3067.)

***Presence-Sensing Devices*** Presence-sensing devices detect whether the operator's fingers or hands are or could be in the point of operation. If they are, the machine will not operate or will stop quickly enough to prevent injury. Presence-sensing devices may not be a suitable alternative for all machines. Each type of device has particular limitations. Guards should protect all areas not protected by presence-sensing devices.

The sensing device must be far enough from the danger point to ensure that someone cannot reach into the point of operation faster than the machine can be stopped. OSHA uses the following formula to establish the safe distance, $D$, between sensing point and point of operation:

$$D = 63\,\text{in/s} \times T_s, \tag{13-1}$$

where

$D$ is in inches from the point of operation,

63 in/s is an assumed hand speed, and

$T_s$ is the stopping time of the machine in seconds.

One must check presence-sensing devices from time to time to be sure they are working properly. Sometimes an indicator light combined with the control circuit notifies the user of a failure. Assuming a device is working properly when it is not could result in an injury.

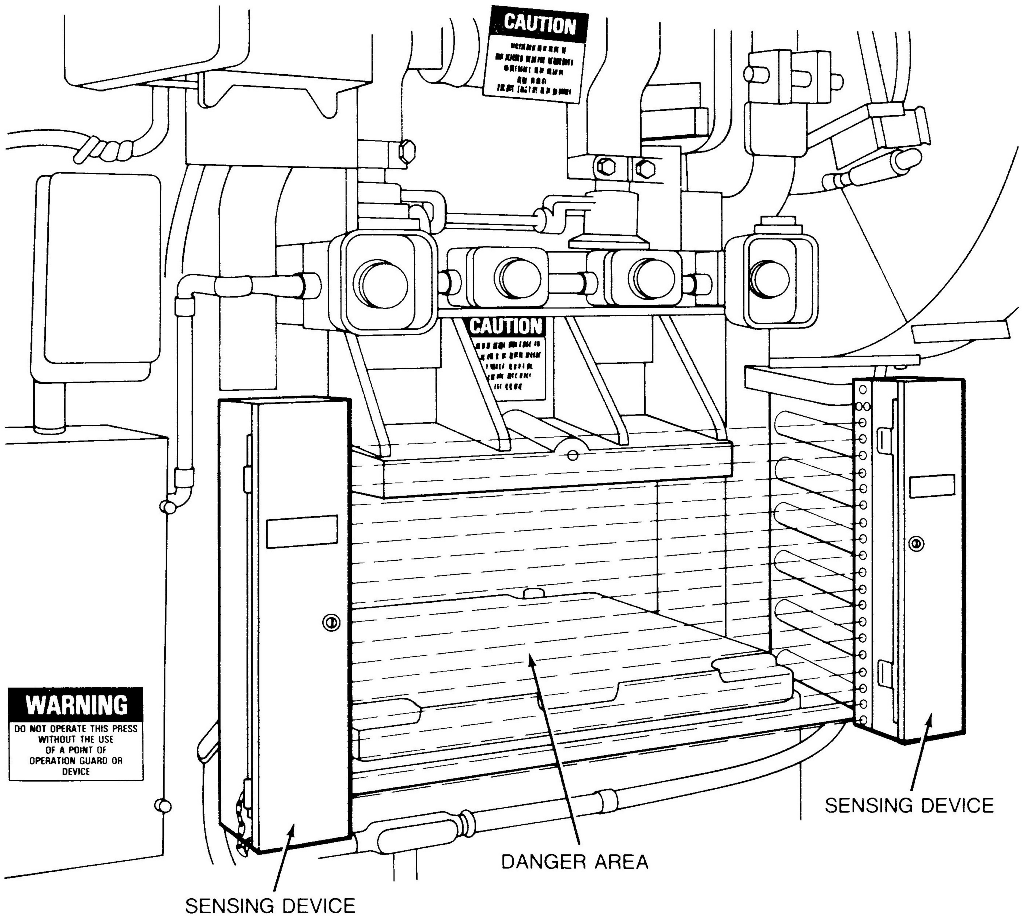



Figure 13-12. Example of a photoelectric presence sensing device on a machine. (From OSHA 3067.)

**Mats** One kind of presence-sensing device is a mat that detects whether someone is standing on it. These mats are placed in locations near a machine where someone could reach into the point of operation. Such a mat can be used to shut off a machine.

**Photoelectric** Another type of presence-sensing device uses light beams and photoelectric sensors (Figure 13-12). An array of beams forms a horizontal, vertical, or combined pattern. If something is inserted into the array that interrupts one or more of the beams, the machine stops or will not operate. Because the array is not easily seen, one must depend on a display to know if it is functioning correctly.

**Radio Frequency Field** Another kind of device uses a radio frequency field. Electronic circuitry that creates the field detects the presence of a human body. The field is positioned around the point of operation by an antenna, which may be a wire or conduit. The sensitivity of the field is adjustable. Grounding characteristics for an operator may change with position and other factors, such as humidity, conductivity of shoes, and so forth, and may affect the reliability of some models.

**Mechanical** Some machines include a mechanical sensing device. For example on a riveting machine, a ring surrounding the point of operation moves down first. If a finger or hand obstructs the ring's full motion, the machine will not cycle the riveting action.

***Pull-Out Devices*** Pull-out devices (Figure 13-13) are mechanisms that attach to an operator's hands and to the moving part of the machine, usually by means of a lightweight cable. This setup couples the motion of the machine with the operator's hands in such a way that the machine action will pull the hands out of the point of operation before they can become injured. To ensure their effectiveness, these devices must be properly fitted and adjusted for each worker. The rigging must be checked each time it is attached to ensure that the device will be effective.

***Hold-Out or Restraint Devices*** A hold-out device is a mechanism that connects the operator's hands to some point of restraint. When properly fitted and adjusted, hands and fingers cannot reach the point of operation.

***Sweep Devices*** A sweep device is a mechanism that is connected to the point-of-operation action of a machine. The device sweeps an operator's hands or body away from the point of operation if they are present when the machine action begins. Sweep devices

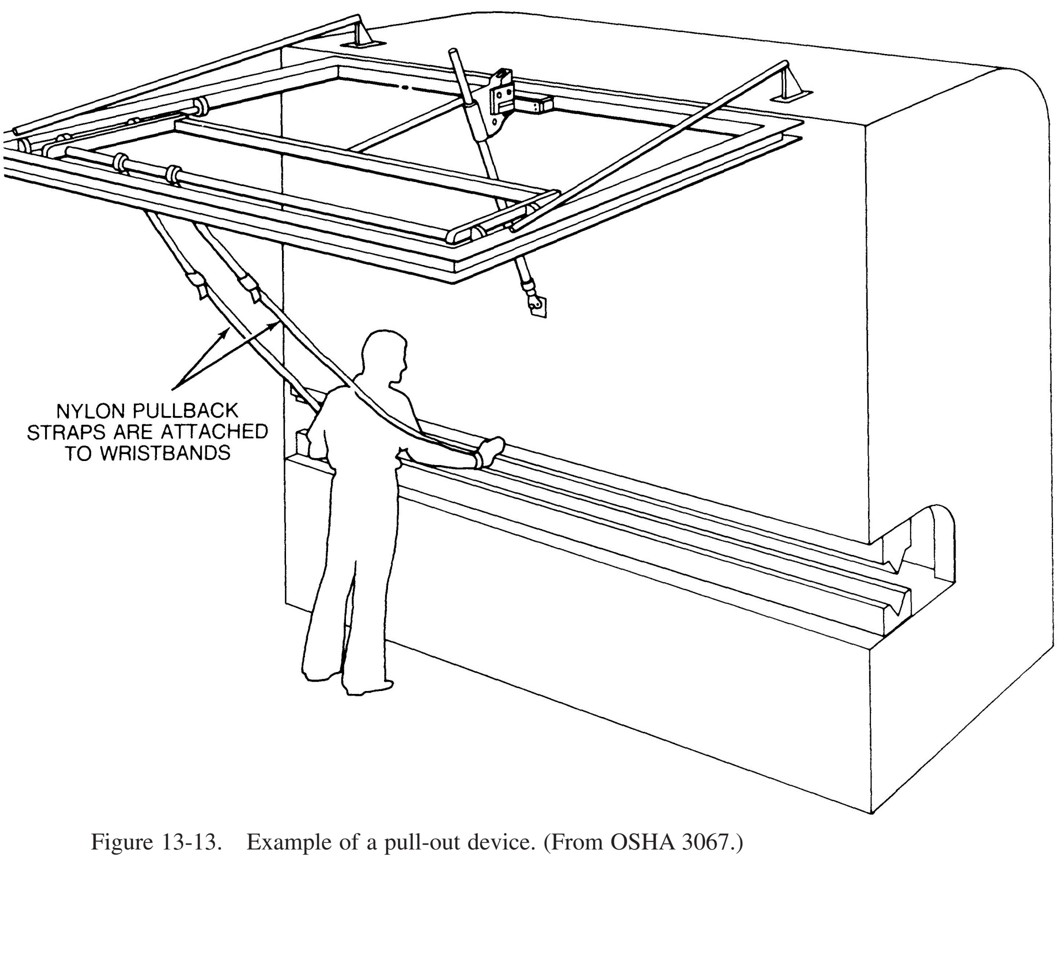



Figure 13-13. Example of a pull-out device. (From OSHA 3067.)

are not allowed under some regulations. In some applications, they may create a shear hazard between the sweep and some other machine component.

***Two-Hand Controls*** A two-hand control device (Figure 13-14) is an electronic or pneumatic control assembly that requires an operator to place pressure on a control with each hand during all or most of the machine operation. The device is designed so that hands cannot be in the point of operation when they are on the controls. The controls must be designed so that they cannot be operated with one hand or arm or by one hand and another part of the body. Some two-hand controls have a time delay limit between activation of two controls. This prevents someone from pressing one control, waiting or doing something else and then pressing the second control with the hand off the first control.

**Distance and Time** The two-hand control must be far enough from the machine so one cannot reach into the point of operation after the machine starts in motion. Equation 13-1 would apply here as well.

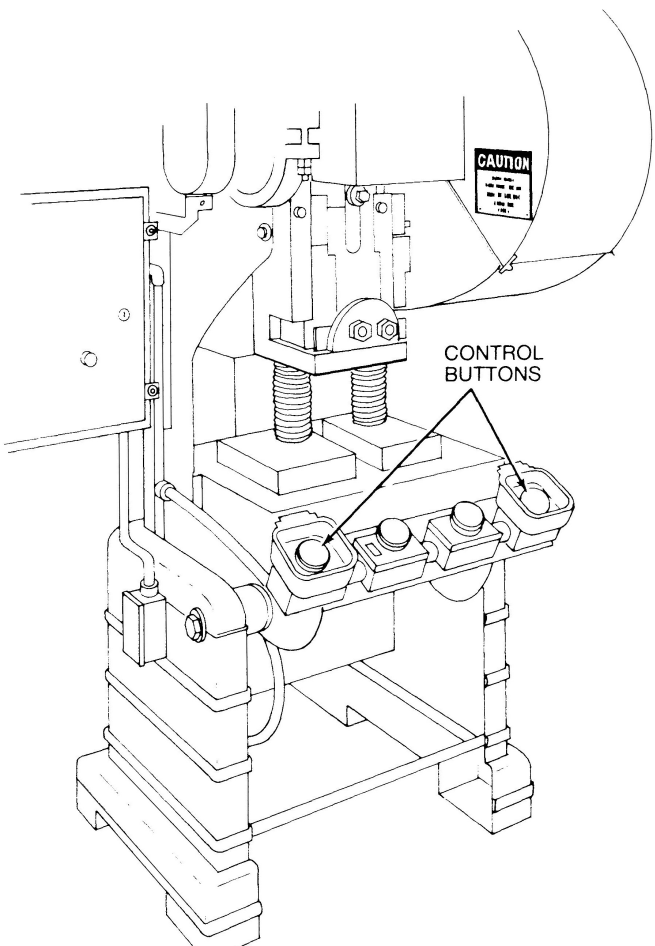



Figure 13-14. Example of a two-hand control device on a press. (From OSHA 3067.)

**Multiple Operators** If there is more than one operator for a machine, each should have a separate set of controls. Controls must be interlocked. All operators must have their hands free of the point of operation before the machine can start its motion.

***Hand-Feed Tools*** Hand-feed tools (Figure 13-15) are special tools that allow an operator to place materials into the point of operation or to remove them without inserting

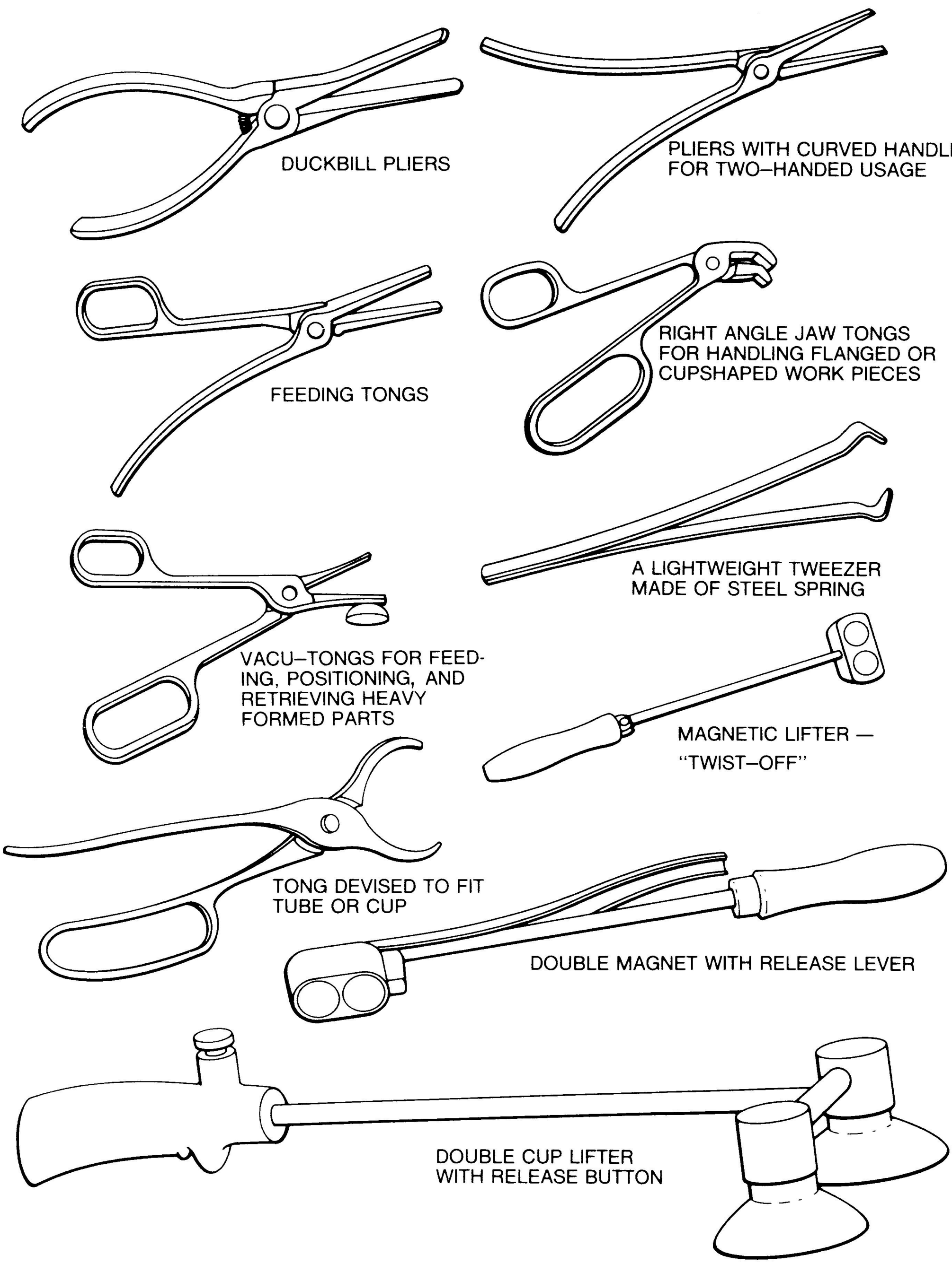



Figure 13-15. Examples of hand-feed tools. (From OSHA 3067.)

hands or fingers. On some machines, such as table saws, jointers, and belt sanders, push blocks and push sticks have a similar use. They keep hands and fingers away from the point of operation.

***Awareness Barriers*** An awareness barrier does not prevent access to the point of operation, but it does alert people to a hazardous area or operation. It may work either of two ways. It may be a guard rail, gate, or similar barrier that prevents easy entry or access to the hazard area, or it may contact any part of the body of a person exposed to the point of operation to let them know that they are near or approaching a hazard. In conjunction with an awareness barrier, a warning should explain the machine's hazard and the purpose of the barrier.

***Awareness Signals*** These are audio or visual signals used with point-of-operation safeguards. The signals alert an operator or others that a hazard exists or is approaching.

***Emergency Stop Controls*** An emergency stop control is an electrical, mechanical, pneumatic, or other control used to stop or de-energize a machine when an emergency occurs. An emergency may include someone getting caught in the machine or point of operation. An emergency control overrides all other controls and requires a separate control to restart the machine. Emergency stop controls should be at locations where an emergency can arise and where operators and others can reach them easily. Stop controls are red, clearly labeled, and require only momentary contact to activate them. They are usually larger than other machine controls, so they are easy to locate and operate. In a machine where hands are occupied when an emergency occurs, there should be a foot-operated emergency stop. Multiple emergency stop controls may be needed if a machine is large or if one emergency stop control is difficult to reach or to access by someone other than the operator. If there are multiple operators, each should have easy access to an emergency stop control. If there are multiple operator positions, there should be an emergency stop control within easy reach of each position. An emergency stop that cannot be reached by a worker who gets caught is not of value to the operator. Emergency stop controls may be combined with braking devices to stop the machine quickly or may reverse the motion to render it safe.

On some machines, a pressure-sensitive body bar, safety trip rod or trip wire, cable, or cord is used. Requiring a worker to reach over a pressure-sensitive body bar to perform some function near a point of operation will allow any excessive leaning to trip the control and stop the machine. Pushing or pulling on a trip rod or trip wire also will stop machines in an emergency.

## Other Machine Safeguards

Depending on the kind of machine, other safeguards may be needed.

***Antirepeat*** Many machines operate one cycle at a time. An operator inserts a part into the machine and then activates the machine, which operates on that part and stops. Then the operator removes the completed part. The operator becomes used to the rhythm of the machine. If, on occasion, the machine cycles more than once, the operator may have reached into the point of operation at the end of the first cycle and injury can occur. Where this situation might occur, the design for a machine action must incorporate an antirepeat mechanism as a safeguard to prevent an inadvertent extra cycle.

***Brakes*** Some machines, like certain presses, have elevated components that may fall because of gravity. Therefore, a mechanical brake is built into them to keep the components in position until a control cycles the machine. Some machines have brakes that can interrupt a machine at any point in its cycle.

Brake monitors determine whether a mechanical brake is performing correctly on each cycle. The monitor displays a position reading. If the brake does not stop the machine component at a desired position within some tolerance, the operator will know that maintenance on the brake is needed.

Other machines, like rubber mills and calenders, use reversing current in the drive motor to stop the rolls when an emergency trip or switch is activated. According to some standards, the rolls must stop within 1.5% of the peripheral no-load surface speed of the roll.

Circular saws and other rotary machine actions tend to rotate for some time after they are shut off. Electronic motor brakes can stop the rotary motion within 1 to 2 s after the power is off.

***Foot Controls*** Foot controls actuate some machines or a machine cycle. They may be inadvertently tripped if something falls on them or if someone inadvertently steps on them. However, a guard over the control and recessing the control inside the guard will prevent most of these occurrences (Figure 13-16). There are a variety of designs for foot controls and foot control guards. Some have a pin that locks them when not in normal use to prevent inadvertent operation of the machine.

When an operator keeps a foot on a foot control between cycles, it is possible to activate it at the wrong time. To help prevent inadvertent operation, foot controls should have a significant resistant force and should require an amount of movement consistent with intentional actions. Human factors literature and other sources give criteria for minimum switch movement.

***Jog Control*** During cleaning, maintenance, or setup operations, it is often necessary to move machine components to certain positions. One means for accomplishing this is with an inching or jogging control. Jog controls allow the machine to be turned on and off

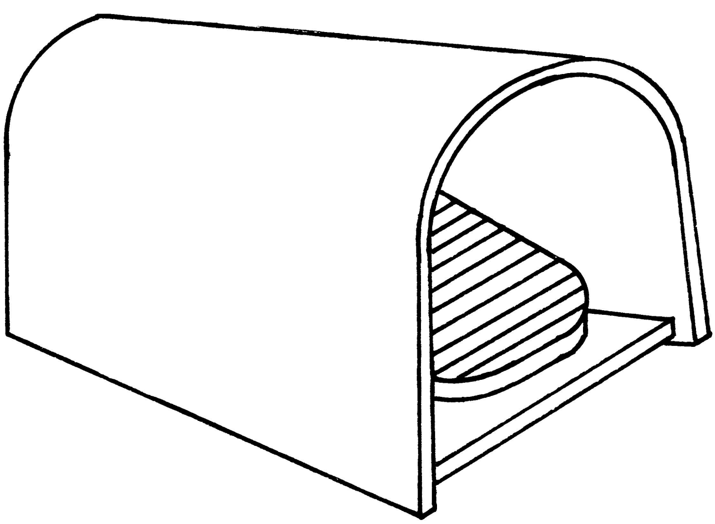


Figure 13-16. Example of a foot control guarded on the top and sides.

quickly where the danger is in turning a machine on for too long and becoming caught or creating some other hazard. When pressed or pushed, a jog control runs the machine; when released, the control stops the machine without any additional action on the part of the user.

***Low-Energy Operation and Inch Controls*** A low-energy mode and low speed (inching) controls can reduce the hazards of machine operation during setup, maintenance, or cleaning. The control may be a mode control switch that has a normal speed or normal energy position and a slow speed or low energy position. In some cases, manual power, such as a hand wheel or crank, may provide the low energy. Because the machine is significantly slowed from its normal operation, an operator has a much better chance to react to dangers and to avoid injury. Fully stopped and de-energized machines are preferred unless there is a clear need for low speed or inching for setup, maintenance, or cleaning.

***Mode Selection*** Some machines operate in different modes. Modes may include continuous operation, single cycle, low energy, or de-energized. A keyed control selects the desired mode. A key is placed into the control and is turned to the desired mode. The operator or supervisor removes the key to lock the selected mode. A key procedure is used to ensure that someone does not change the mode without appropriate safeguards in place. A mode selection switch does not replace lockout and tagout procedures.

***Run Controls*** Run controls turn on a machine and its action or activate the action only. If the machine is turned on inadvertently by someone or something pressing or falling against the power switch, a hazardous condition could result. Putting guards on or recessing run controls prevents accidental starting of a machine. There are various methods for guarding switches and run controls; see Chapter 33.

***Blocks and Stops*** During maintenance and setup activities, the ram on a press could fall and cause injury. To prevent this, a die block or safety block is used to prop it open (Figure 13-17). Some blocks set in a rack attached to the press when not in use, and removal of the block from the rack operates a switch or interlock that de-energizes the machine.

***Antikickback Devices*** Circular table saws have the capability of throwing or "kicking back" stock that binds or catches on the blade. A 2-in × 2-in piece of lumber thrown by a large saw can have enough energy to penetrate an operator's chest. An antikickback dog is a device that allows material to move freely into the saw blade, but pinches the material against the saw table when the material is pulled or pushed backward. A similar device, called antikickback fingers, protects radial saw operators during ripping operations.

## Warnings

One or more warnings are needed on a machine to communicate hazards that may be present. If there are guards for a machine, the warnings should include a notice to keep guards in place and not operate the machine without them. When there are guard devices, the warnings should state the hazards or dangers, any limitation the device may have, and protective actions the operator must take. See also Table 7-1.

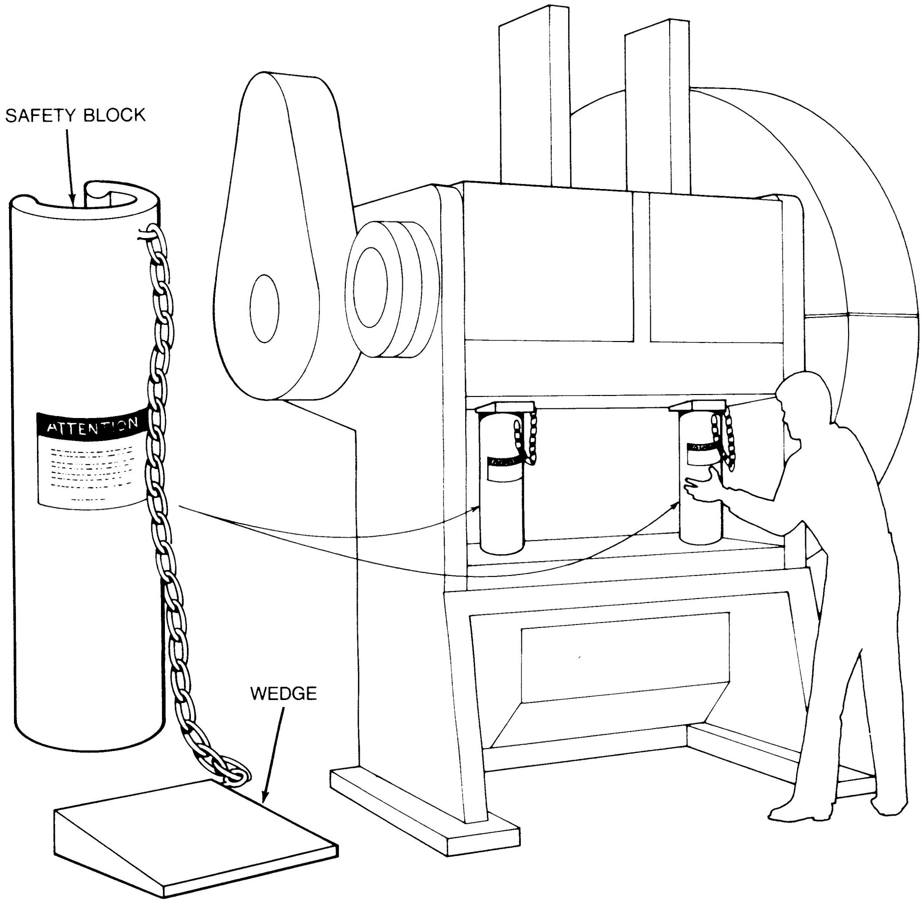



Figure 13-17. Example of a safety block for presses. (From OSHA 3067.)

## Robots

Industrial robots are now quite common. A robot is "taught" or programmed to perform certain movements and functions. Robots have many of the same hazards that machines do, and in addition, their movements are less predictable than simpler machines. The volume of space enclosing the maximum designed reach of the robot or objects it manipulates is the work envelope. One or more safeguard devices protect the work envelope for normal operations. These safeguard devices include presence sensing devices, barriers, interlocked barriers, perimeter guards, awareness barriers, or awareness signals. If an operator must enter the work envelope to maintain or train the robot, additional safeguards are needed. Lockout and tagout procedures, reduced operating speed (10 in/s or less), blocks or stops, emergency shutoff controls, keeping a second person at the robot control panel, and other safeguards may be applied. A pendant control also may help safeguard robots.

***Pendant Control*** A pendant control allows an operator to control a robot from within the work envelope. The pendant control must have certain features. It must be a single point of control; that is, no other controls can operate the robot when it is in the pendant control mode. The robot motions being controlled should be only at slow speed, and when buttons or other controls on the pendant are released, they must stop the robot motion. The pendant control should not have the capability to place the robot in automatic mode and it must have an emergency stop.

## Safeguarding Procedures

Guards and guard devices may not provide enough protection for all the operations and activities involved in the use, maintenance, and repair of machines and tools. A number of safeguarding procedures will help prevent accidents from occurring.

***Training*** An operator of a machine must learn to perform all tasks associated with the machine as well as learning what hazards the machine has and what safeguards protect users from each hazard. Operators should learn where every control is and what it is for, particularly all emergency stop controls. They should know how to make adjustments and to perform setup, maintenance, repair, and cleaning tasks in a safe manner. Learning how to run a machine is not enough. Operators must learn to manage contingencies. They should learn what kinds of things can go wrong, what hazards such situations present, and how to deal safely with them when they do occur.

***Enforcement*** Employers must ensure that workers follow correct and safe operating procedures. Employers and workers must be sure that all guards and guard devices are in place and we working properly. Feedback from workers can provide ideas for making equipment and related operations safer.

***Inspections*** Machines should be inspected regularly to detect potential problems early. Included should be regular checks and testing of guards and guard devices. Any hazards or inadequate safeguards should be corrected before using a machine further.

***Clothing and Jewelry*** Loose clothing, jewelry (particularly rings), and long hair can catch in many machine motions and can pull parts of a body into the machine, causing injury. During machine use, it is good practice not to wear jewelry or loose clothing and to keep long hair covered.

Some machines and operations create hazardous environments for which protective clothing is needed to reduce dangers. One must analyze the hazards of each machine and use appropriate personal protective clothing or equipment.

***Lockout and Tagout Procedures*** During setup, maintenance, or cleaning, a machine should be locked out and tagged out of service. This will prevent anyone from activating it inadvertently or while someone else expects it to be de-energized.

***Zero Mechanical State*** Zero mechanical state (ZMS) recognizes that locking out the main power sources of a machine or system may not remove all sources of energy. Pneumatic, hydraulic, or other fluid lines or components may still be pressurized and may need to be relieved or isolated to make them safe. Valves from other energy sources may not be closed. Springs may have stored energy and need to be blocked or tied. Suspended or loose components may fall or cause movement in the machine and need to be restrained. The ZMS concept recognizes that detailed procedures will help ensure that a machine or system is safe for maintenance, setup, or cleaning operations.

## 13-5 CONTROLS FOR HAND TOOL HAZARDS

Two groups of controls for hand tool hazards are proper practices and safeguards.

### Safe Practices

A number of safe practices that apply to many hand tools are detailed in the succeeding text. In addition, there are individual practices that apply to particular tools. References on hand tools and manufacturers' publications give particular practices.

***Select the Right Tool for the Job*** All too often, people try to make do with an available tool, rather than obtaining the correct one. One example of a wrong use is opening a paint can with a screwdriver, which could slip from the lid and puncture the hand. Other examples of wrong uses are using the wrong-sized screwdriver for a fastener, using a screwdriver for a chisel, striking hard objects or hardened tools with a carpenter's hammer that has a hardened face, or using a pliers for a wrench. Every hand tool has a purpose and is designed with certain features for its purpose. Proper selection will prevent misuse.

***Know the Hazards of the Tool*** Closely associated with the function of each tool are particular capabilities, limitations, and hazards. For example, a carpenter's hammer, like certain other kinds of hammers, has a hardened face. If it strikes another hardened tool or some hard object, the face is likely to spall, causing fragments that can fly into one's eye. Sledge hammers have a softer face that makes them more appropriate for such tasks. The tip of a screwdriver is also hardened, and when it is used for chiselling or prying, it can fragment easily, whereas the struck end of a chisel is intentionally soft so that it will not fragment easily. An ax has a long handle to reach wood objects farther away, whereas a hatchet has a short handle for short swings and nearby wood objects. Adjustable and open-end wrenches do not fit nuts as well as box-end and socket wrenches. Therefore, they should not be used to loosen frozen nuts or to perform final tightening because they are apt to slip.

***Use Tools Correctly*** Socket wrenches have certain torque limits. Using handle extensions or adapters for smaller wrench sizes can cause sockets or wrenches to break. Sockets for hand wrenches are not strong enough for power or impact wrenches. Poor footing and excessive pulling on a wrench may cause one to slip and fall. Wearing eye protection when using striking tools will prevent eye injuries. Using woven metal gloves for cutting operations with knives will prevent hand injuries.

***Maintain Tools*** Inspect tools regularly to be sure that they are in good condition and repair or discard broken, worn or damaged tools. Broken handles on hammers, sledges, axes, and hatchets may cause the head to fly off and strike someone. Sprung or damaged jaws on wrenches can slip, and worn screwdriver tips can slip from the head of a screw and cause injury. Sharpen cutting edges to make cutting tools easier to use and grind the heads of impact tools, like chisels or drift pins, to prevent mushroomed heads, which can fragment.

***Store Tools Properly*** When tools are left lying around, someone may bump into them and become injured; they also create tripping hazards. Pointed tools left in pockets can cause injury if a person falls on them. Tool belts, boxes, chests, and cabinets can help keep tools in order and can keep them safe when not in use. Sharp tools should be stored in protective sheaths when not in use.

## Tool Safeguards

There are a number of safety features found on tools that can help prevent injuries. Certain kinds of tools have particular features.

***Tool Guards*** When using cold chisels, star drills, and other tools intended to be struck, there is the danger of missing the tool head and striking the hand that holds the tool. A round pad of foam with a small hole can slip over the tool and on top of the hand. If one misses the tool, the pad will absorb some of the shock.

Some knives have blade guards that keep the user's hand from sliding down the handle onto the blade (Figure 13-18). Such guards are particularly useful when hands are wet or greasy, such as in meat cutting.

***Handle Design*** Handles on tools come in a variety of shapes (Figure 13-19). Not only do lengths vary, but so do cross sections, which normally vary over the length. Some tools (hatchets, for example) have enlarged ends to minimize the chances of the handle slipping from the hands; others are smaller. Long handles on tools like axes and sledge hammers keep the tool at some distance from the user, allowing for full swings, and keep the tool from striking the legs and feet. Tools with short handles are intended for work closer to the body, which requires partial swings.

The rationale for some handle characteristics is not clear. Recently, however, handle characteristics have received some attention. In the 1950s, Damon and others at Western Electric in Kansas City developed bent handles for needle-nose pliers used in electronics assembly. In the 1970s, without knowledge of previous work, Bennett patented handles for tools and sporting goods. His patent has a bend of $19° \pm 5°$ and a particular aspect ratio for the handle cross section. He noted that when one curls the fingers to grasp something, the opening formed by the fingers is not round, but is oval. He also noted that when one grips some tools, the user's wrist bends to its limit. He chose to bend the handle instead. Examples of Bennett's designs are shown in Figure 13-19(b,c).

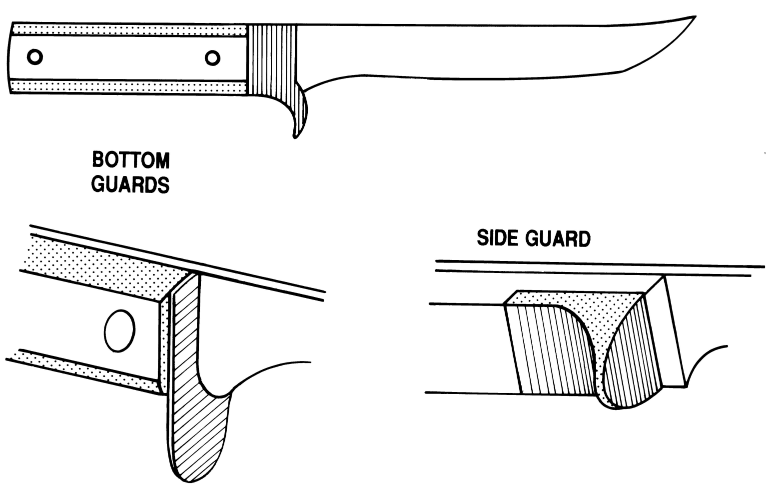
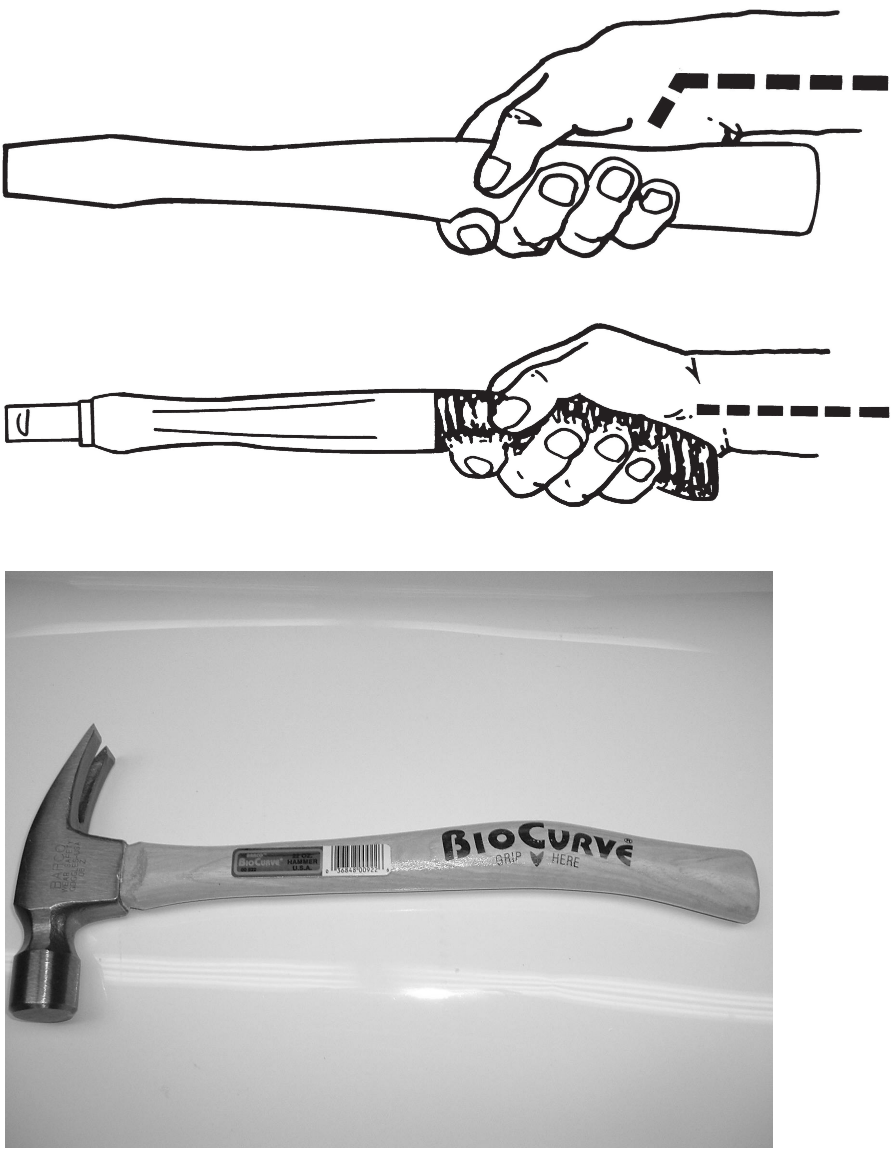



Figure 13-18. Examples of blade guards on knives.




(a)

(b)

(c)

Figure 13-19. Examples of bent handles compared with a straight handle. (a) A conventional hammer handle that requires signficant ulnar deviation of the wrist. (b) A curved handle reduces ulnar deviation. (c) A rip hammer with a BioCurve handle. (d) A mallet with a Bio-Curve handle. (Photos of BioCurve tools provided by and used with permission of BARCO Industries Inc., Reading, PA.)

Handle designs affect the biomechanics of arm and wrist motion. Carpal tunnel syndrome and some related hand and elbow disabilities seem to be relieved by adjustments in the shape or length of handles. For many tools, bending the handle reduces the bending of the wrists. With some handle designs, forces are transferred from the wrist and elbow to more powerful shoulder and back muscles. Bent handles for such tools as pliers, compression cutting tools, hammers, and lopping shears seem to reduce repeated trauma disorders and enhance use.

(d)


Figure 13-19. *continued*

Muscles generate the greatest force when they are about midway through their range of motion. Thus, fingers generate the strongest grip when they are approximately half flexed. The flexion of the wrist joint also affects the ability of the fingers to grip something. For example, when the wrist is fully flexed, it is difficult to grasp something tightly with the fingers.

During use, some tools create pressure in the hand. Examples are pushing on the end of a broom handle, gripping something with a pliers or cutter, and pushing on a paint scraper or putty knife. Special handle shapes can distribute the load against the hand over a greater area. This reduces the likelihood of tissue compression disorders.

High-friction plastics can increase the coefficient of friction between the hand and a tool it holds. Many tools have such plastic grips. There is a potential disadvantage for this material. If there is a tendency for the handle to slip against the skin, one can develop abrasion injuries.

This high-friction plastic material also comes in a moldable form. This permits custom shaping of handles for individual users. Such handles conform to the natural shape of a user's hand and reduce the forces needed for a good grip.

## 13-6 PORTABLE POWER TOOL CONTROLS

### Training

Users of portable power tools need training to use them safely and properly. Training should include how to operate the tools. Users need to understand the hazards of the tool, its action, and its power supply. They need to know what protections are built in and how to protect themselves from hazards during use, and they need to know how to maintain the tools.

## Proper Use and Condition

Like other tools, portable power tools are designed for particular tasks. If used for other purposes, they may create additional hazards.

Tools must be in good condition to perform well and to produce quality work. For example, blades must be sharp, because when they are dull, a user must apply extra force. Guards or other protective devices must be in place and operational.

## Start Switch Lockout

Some power tools have a lockout for the start switch. The idea is to prevent inadvertent operation. A tool cannot operate until a keyed switch selects the operating mode. Some power tools have an extra button to depress before the power switch will operate. For example, a power saw without a lockout button on the start switch could be turned on accidently when picked up by the handle and a finger inadvertently activates the power switch. On some powder-actuated tools, a safety switch must be released before the tool will operate.

## Interlocks

Some tools have interlocks that protect the operator or others. For example, a riding mower has a switch under the operator's seat that shuts off the blades or engine when the operator stands up. This protects the operator from being run over or getting a foot under the mower deck. Riding mowers have an interlock switch that stops the blades or engine when the operator selects reverse gear. This prevents the mower from backing over someone with the blades engaged.

Power-actuated tools have a guard over the driver end. The user presses the guard against the surface into which a fastener is to be installed by the tool. The guard is interlocked to the activating switch or trigger. If the guard is not pressed against a surface, the trigger cannot activate the tools and drive a fastener.

## "Dead Man" Switch

Many power tools have activating switches that shut off power to the tool when the switch is released. Drills, saws, mowers, hedge trimmers, grinders, and other power tools have such controls. The switch that activates the tool action must be depressed at all times during use. If the operator leaves the operator position or lets go of the control, the tool stops. There is little chance of injury to the operator. For some tools, like mowers, standards require that the action of the tool stop within a certain time. This prevents the user from moving to a position of danger while the dangerous part of the machine is still in motion or coasting to a stop.

## Vibration

Continuous use of vibrating tools can result in temporary or permanent disorders, so the design of the tool should minimize vibration. For some tools, vibration is an integral part of the tool and its action, so limiting the duration of use will minimize potential disability from vibration. It may be possible to isolate the vibration within the machine from the operator handles and controls or to reduce its amplitude by design. One option is incorporating isolation pads within the machine or between handles and operator.

### Guarding Tool Action

Many portable power tools have the same dangers as fixed power tools. When any of the five kinds of dangerous machine actions are present, they may need guarding. The goal is to provide guards where possible. For some equipment, guarding may not be possible. For example, one cannot cover the cutting action of a chain saw. Other features, such as blade brake and antikickback designs, reduce the potential for contact with the chain.

### Personal Protective Equipment

The dangers of each kind of power tool and the tool's use will dictate the need for and type of personal protective equipment. Chapter 28 provides more detail about personal protective equipment.

Some personal protective equipment is used in conjunction with certain power tools. For example, there are coveralls designed for use with chain saws. The outer fabric is tough and the chain does not easily cut through it. Another layer of material prevents the chain from contacting the skin.

### Safeguarding Energy Sources

The energy sources for powered tools have hazards particular to them. One must consider these hazards and controls to safeguard them. For example, electrically powered equipment should have the safeguards discussed for electricity. Controls for hazards of gasoline or other flammable fuels used in mowers, trimmers, and other tools are important. Controls for air and fluids under pressure apply to tools with these power sources.

## EXERCISES

**1.** A point-of-operation guard will be installed on a machine with a feed table. An operator will feed material into the machine. The material will be $1\,{}^{1}/_{8}$ in thick and require a ${}^{1}/_{8}$-in clearance in an opening in the guard. How far from the danger line must the guard be located?

**2.** Two in-running rolls (with no feed table) compress parts fed into them. The rolls are each 4 in in diameter, there is a ${}^{1}/_{8}$-in gap between them, and the material is ${}^{5}/_{8}$ in thick before compression in the rolls. A guard will protect the pinch point. The opening for the material will have a ${}^{1}/_{8}$-in clearance. Determine

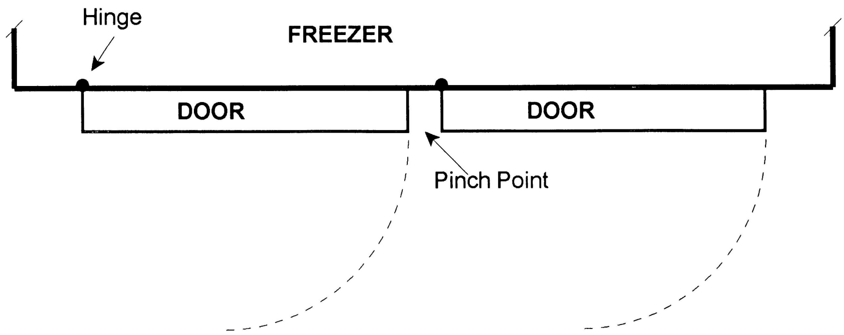
- **(a)** where the danger line is located relative to the center line between the rolls
- **(b)** the location for the guard relative to the danger line

**3.** A calender with 18-in diameter rolls processes rubber. The rolls rotate at 60 rev/min.

- **(a)** What is the surface speed for the rolls?
- **(b)** If the rolls must be stopped in an emergency, what surface distance must not be exceeded? [Refer to OSHA regulations 29 CFR 1910.216(f)(3).]

**4.** A machine will have a presence-sensing device and an interlocking barrier gate. How far from a point of operation must the two-hand trip controls for the operator be located?

**5.** The doors on a food storage refrigerator or freezer in a supermarket are placed close together. When the hinge side rotates, it can create a pinch point for someone other




than the door operator, such as a child accompanying a parent. The design above is a cross-sectional view of two adjacent doors. What are alternate designs for the door structure that will reduce or eliminate the pinch point between doors?

## REVIEW QUESTIONS

1. What are four kinds of hazards of tools and machines?
2. What additional hazards do power sources (such as gasoline, electricity, compressed air, or hydraulic fluid) add to tools and machines beside the hazard of the tool and machine actions?
3. What kinds of injuries can tools and machines inflict?
4. What are cumulative trauma or repeated motion disorders?
5. Describe the symptoms for each of the following:
   - **(a)** trigger finger
   - **(b)** carpal tunnel syndrome
   - **(c)** Raynaud's syndrome
   - **(d)** Dequervain's disease
   - **(e)** bursitis
   - **(f)** perimyotendinitis
   - **(g)** tenosynovitis
   - **(h)** epicondylitis
   - **(i)** ganglion cysts
   - **(i)** rotator cuff
   - **(j)** thorasic outlet syndrome
6. When was the first patent issued for a machine interlock?
7. About when were standards for machine guarding formalized?
8. What functions can machine guards serve?
9. What safeguards are necessary for maintenance, cleaning, and setup of machines?
10. If openings are required in guards, how is protection provided?
11. What criteria are important in guard construction?
12. What are the five kinds of machine motions and the hazards of each?

**13.** Explain the following safeguards:
   **(a)** guards
   **(b)** devices
   **(c)** distance
   **(d)** location

**14.** What safeguards may protect power transmission equipment?

**15.** Describe each of the following point-of-operation guards:
   **(a)** enclosure guard
   **(b)** interlocked guard
   **(c)** adjustable guard
   **(d)** special guard

**16.** Describe the following point-of-operation devices:
   **(a)** automatic or semiautomatic feed and ejection devices
   **(b)** gates or moveable barrier devices
   **(e)** presence sensing devices
   **(d)** pull-out devices
   **(e)** hold-out or restraint devices
   **(f)** sweep devices
   **(g)** two-hand controls
   **(h)** awareness barriers
   **(i)** awareness signals
   **(j)** emergency stop controls, including trip rod, trip wire, and body bar

**17.** Describe the following machine safeguards:
   **(a)** antirepeat mechanism
   **(b)** brake
   **(c)** brake monitor
   **(d)** foot controls
   **(e)** jog control
   **(f)** low-energy control
   **(g)** mode selection
   **(h)** run control
   **(i)** block or stop
   **(j)** antikickback device

**18.** What roles do warnings have in safeguarding machines?

**19.** What safeguards are used for robots?

**20.** What safeguarding procedures are important for machines?

**21.** Describe the following:
   **(a)** lockout and tagout procedure
   **(b)** zero mechanical state
   **(c)** key procedure

**22.** What safeguards are important for hand tools?

**23.** What safeguards are important for portable power tools?

**24.** Describe the following power tool safeguards:

**(a)** start switch lockout

**(b)** interlocks

**(c)** dead-man switch

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B11.3 Safety Requirements for the Construction, Care, and Use of Power Press Brakes

B11.4 Safety Requirements for Shears

B11.5 Safety Requirements for Construction, Care, and Use of Iron Workers Machine Tools

B11.6 Safety Requirements for Construction, Care, and Use of Lathes

B11.7 Safety Requirements for Construction, Care, and Use of Cold Headers and Cold Formers

B11.8 Safety Requirements for the Construction, Care, and Use of Drilling, Milling, and Boring Machines

B11.9 Safety Requirements for the Construction, Care, and Use of Grinding Machines

B11.10 Safety Requirements for Construction, Care, and Use of Metal Sawing Machines

B11.11 Safety Requirements for the Construction, Care, and Use of Gear Cutting Machines

B11.12 Safety Requirements for the Construction, Care, and Use of Roll-Forming and Roll-Bending Machines

B11.13 Safety Requirements for Construction, Care, and Use of Single- and Multiple-Spindle Automatic Bar and Chucking Machines

B11.14 Safety Requirements for Construction, Care, and Use of Coil-Splitting Machines

B11.15 Safety Requirements for Construction, Care, and Use of Pipe, Tube, and Shape Bending Machines

B11.16 Safety Requirements for Powder/Metal Compacting Presses

B11.17 Safety Requirements for Construction, Care, and Use of Horizontal Hydraulic Extrusion Presses

B11.18 Safety Requirements for Construction, Care, and Use of Machines and Machinery Systems for Processing Strip, Sheet, or Plat from Coiled Configuration

B11.19 Performance Criteria for the Design, Construction, Care, and Operation of Safeguarding When Referenced by the Other B11 Machine Tool Safety Standards

B11.20 Safety Requirements for the Construction, Care, and Use of Manufacturing Systems/Cells

B11.21 Safety Requirements for the Design, Construction, Care, and Use of Machine Tools Using Lasers for Processing Materials

B11.22 Safety Requirements for Turning Centers and Automatic Numerically Controlled Turning Machines

B11.23 Safety Requirements for Machining Centers and Automatic Numerically Controlled Milling, Drilling, and Boring Machines

B11.24 Safety Requirements for Transfer Machines

B28.1 Safety Specifications for Mills and Calenders in the Rubber Industry

B65.1 Safety Standard for Printing Press Systems

B65.2 Binding and Finishing Systems

B65.3 Safety Standard for Guillotine Paper Cutters

B65.4 Safety Standard for Stand-Alone Bindery Trimmers

B65.5 Safety Standard for Stand-Alone Platen Presses

OPEI B71.1 Safety Specifications for Consumer Turf Care Equipment—Walk-Behind Mowers and Ride-On Machines with Mowers

OPEI B71.3 Safety Specifications for Snow Throwers

B71.4 Safety Specifications for Commercial Turf Care Equipment

OPEI B71.3 Safety Specifications for Powered Shredder/Grinders and Shredder/Baggers

OPEI B71.8 Safety Specifications for Outdoor Power Equipment—Walk-Behind Powered Rotary Tillers and Hand Supported Cultivators

SNT 101 Safety Requirements for Portable, Compressed Air Actuated, Fastener Driving Tools

SPI B151.1 Safety Requirements for Manufacture, Care, and Use of Horizontal Injection Molding Machines

SPI B151.2 Construction, Care, and Use of Film Casting Machines

SPI B151.4 Construction, Care, and Use of Blown Film Take-Off and Auxiliary Equipment

SPI B151.5 Manufacture, Care, and Use of Plastic Film and Sheet Winding Machinery

SPI B151.7 Requirements for the Manufacture, Care, and Use of Plastics Extrusion Machines

SPI B151.20 Manufacture, Care, and Use of Plastic Sheet Production Machinery

SPI B151.21 Safety Requirements for the Construction, Care, and Use of Injection Blow Molding Machines

SPI B151.27 Safety Requirements for the Integration, Care, and Use of Robots Used with Horizontal Injection Molding Machines
SPI B151.29 Requirements for the Manufacture, Care, and Use of Vertical Clamp Injection Molding Machines
B175.1 Safety Requirements for Gasoline Powered Chain Saws
B175.3 Safety Requirements for Grass Trimmers and Bruchcutters
B177.1 Safety Requirements for Three-Roller Printing Ink Mills
B177.2 Safety Requirements for Printing Ink Vertical Post Mixers
B154.1 Safety Requirements for Construction, Care, and Use of Rivet Setting Equipment
PMMI B155.1 Safety Requirements for Construction, Care, and Use of Packaging and Packaging-Related Converting Machinery
ABMA B165.1 Safety Requirements for Design, Care, and Use of Power-Driven Bruching Tools
RIA R15.06 Safety Requirements for Industrial Robots and Robot Systems
ASAE S493.1 Guarding for Agricultural Equipment
UL 1740 Standard for Safety for Robots and Robotic Equipment
Z50.1 Safety Requirements for Bakery Equipment
Z245.1 Safety Requirements for Refuse Collection, Processing, and Disposal Equipment—Mobile Refuse Collection and Compaction Equipment
Z245.2 Safety Requirements for Stationary Compactors—Equipment Technology and Operations for Wastes and Recyclable Materials
Z245.5 Safety Requirements for Baling Equipment—Equipment Technology and Operations for Wastes and Recyclable Materials
Z245.30 Safety Requirements for Refuse Collection, Processing, and Disposal Equipment—Waste Containers
Z245.41 Safety Requirements for Facilities for the Processing of Commingled Recyclable Materials—Equipment Technology and Operations for Wastes and Recyclable Materials

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B15.1 Safety Standards for Mechanical Power Transmission Apparatus
B107.5M Hand Socket Wrenches (Metric Series)
B107.6 Combination Wrenches (Inch and Metric Series)
B107.8M Adjustable Wrenches
B107.9 Wrenches, Box, Open End, Combination, and Flare Nut (Metric Series)
B107.13M Pliers—Long Nose, Long Reach
B107.20M Pliers (Lineman's, Iron Worker's, Gas, Glass, and Fence)
B107.23 Pliers, Multiple Position, Adjustable
B107.27 Pliers, Multi-Position Electrical Connector
B107.34M Socket Wrenches for Spark Plugs
B107.37M Pliers—Wire Cutters/Strippers
B107.39 Open End Wrenches (inch and Metric Series)
B107.40 Flare Nut Wrenches (Inch and Metric Series)
B107.41M Safety Requirements for Nail Hammers
B107.42M Safety Requirements for Hatchets
B107.43 Electronic Tester, Hand Torque Tools
B107.43M Safety Requirements for Wood Splitting Wedges
B107.44M Safety Requirements for Glaziers' Chisels and Wood Chisels
B107.45M Safety Requirements for Ripping Chisels and Flooring/Electricians' Chisels
B107.46M Safety Requirements for Stud, Screw and Pipe Extractors
B107.47M Metal Chisels
B107.48M Safety Requirements for Metal Punches and Drift Pins
B107.49M Safety Requirements for Nail Sets
B107.50M Safety Requirements for Brick Chisels and Brick Sets
B107.51 Safety Requirements for Star Drills
B107.52M Safety Requirements for Nail-Puller Bars
B107.53M Safety Requirements for Ball Peen Hammers
B107.54 Safety Requirements for Heavy Striking Tools
B107.55M Safety Requirements for Axes
B107.56 Safety Requirements for Body Repair Hammers and Dolly Blocks
B107.57 Safety Requirements for Bricklayers' Hammers and Prospecting Picks
B107.58M Safety Requirements for Riveting, Scaling, and Tinners' Setting Hammers
B107.59 Slugging and Striking Wrenches
B107.60 Pry Bars

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