SAFE WORK

S SPOT THE HAZARD
A ASSESS THE RISK
F FIND A SAFER WAY
E EVERYDAY

EVERYONE'S RESPONSIBILITY

Guideline for Safeguarding Machinery and Equipment

WORK SAFE BC

June 2008

Manitoba

Guideline
for Safeguarding
Machinery and Equipment

Workplace Safety & Health
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WORK SAFE BC

Manitoba

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Contents

Introduction 1

Who should read this manual? 1
Using this manual 2
The relationship between safeguarding and lockout 2
"Guarding" and "safeguarding" 3
Application of Manitoba Regulation 217/2006 and relevant standards 4
Web-based resources 4

1 Hazard Recognition 7

Machinery and equipment hazards 7
Mechanical hazards 7
Recognizing mechanical hazards 7
Principal mechanical components of machinery 7
Health hazards 10
Other hazards 11

2 Risk Assessment 15

What is risk? 15
Assessing risk 15
Hierarchy of safeguarding controls 18

3 Design and Selection Criteria for Safeguards 21

What is a safeguard? 21
Classification of safeguards 21
Barrier guards 21
Safeguarding devices 22
Alternative Mechanism 23
Training, supervision, and procedures 23
Personal protective equipment 23
Barrier guards 24
Typical barrier guards 24
Design and performance requirements for barrier guards 25
Power transmission guards and enclosures: maximum permissible openings 26
Point-of-operation (feed) guards: maximum permissible openings 27
Perimeter fences and rail enclosures: reach distances to moving parts 28
Safeguarding devices 30
Typical safeguarding devices 30
Design and performance requirements for two-hand controls and trips 33
Design and performance requirements for presence-sensing devices 35

How they work....35
Photoelectric light curtains....36
Pressure-sensitive safety mats....36
Design and performance requirements for safety interlocks....37
How they work....37
Movable gate....38
Miscellaneous emergency body contact devices....40
How they work....40
Grab wire and pull wire devices....41
Shields and awareness barriers....41
How they work....41
E-stops....43
How they work....43
Guide to selecting the right safeguard....44

4 Some Common Safeguarding Applications....51

Power transmission guards....51
V-belt/chain-sprocket guard....51
PTO drive shaft guard....52
Rotating shaft and coupling guard....52
Conveyors....53
Belt conveyors....53
Screw (auger) conveyors....54
Safety rules for conveyors....55
Feed rolls....56
Safeguarding feed rolls in general....56
Safeguarding design criteria for feed rolls fed by hand....56
Metal-forming equipment....58
Punch presses....58
Types of punch presses....58
Methods of safeguarding....59
Brake presses....60
Types of brake presses....60
Methods of safeguarding....61
Power shears (sheet metal and plate)....62
Methods of safeguarding....63
Guard design criteria for shears with capacities up to 12 mm (½ inch)....64
Guard design criteria for shears with capacities over 12 mm (½ inch)....64

Iron workers 64
Hand-fed powered metal-forming rolls 65
Other powered roll formers 65
Abrasive equipment 66
Proper storage and handling of abrasive wheels 66
Design criteria for abrasive wheel guards 67
Safety rules for bench and pedestal grinders 67
Woodworking equipment 68
Safety and health hazards 68
Safety hazards 69
Health hazards 69
Point-of-operation hazards 69
Kickbacks 70
Tool projectiles 70
Preventive measures 70
Engineering controls (guards) 70
Administrative controls (safe work practice) 71
Personal protective equipment 71
Safeguarding commonly used woodworking machines 71
Table saw 72
Radial arm saw 73
Band saw 75
Jointer 77
Shaper 79
Industrial robots and robotic systems 80

Appendices 83

Appendix 1 – Maintenance and Repair 85
Appendix 2 – Personal Protective Equipment 89
Appendix 3 – Machine Risk Assessment Survey 91
Appendix 4 – Safeguarding Checklist 93
Appendix 5 – Standards References 95

Introduction

Introduction

While adjusting a conveyor belt, a millwright is drawn into the unguarded tail drive of a belt conveyor and suffers fatal crushing injuries. A young worker feeding sheet rubber into a guillotine shear loses both hands when the machine cycles unexpectedly. A lumber piler cleaning up around a lumber sorting table (green chain) is strangled when his loose clothing is caught on an exposed keyway at the end of a slowly rotating shaft.

Accidents associated with unguarded equipment and machinery often result in injuries, amputations, or death.

These are three examples of serious injury or death resulting from unguarded or inadequately safeguarded machinery and equipment, which can happen in any workplace that uses powered equipment.

Each year, physical contact with machines and powered equipment account for a significant number of life-altering injuries, including amputations and disfigurement, and may also result in the death of a worker. Most of these accidents can be prevented by effective safeguarding, lockout procedures, and supervision and training.

Why is safeguarding important? It is impossible to predict what people will do around powered machinery, no matter what their level of experience or training. Effective safeguarding protects against both human error and lapses in judgment, as well as accidental contact with moving parts.

Who should read this manual?

This manual is for everyone who owns, operates, maintains, or sells powered machinery and equipment.

- Employers will find information to help them comply with the Workplace Safety and Health Act (W210) and The Workplace Safety and Health Regulation (MR217/2006). It will also help them exercise due diligence in providing a safe work environment.
- Supervisors will find information to help them assess the risks to their workers from harmful contact with machinery and equipment. It will also help them evaluate safeguarding solutions that satisfy the competing needs of safety, production, and quality assurance.
- Workers will gain greater awareness of the hazards associated with equipment operation and maintenance and of the safeguarding protection they have a right to expect.
- Suppliers will understand what they must do to provide machinery and equipment that comply with Manitoba Regulation 217/2006. They will have a quick reference to different options for meeting this responsibility.

This manual will also be useful to personnel involved in risk assessment, maintenance, and operations management; safety and health committees; and safety professionals.

Using this manual

This manual provides general information that employers can use to develop safeguarding solutions for their specific machinery and equipment. It is not a complete "how-to" guide to safeguarding. Each safeguarding situation should be evaluated on its own merits and the general principles described here should be applied. This manual does not provide "blueprint" solutions or replace the need for employers to consult the relevant standards *and manufacturers' recommendations* when faced with technically complex safeguarding problems.

Note the following:

- In this manual, the word "must" indicates that a particular requirement is found in the Workplace Safety and Health Regulation (MR217/2006) or a referenced standard. Requirements for safeguarding of machinery are found in Part 16 Workplace Safety and Health Regulation (MR217/2006), Machines, Tools and Robots, which refers to Canadian Standards Association (CSA) Standard Z432, Safeguarding of Machinery.
- The word "should" indicates that a particular course of action, although not specified in the Workplace Safety and Health Regulation (MR217/2006), will improve safety in the workplace.
- In the Workplace Safety and Health Regulation (MR217/2006), the word "worker" includes supervisors, managers, and workers.
- The information provided in this manual is for general application and is not intended to replace the contents of the standard.

The relationship between safeguarding and lockout

It is important to distinguish between safeguarding and lockout. **Safeguarding** is the first line of defence in ensuring the safety of workers operating powered machinery and equipment. **Lockout** protects workers when machinery or equipment is shut down for maintainance (including repairs and clearing jams). In all cases, training and supervision are essential to ensure worker safety around machinery.

Lock-out means ensuring that a machine, tool, pipe, or other equipment is not able to start or transmit energy when it is being maintained, serviced, repaired, or adjusted. Refer to Appendix 1 – Maintenance and Repair for more information on lock-out requirements.

"Guarding" and "safeguarding"

The terms "guarding" and "safeguarding" tend to be used interchangeably, but they have precise meanings in the language of machinery and equipment safety.

Safeguard is the umbrella term for a number of measures that provide workers with effective protection from harmful contact with hazardous moving parts or other harmful conditions. Safeguards include barrier guards, safety devices, shields, awareness barriers, warning signs, or other appropriate means, used singly or in combination.

Guard and ***barrier guard*** refer to a specific type of safeguard. Guards are physical barriers or covers designed, constructed, and installed over moving parts to prevent any contact with them. Guards are the simple solution to protecting workers when access to moving parts, such as belts and drive chains, is not required during operation. They are reliable and cost-effective, and require low maintenance when properly designed and installed.

Safeguarding devices include a number of alternatives to barrier guards, such as interlocked movable barrier guards, two-hand controls, and electronic presence-sensing devices such as light curtains and pressure-sensitive mats. These solutions are more complex and technical but are designed to provide protection during normal operation, such as when materials are fed into a machine for processing.

Parts 3 and 4 of this manual provide detailed information about the characteristics, advantages, limitations, and selection of guards and safeguarding devices.

Requirements for safeguarding powered machinery and equipment are found in Part 16 of the Workplace Safety and Health Regulation (MR217/2006), Machines, Tools and Robots.

Application of the Workplace Safety and Health Regulation (MR 217/2006) and relevant standards

Requirements for safeguarding machinery and equipment are found in the Workplace Safety and Health Regulation (MR217/2006), Part 16, Machines, Tools and Robots. The general safeguarding reuirements of Part 16 always apply, even if there is also a specific code or standard covering a particular device.

Various standards organizations in North America, Europe, and around the world have produced written standards for almost all types of powered machinery. These publications are an excellent resource in determining how to safeguard specific types of equipment not mentioned in the Workplace Safety and Health Regulation (MR217/2006). Appendix 5 of this manual provides a list of standards that are referred to in the Workplace Safety and Health Regulation (MR217/2006).

Web-based resources

Links to Safe Work online resources related to safeguarding can be found at gov.mb.ca/labour/safety. Links to other web sites with information about safeguarding are also provided.

1

Hazard Recognition

Machinery and equipment hazards

Hazards created by machinery and equipment can be classified as **mechanical** and **non-mechanical.**

Mechanical hazards

Recognizing mechanical hazards

A good way to recognize mechanical hazards is to observe how the moving parts of a machine operate and how parts of a worker's body are likely to come into harmful contact with them.

Some moving machinery and equipment parts can endanger a worker in more than one way. For example, an abrasive wheel can explode and cause serious impact injuries. Or, minor abrasion can result when a worker's hand accidentally rubs against the wheel.

Machine parts generally move in one of three ways: they rotate, they slide, or they can rupture, fragment, and/or eject.

- Single rotating parts, such as shafts or couplings, present a risk of snagging or entanglement. Two or more parts rotating together, such as feed rolls and V-belt and pulley drives, create nip points (see Figures 1.1 and 1.2).
- Parts that slide or reciprocate, such as dies in punch presses, create shearing or crushing hazards.
- Parts that can rupture or fragment, such as an abrasive wheel, may cause impact injuries.

Figures 1.1 to 1.5 illustrate common mechanical hazards where hands, limbs, hair, clothing, and sometimes the entire body can be injured from harmful contact with unguarded moving machine parts. The illustrations show typical cases, not all possibilities.

Principal mechanical components of machinery

Most machines have three principal components:

- A power source (often an electrical motor)
- A power train that transfers moving energy
- Tooling

Hazards from these components generally involve the following:

- Power transmission parts. These are the moving parts of the power train. They usually consist of belts, pulleys, chains, sprockets, gears, shafts, and couplings. Many of the moving parts illustrated in Figures 1.1 and 1.2 are power transmission parts.
- Point of operation. This is where the tooling of the machine is contained and the machine's work is performed. The term "feed point" is sometimes used to describe the working area of the machine.

The types of machine components and drives shown in Figures 1.1 to 1.5 are very common in most industrial operations. They account for a large number of serious injuries in the workplace.

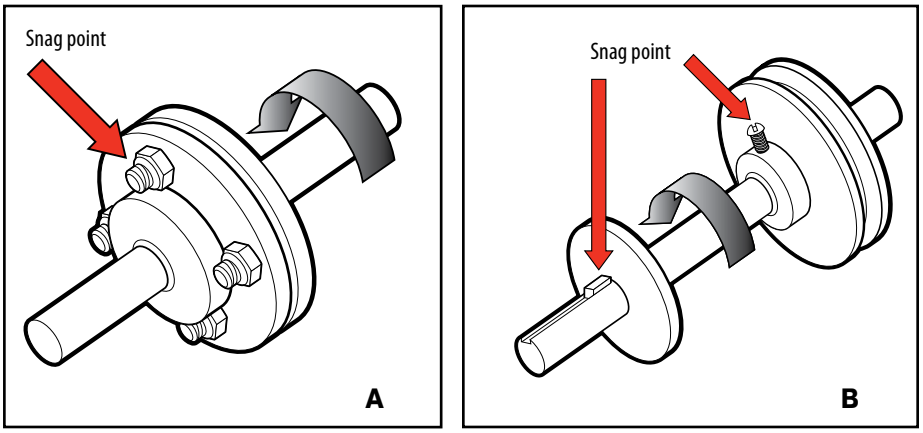


Figure 1.1. Single rotating parts presenting a snagging/entanglement hazard. (A) Snagging hazard from projecting flange bolts on rotating coupling. (B) Snagging hazard from projecting keyway and set screw on rotating shaft.

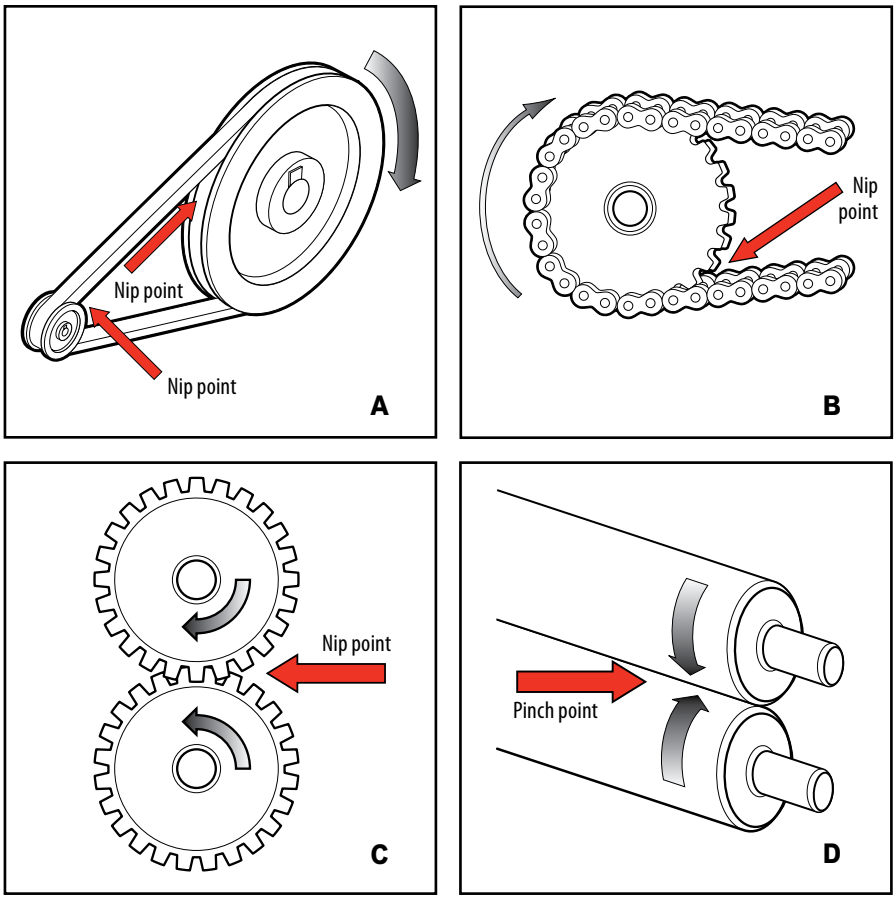


Figure 1.2. Multiple rotating parts presenting an in-running nip point hazard. (A) V-belt and pulley drive: a common source of in-running nip points on powered industrial machinery. (B) Typical chain-sprocket drive. (C) Typical exposed gears. (D) Typical feed rolls.

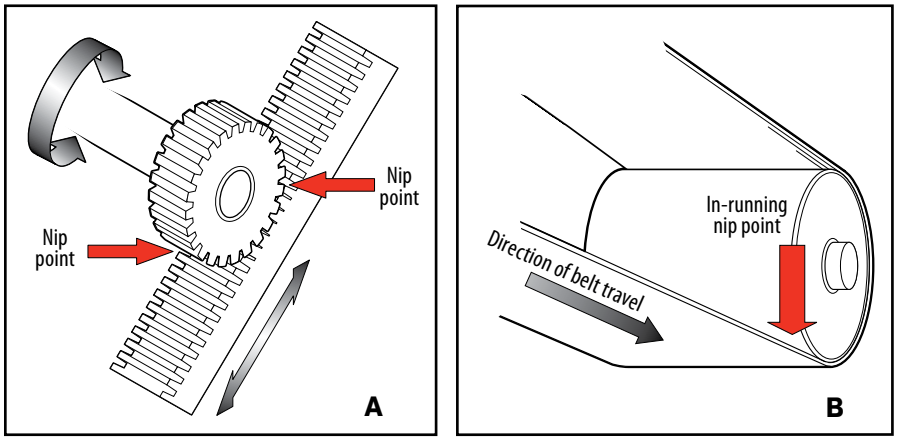


Figure 1.3. Combination of rotating and sliding parts and reversing parts, creating two in-running nip point hazards. (A) Rack and pinion gears. (B) Conveyor belt spool.

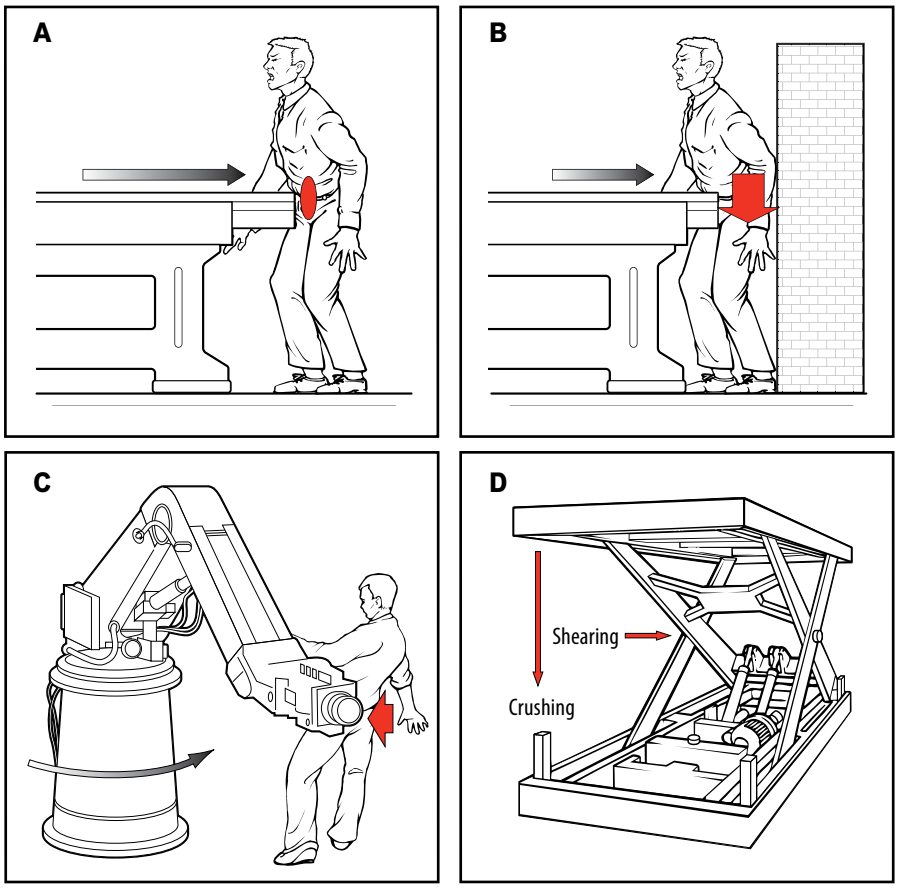


Figure 1.4. Sliding/pivoting movement creating struck by/crushing hazards.
(A) Sliding milling table striking worker in abdomen.
(B) Sliding milling table crushing worker against adjacent wall. (C) Worker struck by robot arm.
(D) Scissor lift creating crushing/shearing hazards.

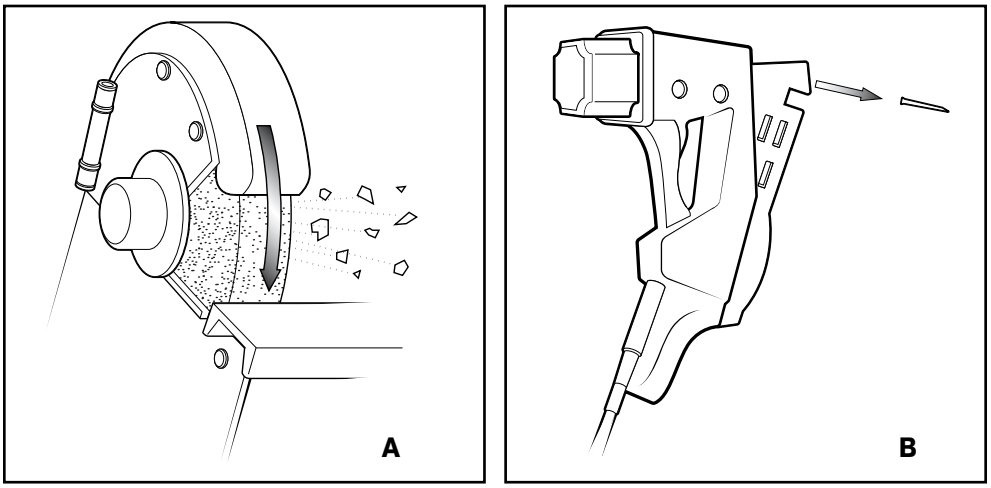


Figure 1.5. Hazards from fragments and projectiles.
(A) Fragments from exploding abrasive wheel. (B) Projectile from pneumatic nail gun.

Health hazards

Workers operating and maintaining machinery can suffer adverse effects other than physical injury caused by moving parts. They can be exposed to hazards through inhalation, ingestion, skin contact, or absorption through skin. For example, without adequate safeguards, control measures, and personal protective equipment, a worker may be at risk of occupational disease resulting from exposure to:

- Toxic or corrosive chemicals that can irritate, burn, or pass through the skin
- Harmful airborne substances that can be inhaled, such as oil mist, metal fumes, solvents, and dust
- Heat, noise, and vibration
- Ionizing radiation such as X-rays and gamma rays
- Non-ionizing radiation such as ultraviolet light (UV), radio frequency (RF) energy, and lasers
- Biological contamination and waste
- Soft tissue injuries (for example, to the hands, arms, shoulders, back, or neck) resulting from repetitive motion, awkward posture, extended lifting, and pressure grip

Other hazards

Some hazards are associated with things other than moving parts:

- Slips and falls from and around machinery during maintenance
- Unstable equipment that is not secured against falling over
- Fire or explosion
- Pressure injection injuries from the release of fluids and gases under high pressure
- Electrocution from faulty or ungrounded electrical components

Machines must be safeguarded to protect workers from these non-mechanical hazards as well as the more obvious mechanical hazards.

Sometimes a safeguard used to eliminate or minimize a mechanical hazard can be modified to also minimize a non-mechanical hazard. For example:

- A guard designed to prevent access to moving parts may also absorb noise.
- Welding curtains designed to shield against arc flash can also protect against spatter and burns.
- Guards surrounding abrasive wheels can also be used as a shroud for local exhaust ventilation.

2

Risk Assessment

Risk Assessment

What is risk?

Risk is a sliding scale measure of how serious a safety concern is. It takes into account a number of factors. The two most important factors affecting risk are:

- How likely is it that an accident will occur?
- If an accident does occur, how serious would injury be?

The first factor is a measure of probability (how likely?). The second is a measure of severity (how serious?).

The level of risk is based on the combination of these two factors. For example, in one case, the likelihood that a worker will come in contact with dangerous moving parts of a machine is low, but if he does, it is certain that he will lose his arm; the level of risk is *high.* In another case, the probability of harmful contact with moving machine parts is low, and the expected injury is only a mild abrasion; the level of risk is *very low.* If harmful contact is almost certain and the expected injuries are very severe, the risk level is *extremely high.*

Never ask the question, "What is a worker likely to do?" In a given situation, with the pressures of production, you cannot reliably predict what someone is likely to do. The question you need to ask is, "What *can* they do?" In general, if someone can access a hazard, additional safeguards are warranted.

Assessing risk

To realistically assess the risks of machinery and related equipment, it is necessary to understand how the moving parts of a machine can injure a worker. Chapter 1 of this manual, which deals with hazard recognition, provides some of this information.

A risk assessment must involve the operator, maintenance personnel, supervisor and the workplace safety and health committee/ representative. You should also consult with the manufacturer, suppliers of safeguards, and safety professionals. Each party sees the machine from a different perspective, and will provide a valuable contribution.

Gathering the information necessary for a good risk assessment may require repeated observations, especially when determining what the worker does when normal production flow is interrupted. The length of time that a piece of equipment is in service without causing an injury has no bearing on whether or not it is safe.

Operators are at greatest risk of injury when hand feeding an unguarded machine activated by a foot control.

Some significant factors that increase the probability of contact with unguarded hazardous machine moving parts include:

- Lack of familiarity with the machine
- Hand feeding a machine activated by a foot control
- Reaching into a machine to clear jams and misfeeds
- Boredom and repetition
- Frequent access to danger areas of the machine for setup and adjustments
- Lack of operator training and experience
- Machine cycle speed

There are a number of machinery risk assessment models in use. Some are highly technical in nature (**quantitative** risk assessments), others are more observation-based (**qualitative** risk assessments). The model shown in Figure 2.1 is a simplified combination of the two approaches. (A blank form is found in Appendix 1 of this manual.)

The main purpose of a risk assessment is to decide which machine should be given priority, and which parts of the machine should be safeguarded first.

Machine Risk Assessment Survey

Company Name	**Date of Survey**	**Survey done by:**
ABC Food Processors Ltd.	March 10, 2005	1. Raj Nagal (supervisor) 2. Bill Knight (maintenance) 3. Lindsay Hall (operator)
Machine Name	**Machine Function**	
Integrated Wrapping Line	Tray Wrapper	

Identify and describe *every* hazardous machine motion or harmful condition to which the worker's body parts are exposed (e.g., rotating shafts, in-running nip points, shearing parts, reciprocating parts, punching action, impact hazards, flying debris, abrasive surfaces, electrical hazards, hot/toxic fluids, vapours, emissions, radiation). Be as descriptive and detailed as possible.	**Describe the worst injury that would reasonably occur due to each hazard.** Use the following descriptions as a guide: • **Fatal** • **Major** (normally irreversible: permanent spinal damage, loss of sight, amputation/crushing, respiratory damage) • **Serious** (normally reversible: loss of consciousness, burns, fractures) • **Minor** (bruising, cuts, light abrasions)	**Estimated severity of injury:** Minor = 1 Serious = 5 Major = 7 Fatal = 10	**Estimated likelihood of injury** (see Note 1): Unlikely = 1 Possible = 5 Probable = 7 Certain = 10	**Estimated level of risk** (see Note 2): Estimated severity × estimated likelihood
1. Initial infeed belt creates pinch point near front roller.	Minor bruising of fingers	1	5	5
2. Crushing hazard between tray wrap film folder arms and machine frame	Amputation injury to fingers or severe crushing of hands	7	7	49
3. Outfeed tray/film heat belt is very hot	Burns to hands	5	5	25
4. Web belt drive unit for outfeed belt has no guard – infrequent access required	Bruising of fingertips	1	5	5

Note: Gathering this information may require repeated observations, especially when determining what the worker does when normal production flow is interrupted.

Recommended safeguarding to eliminate or reduce the risk to an acceptable level (see Note 3)

1. Realign belt to eliminate pinch point.	3. Lower exhaust ventilation capture hood a few inches to close off access to this hazard. Place warning decal near burn hazard.
2. Design and install interlock gate guard over moving arms; operator can then make minor adjustment without locking out.	4. Extend side flange to enclose access to chain-sprocket drive.

Note 1. The following factors may be useful when estimating the likelihood of injury:

- Machine cycle speed
- Hand feeding with foot control
- Operator training and experience
- Boredom factor (repetition)
- History of jams and misfeeds resulting in frequent access to danger areas of the machine
- Previous injuries on this machine or machines of this type

Note 2. Use the estimated level of risk to set the priority for implementing safeguarding measures. The higher the estimated level of risk, the more urgent it is to implement safeguarding solutions.

Note 3. Always follow the hierarchy of safeguarding controls regardless of the perceived level of risk.

Figure 2.1. Sample completed machine risk assessment survey form, with hierarchy of safeguarding controls to be used.

Hierarchy of safeguarding controls

When selecting a safeguard or a combination of safeguards, always start at the top of the hierarchy shown below. Choose a less effective safeguard only when the more effective solution is impracticable.

For example, you may be able to eliminate the need to hand-feed a machine by installing an automated feeder. Installing a fixed barrier guard across a feed point may be practicable if the feed stock is a flat sheet metal blank; for larger material, you may have to allow access to the point of operation using two-hand controls or a light curtain (a presence-sensing device) instead.

Hierarchy of Safeguarding Controls			
Most effective	1. Elimination or substitution	• Eliminate human interaction in the process • Eliminate pinch points • Automate material handling	
↓	2. Engineering controls (safeguarding technology)	• Mechanical hard stops • Barrier guards • Interlocked guards	• Presence-sensing devices • Two-hand controls
↓	3. Awareness	• Lights, beacons, strobes • Computer warnings (PLC-generated) • Restricted space painted on floor	• Beepers • Horns and sirens • Warning signs and labels
↓	4. Training and procedures (administrative controls)	• Safe work procedures • Safety equipment inspections	• Training • Lockout
Least effective	5. Personal protective equipment	• Safety eyewear • Face shields • Hearing protection	• Gloves • Respirators

3

Design and Selection Criteria for Safeguards

Design and Selection Criteria for Safeguards

What is a safeguard?

A safeguard is a solution or a combination of solutions that eliminate or reduce the risk of exposure to hazardous moving parts or other harmful conditions. Safeguards range from fixed barrier guards (most effective) and safeguarding devices to safe work procedures and personal protective equipment (least effective) (see the hierarchy of safeguarding solutions on page 18). A comprehensive risk assessment will determine which safeguards are most effective.

Classification of safeguards

There are six general ways to safeguard machinery and equipment:

- Barrier guards
- Safeguarding devices
- Location
- Awareness means
- Training and procedures
- Personal protective equipment

Barrier guards

Properly designed and installed barrier guards provide the most effective protection to workers. **Fixed barrier guards** are the first choice of engineering control to keep workers from contacting hazardous moving parts or to contain harmful fluids and projectiles, particularly when access is not normally required during operation. Fixed barrier guards must be *secured with at least one fastener requiring a tool for removal.*

When a barrier guard must be moved aside to enable a worker to access a point of operation or feed point during normal production work, the guard must be **interlocked** to disable the control system until the guard is put back in place and the control system is reset. Some barrier guards are adjustable to allow materials of varying thickness to be fed into a machine. Some guards are attached to the tooling or dies that fit into a machine. These are a special type of barrier guard called **die enclosure guards.**

A common requirement of all barrier guards is that they prevent a worker from reaching around, over, under, or through the guard to the danger area.

A common requirement of all barrier guards is that they physically prevent a worker from reaching around, over, under, and through the guard to the danger area. Unless interlocked with the control system, a barrier guard must be secured with at least one fastener requiring a tool for removal.

Safeguarding devices

Properly selected safeguarding devices can provide a high level of protection to workers during normal production. **However, they are not a substitute for locking out when** clearing obstructions and performing maintenance.

Access to feed points and ejection of formed parts is often required during normal machine operation. This may make the use of a fixed barrier guard, or even an interlocked guard, impracticable. Fortunately there are a number of safeguarding devices that can provide a high level of protection to workers.

These devices generally operate in one or a combination of ways:

- Requiring the operator to remove his or her hands or entire body from the danger area before the machine can be cycled. Two-hand controls and interlocked gate guards function this way.
- Stopping the machine if the operator or another worker enters the danger area while the machine is cycling. Presence-sensing devices such as light curtains and photoelectric devices and pressure-sensitive mats function this way. These devices depend for their effectiveness on a very reliable braking system and associated control system.
- Physically restraining the operator from reaching into the danger area of the machine at any time. This can be done through the use of a restraint device such as a safety belt and lanyard.
- Involuntary tripping or activation of an emergency stop device if all or part of a worker's body approaches or enters the danger area. Examples include a "crash bar" or "belly bar" in front of a trim saw in-feed lug chain; the emergency contact bar in front of the in-running feed rolls of a flatwork ironer; and the emergency trip wire installed along a conveyor system.
- Limiting machine movement or travel to a safe range or speed. Examples include operating the machine in a "jog," "inch," or "setup" mode, activated by special control buttons (printing presses); limiting die movement to 6 mm (¼ inch) or less before a piece can be inserted into the dies; an anti-repeat device that prevents a machine from performing more than one cycle (single-stroke mode).
- Locating the worker in a safe place before the machine can be started. Examples include a foot control fastened to the floor a safe distance from the machine (called "captive" or "hostage" control); the activating control for an X-ray machine located in an isolated room.

- "Hold-to-run controls," which require the operator to keep the control activated in order for the machine to continue to operate (also known as "deadman" or "operator-maintained" controls).
- "Captive key systems," which use a series of keys and locks to start or shut down a hazardous operation in a prescribed and safe sequence.

All safeguarding devices should be inspected on a regular basis by a qualified, competent person, and by the machine operator as part of a pre start-up checklist.

All safeguarding devices must be designed, constructed, installed, used and maintained according to CSA Standard Z432, Safeguarding of Machinery.

Alternative mechanism

It is not practical to safeguard against some machine hazards using the methods described above. In these cases, an alternative device/ mechanism, system or change in work procedure must be used to protect the safety and health of workers. Before deciding on the alternative mechanism, system or work procedure to be used, you will need to consider that it must provide the same or greater protection to the worker as that provided by a safeguarding device (as required under Part 16.5(1) of the Workplace Safety and Health Regulation).

Training, supervision, and procedures

Also known as **administrative controls,** training, supervision, and procedures are near the low end of the hierarchy of protection because their effectiveness depends on human factors such as adequate training and supervision.

Personal protective equipment

Personal protective equipment may have to be used even when other machine hazards are effectively safeguarded. In some cases, such as operating a powered forging hammer, the only protection available to the operator, besides training and safe work procedures, may be eye and face protection, hearing protection, and hand protection.

Barrier guards

Typical barrier guards

Figures 3.1 to 3.3 show examples of typical barrier guards.

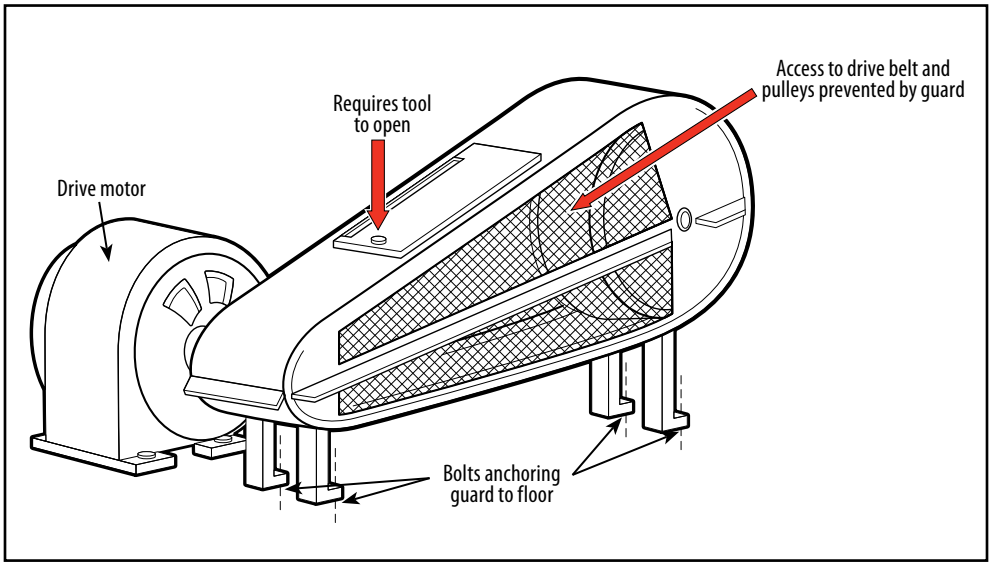


Figure 3.1. Fixed power transmission guard.

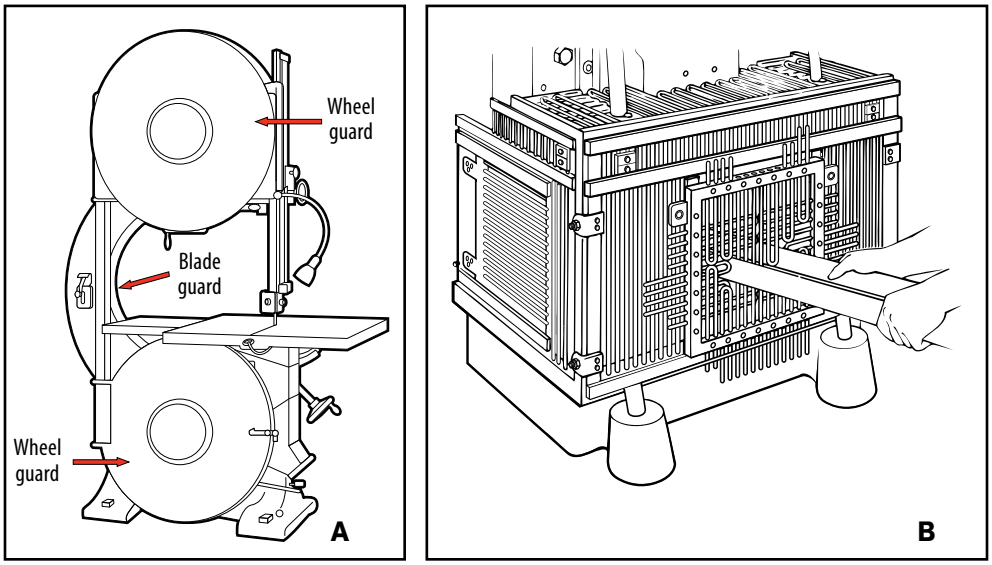


Figure 3.2. Adjustable guards. (A) Adjustable band saw guard. (B) Adjustable power press feed guard.

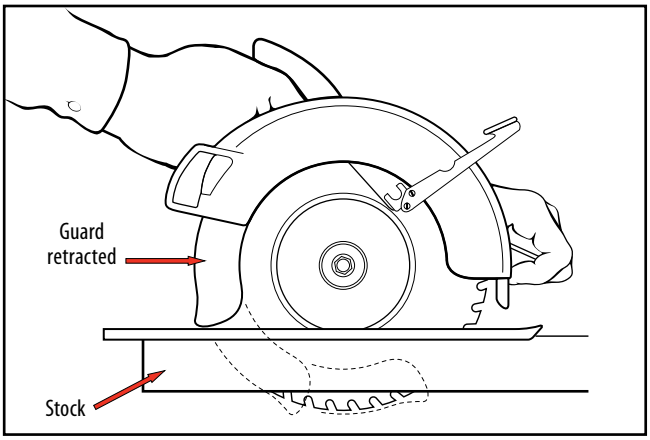


Figure 3.3. Handheld circular saw guard, an example of a self-adjusting (self-retracting) guard. Guards designed for right-handed people can sometimes cause problems for those who are left-handed. A left-handed person often has difficulty operating a handheld circular saw.

Design and performance requirements for barrier guards

Barrier guards are the preferred means of safeguarding when access is **not** required during normal operation.

Fixed barrier guards **must:**

- Prevent access to the danger area from all directions (AUTO: around, under, through, over)
- Not create additional pinch points or other hazards
- Safely contain broken parts (such as belts and chains).
- Be secured by at least one fastener requiring a tool for removal, unless properly interlocked with the machine control system
- Allow for safe lubrication and minor adjustments

AUTO –

Fixed barrier guards must be designed to prevent access to the danger areas by reaching
Around
Under
Through
Over

Fixed barrier guards **should:**

- Offer good visibility to feed points
- Stand up to normal wear and tear
- Meet normal production and quality needs
- Be difficult to modify or defeat

Power transmission guards and enclosures: maximum permissible openings

Materials used for constructing power transmission guards generally consist of woven wire, or expanded or perforated metal. Mesh or grid guards must be installed with sufficient clearance to prevent any person from reaching through the openings and contacting the danger point. This is done by placing the guard at a safe distance from hazardous moving parts.

The effectiveness of a guard opening can be judged by a reach test **carried out with the machinery locked out and safely at rest.** The relationship between the size of the opening in the guard and the distance to the danger point is illustrated in Figure 3.4.

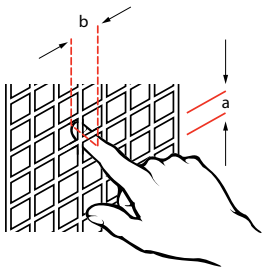
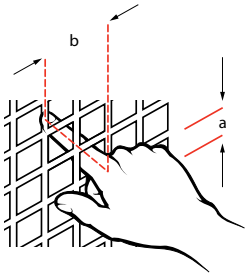
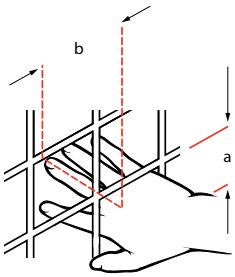
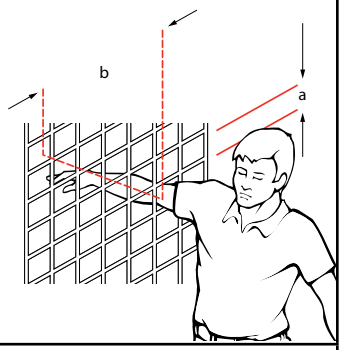
Fingertip	Finger	Hand to Ball of Thumb	Arm to Armpit
			
If *a* is between 4 and 8 mm (3⁄16 and 3⁄8 in), then *b* must be at least 15 mm (5⁄8 in).	If *a* is between 8 and 12 mm (3⁄8 and 1⁄2 in), then *b* must be at least 80 mm (3 1⁄8 in). If *a* is between 12 and 20 mm (1⁄2 and 3⁄4 in), then *b* must be at least 120 mm (4 3⁄4 in).	If *a* is between 20 and 30 mm (3⁄4 and 1 1⁄8 in), then *b* must be at least 200 mm (7 7⁄8 in).	If *a* is between 30 and 150 mm (1 1⁄8 and 6 in), then *b* must be at least 850 mm (33 1⁄2 in).
a = vertical dimension of the guard opening b = distance from the nearest danger point inside the guard			

Figure 3.4. Relationship between size of opening in a grid guard and distance to the danger point.

Point-of-operation (feed) guards: maximum permissible openings

Point-of-operation guards (also known as feed guards) are often designed with *horizontal* members to enable the operator to insert flat stock into the machine. Figure 3.5 shows how the openings between the horizontal guarding members *decrease as* the worker's fingers come *closer to* the pinch point.

Hand-feeding equipment usually presents the highest risk of injury to a worker. Feed guards must be carefully designed to ensure that the worker's hands cannot access the danger point. Table 3.1 and Figure 3.5 give the necessary clearances for an effective point-of-operation guard with a horizontal slotted feed opening.

Table 3.1. Maximum permissible openings in point-of-operation guards based on distance to hazard.

Barrier opening size (smallest dimension)		Minimum distance from hazard	
mm	**in**	**Slotted opening**	**Square opening**
6.1 – 11.0	¼ – ⅜	≥64.0 mm (2½ in)	≥48 mm (2 in)
11.1 – 16.0	⅜ – ⅝	≥89.0 mm (3½ in)	≥66 mm (2⅝ in)
16.1 – 32.0	⅝ – 1¼	≥166.0 mm (6½ in)	≥166.0 mm (6½ in)
32.1 – 49.0	1¼ – 2	≥445.0 mm (17½ in)	≥445.0 mm (17½ in)
49.1 – 132.0	2 – 5	≥915.0 mm (36 in)	≥915.0 mm (36 in)

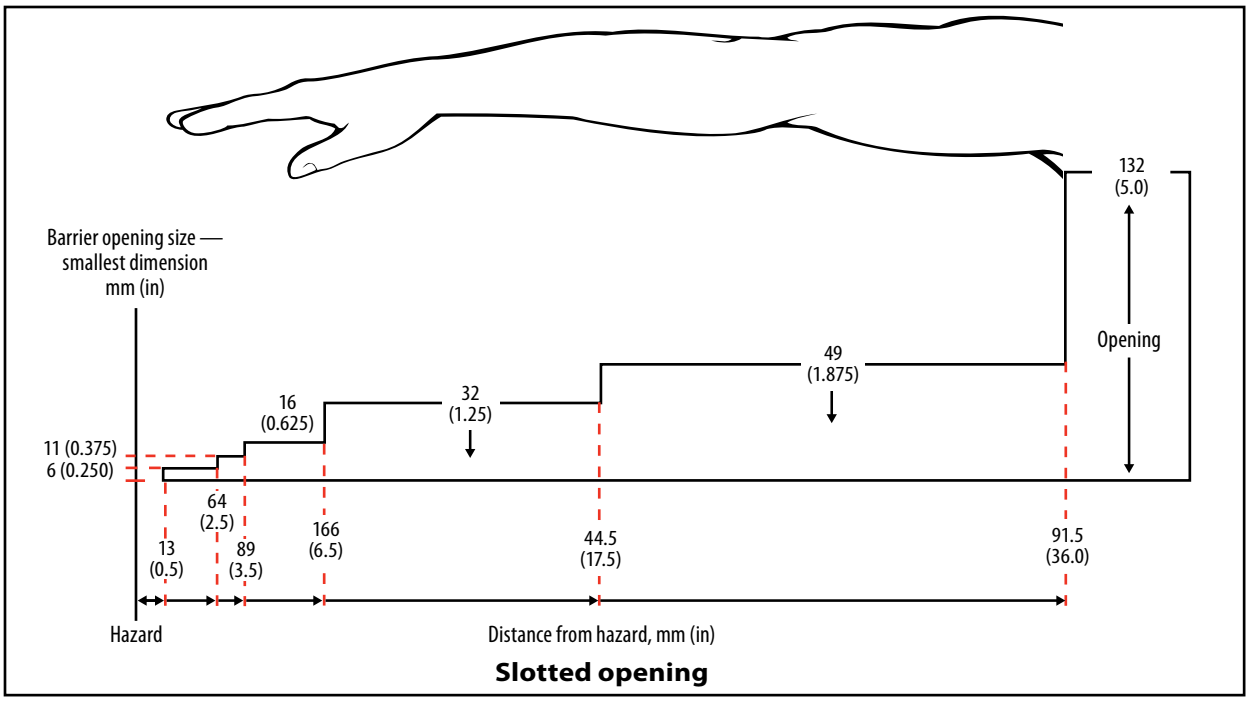


Figure 3.5. Visual representation of Table 3.1.

Perimeter fences and rail enclosures: reach distances to moving parts

For **low- and medium-risk** situations, a perimeter fence or rail enclosure can be used to effectively protect a worker from contacting hazardous machine parts. Where possible, a perimeter fence or rail enclosure should be at least 1.8 metres (6 feet) high. If this is not practicable, the reach distance from the guardrail or perimeter fence to the danger point must be in accordance with Figure 3.6 and Table 3.2. For example, if the height of the danger zone (**A**) is 1,400 mm (55 inches) and its horizontal distance (**C**) from the proposed protective barrier is 1,000 mm (40 inches), the height of the protective barrier (**B**) must be at least 1,120 mm (44 inches).

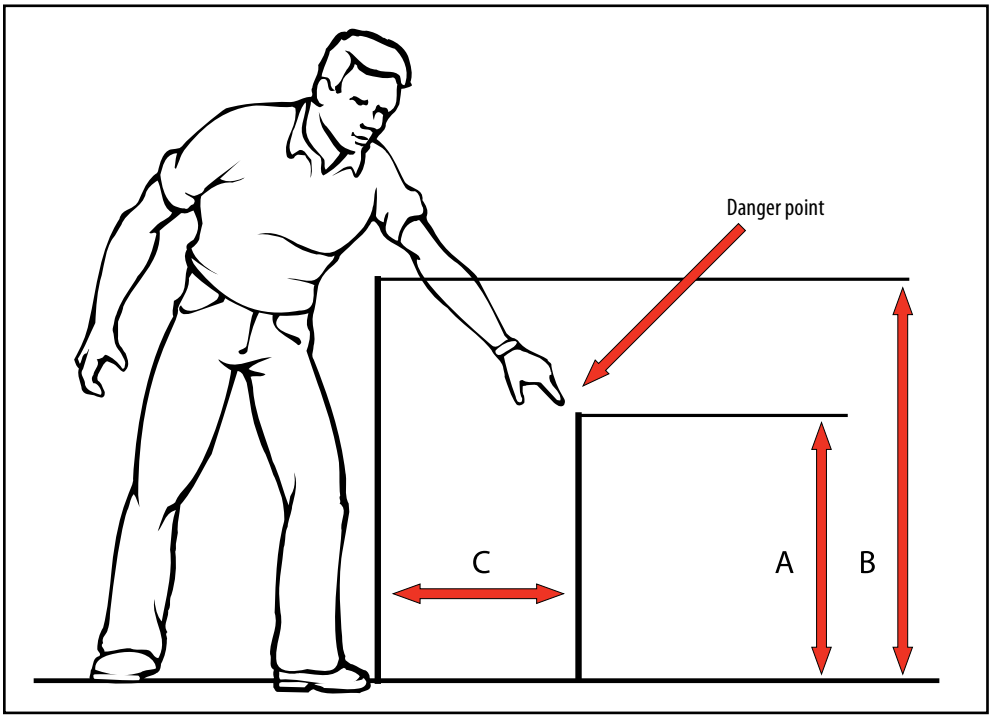


Figure 3.6. Factors to consider in designing a protective barrier: A = height of the danger zone, B = height of the protective barrier, C = horizontal distance to the danger zone.

Table 3.2. Recommended height of protective barriers based on distance to hazard.

Height of danger zone (**A**), mm (in)	Height of fixed barrier or protective structure (**B**),* mm (in)								
	1000 (40)	1120 (44)	1400 (55)	1600 (63)	1800 (71)	2000 (78)	2200 (86)	2400 (94)	2500 (98)
	Horizontal distance to danger zone (**C**), mm (in)								
2500 (98)	–	–	–	–	–	–	–	–	–
2400 (94)	100 (4)	100 (4)	100 (4)	100 (4)	100 (4)	100 (4)	100 (4)	100 (4)	–
2200 (86)	600 (24)	600 (24)	500 (20)	500 (20)	400 (16)	350 (14)	250 (10)	–	–
2000 (78)	1100 (43)	900 (36)	700 (28)	600 (24)	500 (20)	350 (14)	–	–	–
1800 (71)	1100 (43)	1000 (40)	900 (36)	900 (36)	600 (24)	–	–	–	–
1600 (63)	1300 (51)	1000 (40)	900 (36)	900 (36)	500 (20)	–	–	–	–
1400 (55)	1300 (51)	1000 (40)	900 (36)	500 (20)	100 (4)	–	–	–	–
1200 (48)	1400 (55)	1000 (40)	900 (36)	500 (20)	–	–	–	–	–
1000 (40)	1400 (55)	1000 (40)	900 (36)	300 (20)	–	–	–	–	–
800 (32)	1300 (51)	900 (36)	600 (24)	–	–	–	–	–	–
600 (24)	1200 (48)	500 (20)	–	–	–	–	–	–	–
400 (16)	1200 (48)	300 (12)	–	–	–	–	–	–	–
200 (8)	1100 (43)	200 (8)	–	–	–	–	–	–	–
0 (0)	1100 (43)	200 (8)	–	–	–	–	–	–	–

Note: Barriers are not foolproof and they cannot stop a person intent on gaining access. Therefore, as a person's intent to reach a hazardous part *increases* (for example, climbing on chairs, ladders, or the barrier itself), the protection provided by a barrier will *decrease.* You may have to consider providing a fully guarded enclosure.

Safeguarding devices

Typical safeguarding devices

Figures 3.7 to 3.12 show examples of typical safeguarding devices.

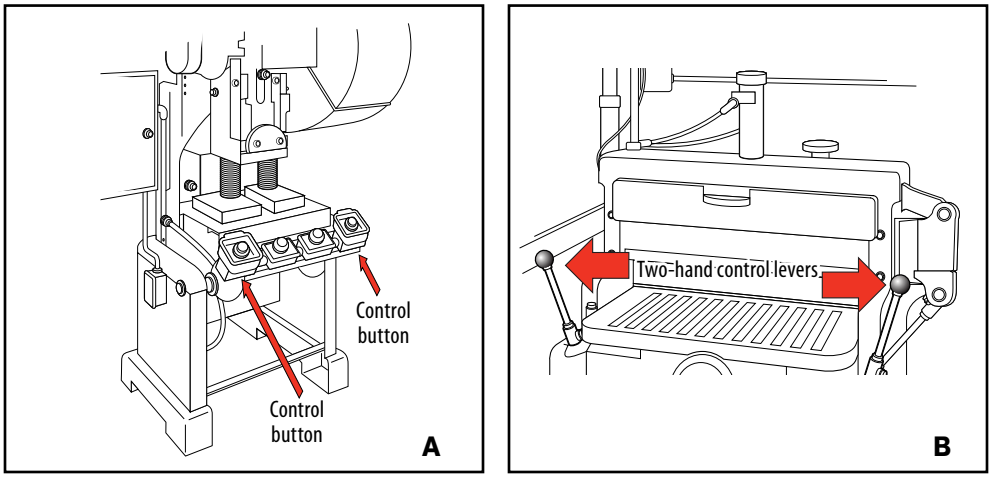


Figure 3.7. Two-hand controls. (A) Two-hand controls – power press. The press will not cycle unless both run buttons are activated using both hands within a certain time period of each other. (B) Two-hand control levers – paper guillotine shear. The shear will not cycle unless both levers are activated, which requires the use of both hands within a certain time period of each other.

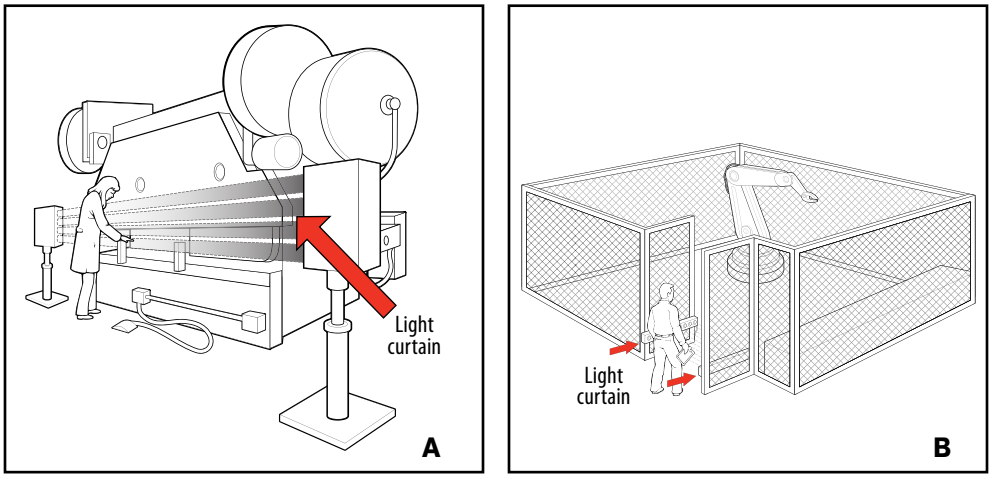


Figure 3.8. Light curtain or similar photoelectric sensing device. (A) Light curtain – brake press. The press is operated in the normal manner using the foot control. It will stop if hands enter the light beam-protected zone. (B) Light curtain – access to robotic cell. The robot is deactivated if a person enters the doorway protected by a light curtain safeguarding device.

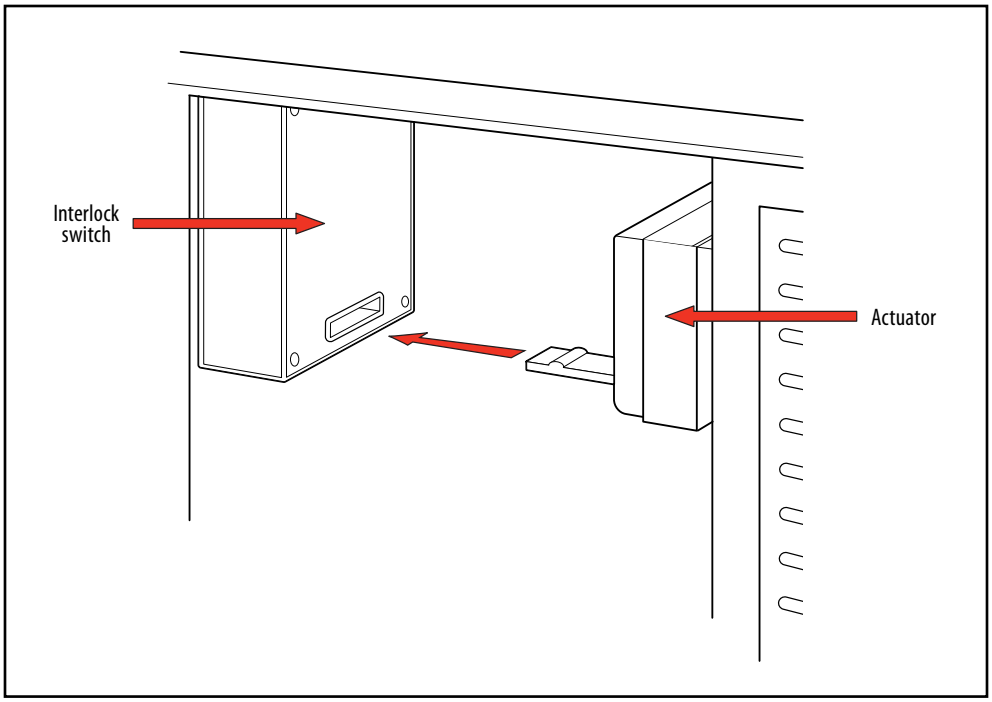


Figure 3.9. Interlocked guard. The interlocked door must be closed before the machine can be started.

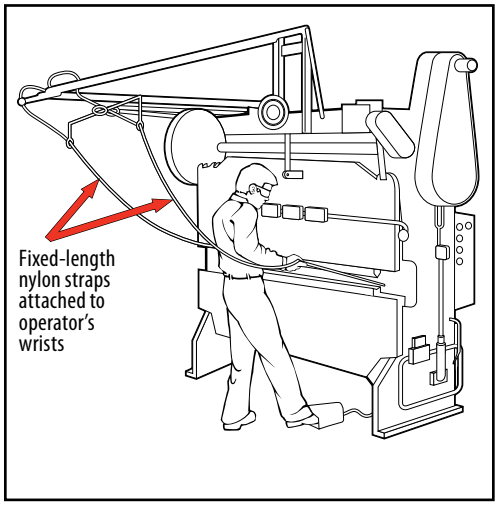


Figure 3.10. Restraint device (not in common use). Brake press operator using fixed restraint device. The operator's hands cannot reach the danger area; hand tools would be required for access.

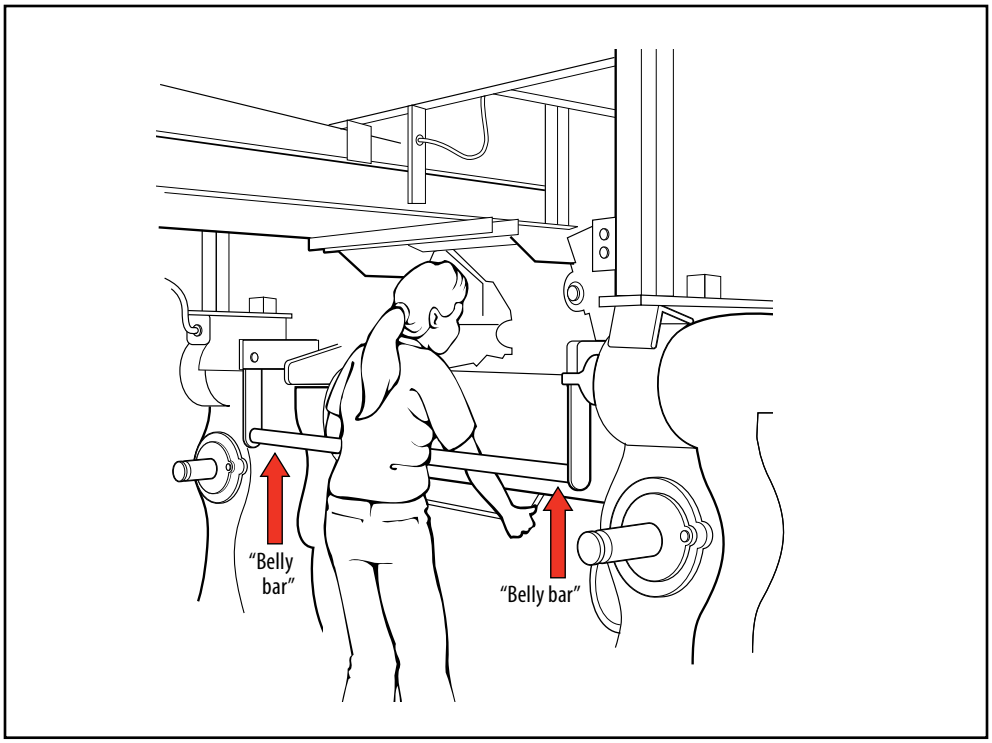


Figure 3.11. Emergency contact or tripping device in the form of an emergency "belly bar" on a calender. The operator cannot reach into the in-running feed rolls without automatically activating the machine's emergency stop bar.

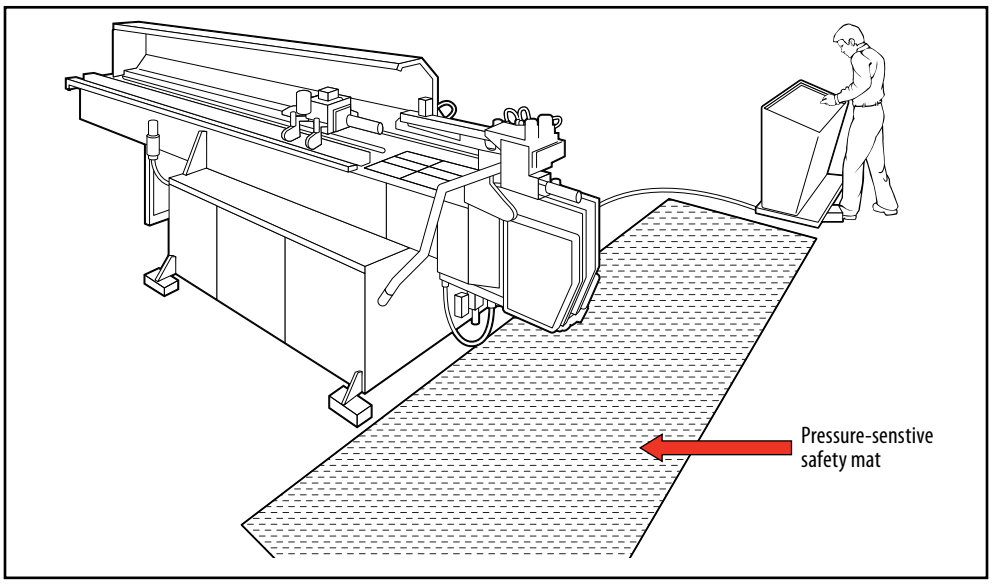
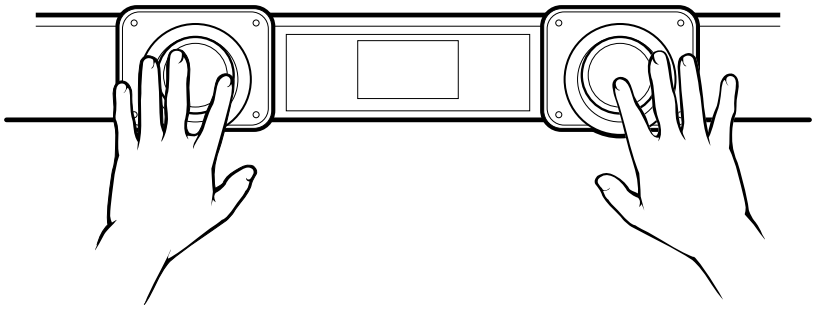


Figure 3.12. Pressure-sensitive safety mat safeguarding access to machine. The machine will come to an emergency stop if anyone, including the operator, steps on the mat.

Design and performance requirements for two-hand controls and trips

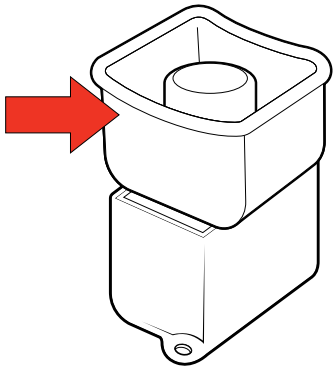
There are two types of two-hand operations:

- Two-hand controls, where both controls (buttons, levers, sensors) must be activated at the same time and kept engaged throughout the entire hazardous portion of the machine cycle. If the controls are released, the machine either stops or returns to top of stroke (the position that opens the dies). This type of machine operation is called part revolution clutch or friction clutch. It is commonly found with pneumatic clutches/brakes and with hydraulically powered machinery such as brake presses.
- Two-hand trips, where both controls must be activated at the same time to initiate the machine cycle but releasing the controls will not interrupt the machine cycle. This type of machine operation is called full revolution clutch or mechanical clutch.



Two-hand controls and trips must be designed and installed so that each control is:

- Protected against unintended or accidental operation. This is usually achieved by surrounding the activating button with a “ring” guard.



- Separated or otherwise designed to require concurrent use of both hands to activate the controls (should prevent improper operation by hand and elbow).
- Designed so that both hands must be released before another cycle can be initiated. This is called an anti-repeat or anti-tie down feature. If the operator can run the machine with one of the controls tied down (using tape, rubber band, wedge, etc.), then the two-hand controls are not properly designed or constructed.
- Located at a safe distance from the nearest hazard so that the operator cannot reach the hazard with a hand or other body part before all hazardous motion of the machine cycle has stopped. This safe distance is calculated using a universally adopted measurement called the hand speed constant. This constant is the speed of an average person reaching into a machine's point of operation to retrieve an object or correct a fault, and is 1,600 mm (63 inches) per second.

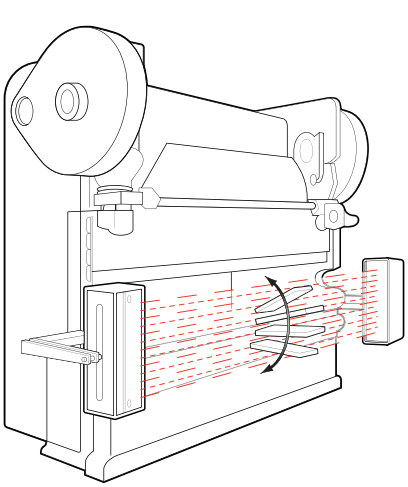
In a simple example, the safe location of a two-hand control for a machine that comes to a complete stop in 1 second after the controls are released would be 1,600 mm (63 inches) from the nearest point of operation. For a machine that stops in one-half second, the safe distance would be 826 mm (32½ inches); for a machine that stops in one-quarter second, it would be 413 mm (16¼ inches), etc.

Determining the precise stopping time of a machine cycle requires specialized measuring equipment. The response time of the control system components (air valves, friction brakes, etc.), as well as the actual braking effort, are all elements that determine the actual stopping time. Refer to *CSA Standard Z432, Safeguarding of Machinery.*

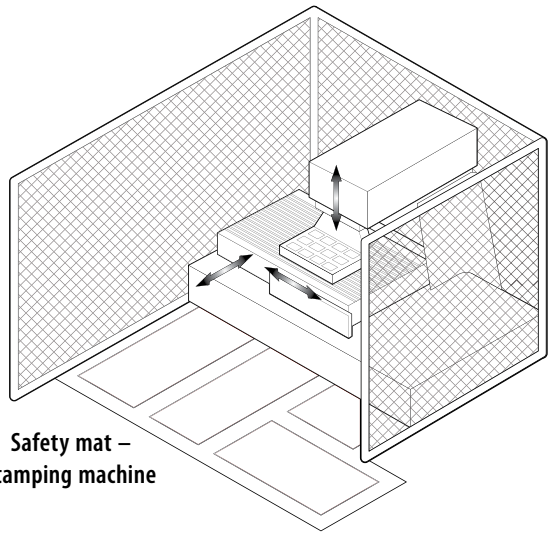
When two-hand trip is used to safeguard a mechanical clutch power press, the number of engagement points on the flywheel will have an effect on the stopping time calculation. Refer to *CSA Standard Z142, Code for Punch Press and Brake Press Operation: Health, Safety and Guarding Requirements.*

> ***WARNING!*** *Two-hand controls alone may not provide sufficient safeguarding. Additional barrier guards may be required to protect workers other than the operator.*

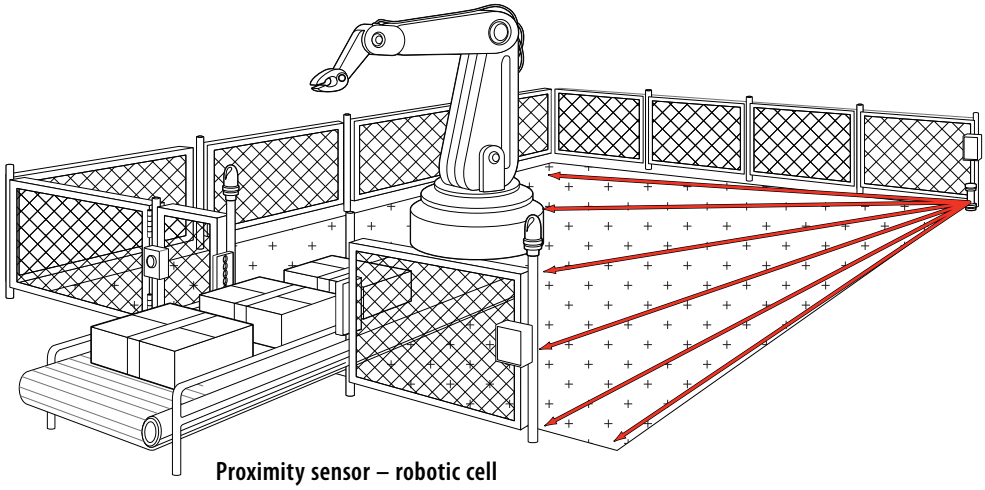
Design and performance requirements for presence-sensing devices



Light Curtain – brake press



Safety mat – stamping machine



Proximity sensor – robotic cell

How they work

Unlike barrier guards and two-hand controls, presence-sensing devices do not prevent access to a hazardous point of operation. However, they prevent dangerous machine motion if any part of a worker's body is in the danger area when a machine cycle is initiated. They are a good choice of safeguard when frequent access is required for loading parts and making adjustments during normal operation and physical guarding is too restrictive. These safety devices prevent dangerous motion while permitting **unrestricted access** by sensing the presence of the operator and sending a stop signal. Examples include light curtains, proximity sensors, and safety mats.

There are many technical factors, such as machine control reliability and safety distance, that affect the proper selection and positioning of light curtains, proximity sensors, and safety mats. Refer to the following standards referred to in the Workplace Safety ad Health Regulation (MR217/2006):

- CSA Standard Z432, Safeguarding of Machinery
- CSA Standard Z142, Code for Punch and Brake Press Operation: Health, Safety and Guarding Requirements
- CSA Standard Z434, Industrial Robots and Robot Systems – General Safety Requirements
- CSA Standard Z460 – Control of Hazardous Energy and Lock Out
- CSA Standard Z114 – M1977 Safety Code for the Woodworking Industry

There are four important limitations when selecting these safeguards:

- Presence-sensing devices alone may not provide sufficient safeguarding. Additional barrier guarding may be required to protect workers other than the operator.
- Presence-sensing devices must never be used to safeguard a machine with a full revolution clutch.
- No attempt should be made to install a presence-sensing device until the requirements of the relevant standards have been reviewed.
- Presence-sensing devices are to be used during normal production only. **They are not a substitute for lockout!**

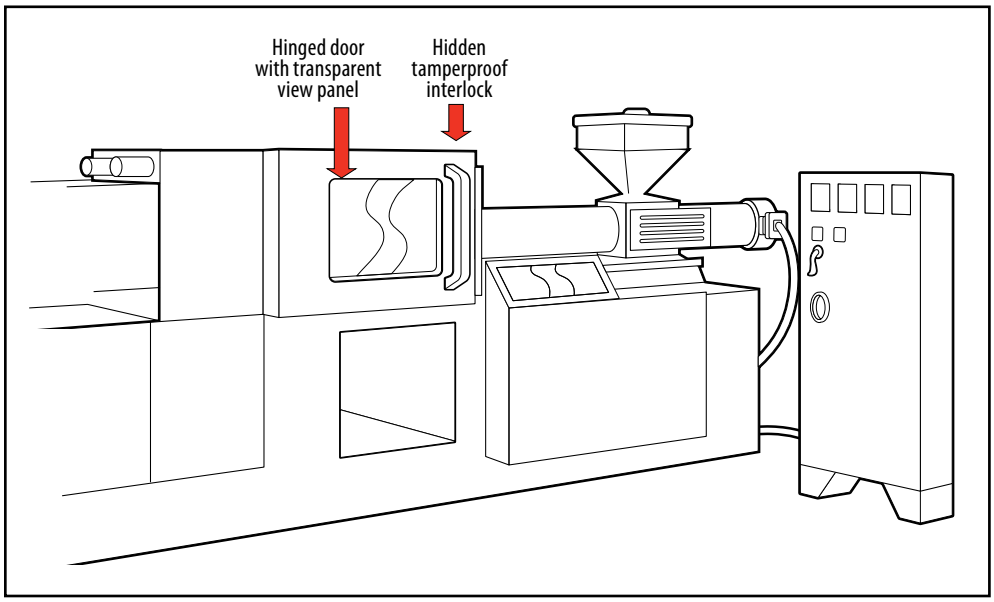
Photoelectric light curtains

These devices emit a "curtain" of harmless infrared light beams in front of the hazardous area. When any of the beams is blocked, the light curtain control circuit sends a stop signal to the machine's control system. This type of safeguard offers the maximum protection with the minimum impact on normal machine operation. It is particularly well suited to safeguarding brake press operations. *Note: steam or dust can inadvertently affect a light curtain.*

Pressure-sensitive safety mats

These devices are used to guard the floor area around a machine. A matrix of interconnected mats is laid around the hazard area, and the proper amount of pressure (such as an operator's footstep) will cause the

mat control unit to send a stop signal to the guarded machine. Pressure-sensitive mats are often used within an enclosed area containing several machines, such as flexible manufacturing or robotics cells. When access into the cell is required (for example, in the case of robot "teaching"), the mats prevent dangerous motion if the operator strays from the safe area.



Horizontal injection molding machine with interlocked gate guard

Design and performance requirements for safety interlocks

How they work

If access to a point of operation (a feed point) is required during normal operation, a movable openable barrier guard interlocked with the machine's power source can be a reliable and cost-effective solution. The control power for the machine is routed through the safety contact of the interlock. The interlock ensures that the machine will not operate if the guard is in the open position. The power source for the machine is usually electrical, but it could also be pneumatic or hydraulic.

If the interlocked guard can be opened during operation, the machine will stop. This is called **simple interlocking.** Some interlock switches also have a locking device that locks the guard door closed and will not release it until the machine comes to a safe stop. The feature is found in some households' spin cycle washing machine. It is referred to as **power interlocking.** It is used with machinery such as tumblers and centrifuges, where the coasting-down time may take several seconds to several minutes.

Several technical factors affect the proper selection and positioning of safety interlocks. These are described in detail in *CSA Standard Z432, Safeguarding of Machinery,* which should be reviewed when designing or selecting an interlock system.

Here are some key points to consider when selecting a safety interlock system:

- Is the interlock switch recommended by the manufacturer for use in a safety-related application? Most interlock switches are intended for use in production processes. They may not have the integrity and reliability required for worker safety.
- Where the risk assessment indicates a high level of risk, there may be a need to monitor the integrity of the safety interlock circuit. In addition, the use of redundant interlocks may be required.
- Safety-rated interlock switches feature positive-break normally closed contacts. This ensures that the electrical contacts are forced open by a non-resilient mechanical action (that is, they do not rely on spring action to open the contacts). The international symbol for positive-break contacts is ⊖.
- Interlock switches should be tamper-resistant and difficult to defeat or bypass using readily available means, such as a piece of wire, tape, simple hand tool, and so on. Safety interlock manufacturers address this by designing two-piece keyed interlocks or interlocks using coded magnet sensors.
- Interlocks should be installed using "positive-mode" mounting. When mounted in the positive mode, the non-resilient mechanical mechanism that forces the normally closed (NC) contacts to open is directly driven by the safety guard. In this mounting mode, opening the safety guard physically forces the NC contacts to open.
- Power interlocks may require that certain parts of the machine retain a supply of power when the machine is shut down. The implementation of lockout procedures should address this concern. Lockout must be performed if this safeguard becomes ineffective.

Movable gate

A unique safeguarding application using interlocking is the movable gate device. It is commonly used to provide protection to an operator when hand-feeding parts into a punch press, but it can be applied to various other machines. See Figure 3.13.

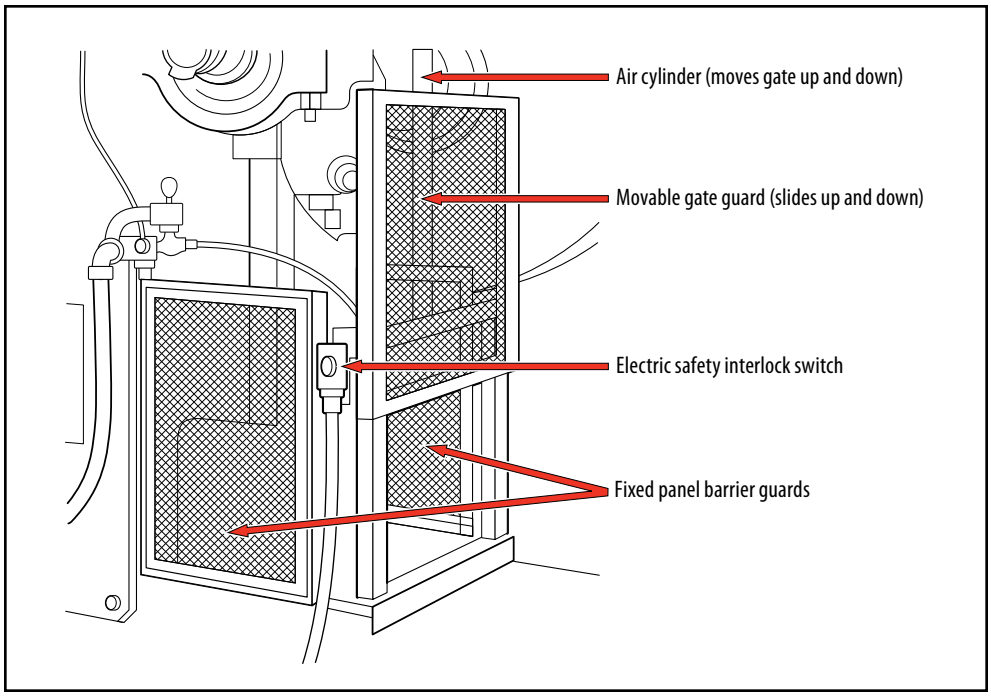


Figure 3.13. Movable interlocked gate mounted on a punch press.

When the machine completes its cycle or returns to top of stroke (in the case of a power press), the gate automatically opens, allowing the operator to remove the formed part. The operator then places a feed stock (blank) into the machine and activates the controls to start another cycle. This can be done with either a foot control, a single hand control, or even two-hand controls (preferred). The gate must close before the machine can cycle. A low-pressure air cylinder attached to the gate performs this closing function. If there are any obstructions under the gate (such as the operator's hands), the gate will not fully close. The interlock switch will prevent further machine operation until the obstruction has been removed and the controls reset.

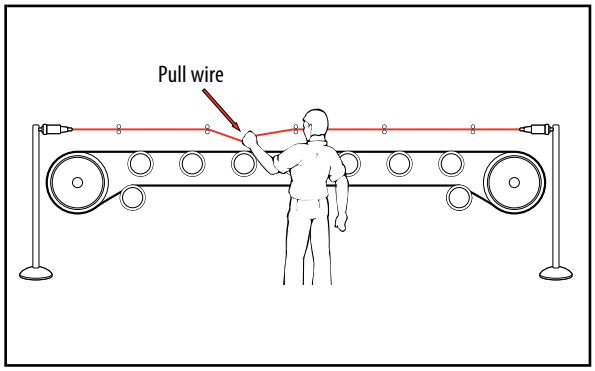
There are two types of movable gate guards. The **A type** is used to safeguard machines with **full revolution clutches** (see page 33). The following is a typical sequence of operation of a complete cycle on a machine that uses an "A" gate:

1. Place part in machine and initiate the cycle. As long as there are no obstructions, the gate will close.
2. The machine makes one complete cycle.
3. The gate opens *after* the cycle has ended.

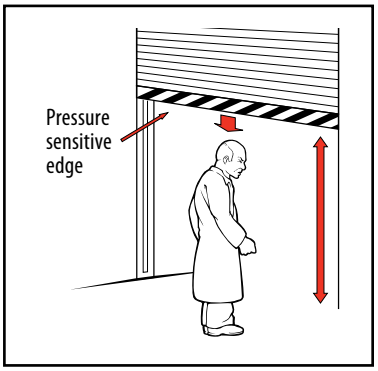
The **B type** protects the operator only on the downstroke of press cycle (or closing stroke of a machine). This type can be used to safeguard only machines with **part revolution clutches** (see page 33). The following is a typical sequence of operation on a machine that uses a "B" gate:

1. Place part in machine and initiate the cycle. As long as there are no obstructions, the gate will close.
2. Once the machine reaches the portion of the cycle where the point-of-operation hazard has been eliminated, and before the cycle has ended, the "B" gate opens, allowing the operator to remove the formed part.

Miscellaneous emergency body contact devices



Emergency trip wire – Conveyor system



Safety contact bumper – Overhead door machine

How they work

These safeguarding devices function somewhat like presence-sensing devices. The difference is that they may permit access to the actual danger area before they are activated and send a stop signal to the machine, thus entailing a limited risk of injury. They may, however, be the only reasonable choice of safeguarding when other, more effective means are not practicable.

Whenever possible, grab wires, pull wires, and contact bars such as "crash bars," "belly bars," and similar devices should be mounted so that they will be activated involuntarily as the worker approaches the danger area. For example, a worker accidentally falling onto a conveyor belt would automatically activate the emergency trip wire.

A pre-shift inspection and test should be done wherever these devices are installed.

Grab wire and pull wire devices

These devices usually allow the worker a **"first/last chance"** to stop the machine in the event of accidental contact. They must be selected and mounted so that a pull on the wire/cable from any direction will activate the emergency stop. The activating switch must also sense a **broken or slack cable condition,** which will automatically activate the emergency stop. Figures 3.14 and 3.15 show two examples of safe pull wire installations.

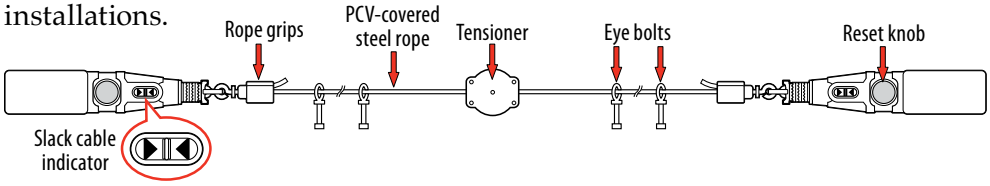


Figure 3.14. Pull wire system using two emergency stop switches. The switch is activated by a pull from any direction.

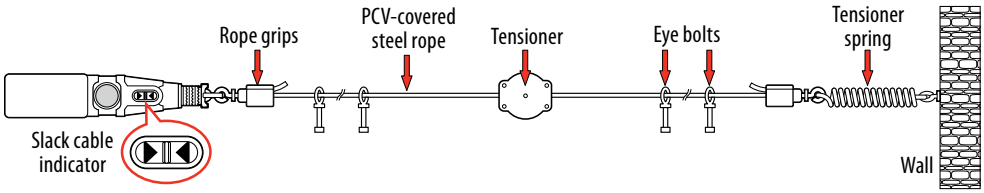
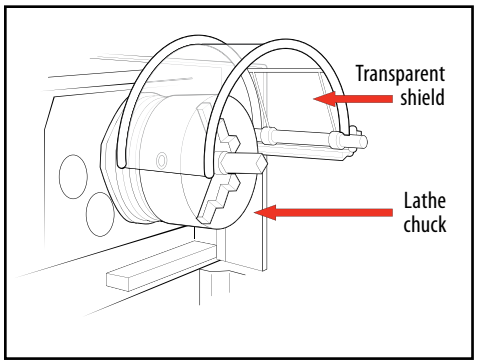
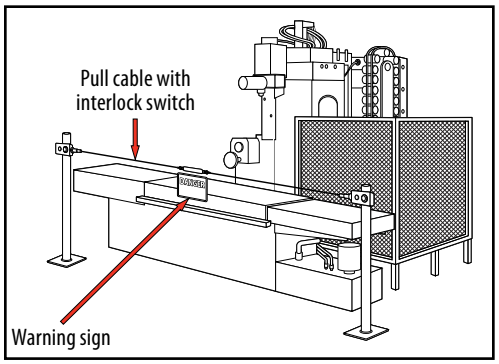


Figure 3.15. Pull wire system using one emergency stop switch and a wall-mounted tension spring. The switch is activated by a pull from any direction.

Shields and awareness barriers



Awareness barrier – lathe chuck



Awareness barrier – sliding table

How they work

Shields, usually in the form of transparent barriers, are typically installed on lathes, milling machines, boring machines, and drill presses. They can also be used on woodworking machines. They are generally intended to deflect chips, sparks, swarf, coolant, or lubricant away from the operator and other workers in the machine area. Besides providing some protection as a barrier, most shields also provide good visibility into the point of operation.

Awareness barriers include installations such as electrically interlocked pull cable assemblies installed in the rear area of machines such as brake presses and shears to restrict worker entry. These areas are often out of the operator's view. The machine is stopped if someone pulls or loosens the cable. It is recommended that a sign denoting the danger be placed on the pull cable.

Although shields and awareness barriers offer some degree of safeguarding, *they cannot be considered guards because they only restrict but do not prevent access to the danger area.*

When installing these devices and before moving them from their normally applied position, always turn off power to the machine; follow lockout procedures if there is a risk of accidental startup.

E-stops

How they work

"E-stop" is the industry term for **Emergency Stop.** It is a red mushroom-shaped stop button that is manually depressed in the event of an emergency condition, upset condition, or accident.

An emergency stop is not considered a primary safeguarding device. Because it requires intentional activation, it seldom prevents accidents. An emergency-stop device is an after-the-fact device. It may, however, prevent an unsafe machine operation from continuing and, when activated, will stop a machine after an accident has occurred.

The various published safeguarding standards contain specific requirements for E-stops, including how many are required and where they should be located. The following requirements apply to all E-stop installations:

- Located within immediate and unimpeded reach of the operator or other persons directly affected by the machine operation.
- Mushroom-shaped and red in colour.
- Designed to allow immediate activation with any part of the body (no ring guards or recessed position).
- Requires a manual push to activate and a manual pull to reset; remains in the depressed position when activated (not a "hold-to-run" type switch).
- A check for safe machine operation is required before an E-stop is reset.
- Must be hard-wired into the control circuit to allow the magnetic coil to drop out (cannot be routed through a Programmable Logic Controller [PLC] except for monitoring purposes).
- The machine must not restart merely by pulling out and resetting the E-stop. A second, independent control must also be activated before the machine will restart.

Guide to selecting the right safeguard

If all machines were alike, it would be simple to design a universal guard and install it during the fabrication of the machine. Machines are not all alike, however. To further complicate the problem, purchasers of the same model of machine may use it in different ways and for different purposes, and these may change during the lifetime of the machine. In some cases, machines are used for purposes that the manufacturer did not envision. It is important that you ensure that you have the right machine and tool for the work being performed. Don't modify or adapt machinery without consultation with the manufacturer or other qualified person (for example, a Professional Engineer). This is why effective point-of-operation safeguarding cannot always be installed by the manufacturer.

In many cases, a safeguard can be selected only after the user has performed a risk assessment. The decision chart in Figure 3.17 and the guide in Table 3.3 may assist in the selection process.

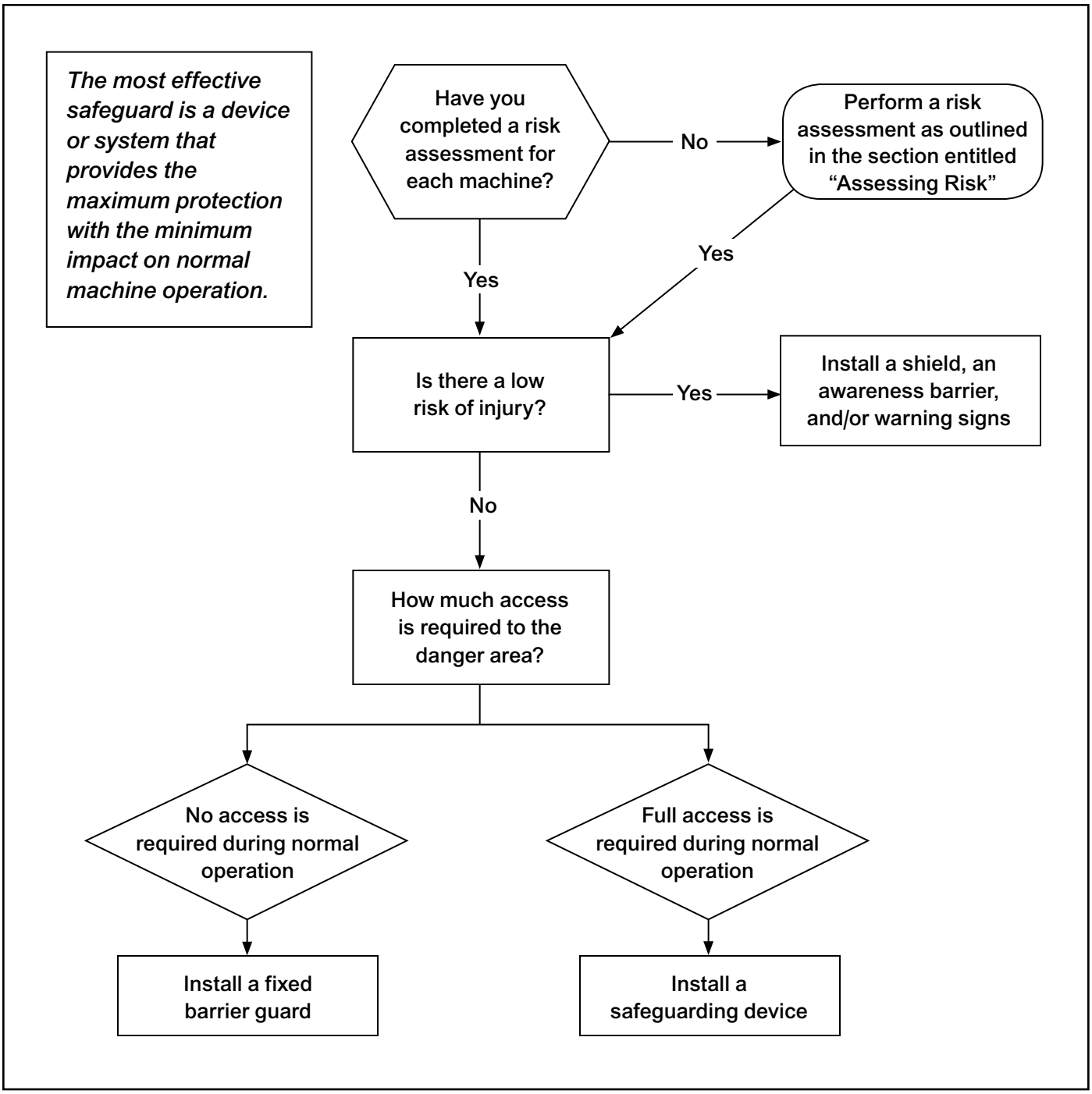


Figure 3.17. Selecting the right safeguard.

Table 3.3. Guide to selecting the right safeguard.

Type of Safeguard	Typical Applications	Action of Safeguard	Advantages	Limitations
Physical guards				
Fixed power transmission barrier guard	• V-belt drives • Chain sprocket drives • Motor couplings and power take-offs (PTOs) • Flywheels	• Completely prevents hands or body parts from entering the danger area	• Provides complete protection if kept in place • Easy to install	• May interfere with lubrication unless modified
Fixed point-of-operation barrier guard	• Bread slicers • Meat grinders • Sheet metal shears • In-running nip points of rubber, paper, and textile rolls • Power presses	• A complete enclosure that admits feed stock or removal of finished product but will not allow hands into danger zone	• Provides complete protection if kept in place • May leave both hands free • Suitable for any type of machine clutch (part/full revolution)	• Generally limited to flat feed stock • May require special tools to remove jammed stock • May interfere with visibility
Barrier guard (hinged or sliding) with simple interlocking	• Most power presses • Balers/compactors • Foundry presses • Robotic systems	• Opening the guard will stop the machine • Machine will not start with guard open	• Leaves both hands free for feeding • Opening and closing of guard can be automatic	• Location of controls must comply with safety distance requirements • Depends on control reliability for safe functioning
Barrier guard (hinged or sliding) with powered interlocking (guard locking)	• Foundry tumblers • Laundry extractors, dryers, and tumblers • Centrifuges • Paint mixers • Some dough and pastry mixers	• Machine will not start with guard open • Guard cannot be opened until machine movement is at complete rest	• Provides complete and positive enclosure until machine is at rest • Does not inhibit production	• Requires careful adjustment and maintenance • May not function in the event of electrical or mechanical failure
Automatic or semi-automatic feed with point of operation enclosed	• Power press blanking operations • Coining and stamping machines • Drop chute chippers • Pastry machines	• Stock fed by chutes, hoppers, conveyors, rolls, movable dies, etc. • Enclosure will not admit any part of the body	• Increase in production • Worker cannot place hand in danger zone	• High installation cost for short runs • May require skilled maintenance
Limited feed opening or slide travel	• Foot-powered shears • Some punch and brake presses	• Feed opening or machine travel is limited to 6 mm (¼ inch) or less • Fingers cannot enter danger area	• Provides positive protection • No maintenance or adjustment needed	• Small opening limits size of stock • Requires effective supervision/training

Type of Safeguard	Typical Applications	Action of Safeguard	Advantages	Limitations
Other safeguards				
Two-hand controls	• Hand-fed power press operations • Hydraulic presses • Re-bar formers • Tube benders • Paper guillotine shears	• Simultaneous activation of both controls initiates a machine cycle • Releasing either control during cycle causes machine to stop	• Forces both hands out of danger zone • No interference with hand feeding • No adjustments required • Easy to install • Allows feeding and removal of complex parts not possible with a barrier guard	• Location of controls must comply with safety distance requirements • Depends on control reliability for safe functioning • Hands not free to support feed stock • Hazards to workers other than the operator must be safeguarded
Presence-sensing device: • Light curtains • Radio frequency antennae • Pressure-sensitive mats	• Brake presses • Part revolution (air clutch) presses only • Robotic systems	• When sensing field is interrupted, a stop signal is sent to quickly stop the machine	• Does not interfere with normal feeding or production • No obstruction on the machine or around the operator	• Expensive to install • Location of device must comply with safety distance requirements • Depends on control system reliability for safe functioning • Hazards to workers other than the operator must be safeguarded • May require frequent adjustment/calibration
Limited machine movement devices (“jog,” “inch,” and “setup” modes)	• Printing presses • Power presses (during setup and maintenance)	• Provides operator or maintenance with a means to “inch” or “jog” machine movement during setup	• Gives operator and maintenance safe control over hazardous machine movement	• Can be dangerous if used during production mode on power presses (the CSA Standard notes that these must not be used for production purposes)
Self-adjusting feed guard	• Band saws • Table saws • Mitre saws • Circular hand saws • Jointers • Wood shapers • Large-capacity steel plate shears	• Barrier or enclosure will admit operator’s hands but warn him before danger zone is reached	• Makes hard-to-guard machines safer • Generally does not interfere with production • Easy to install • Admits varying sizes of stock	• Protection not complete at all times – hands may enter danger zone. • Guard may be easily defeated • Choice of last resort

Type of Safeguard	Typical Applications	Action of Safeguard	Advantages	Limitations
Emergency body contact devices: • Crash bar • Panic bar • Trip wire • Belly bar	• Trim saws • Flat roll ironers • Calenders • Rubber mills • Platen presses • Conveyors • Wood chippers	• Without intentional movement, worker contacts the emergency stop device, which sends a stop signal to the machine	• Makes hard-to-guard machines safer • Does not interfere with production	• Requires proper installation and maintenance • Depends on control system reliability for safe functioning • May require installation of a machine braking system
Passive worker restraint devices (“hold-backs”)	• Horizontal-fed sawmill chippers • Soil auger feed points • Power press operations	• Worker is tethered by means of a safety belt and lanyard, or by hand wristlets and fixed cables, and cannot access the danger area	• Easy to install • Inexpensive • Permits maximum hand feeding	• Can be difficult to supervise • Worker resistance (changing old habits) • Must be adjusted to individual operator
Active worker restraints (“pull-backs”)	• Mechanical clutch power presses • Brake presses • Embossing presses	• A cable-operated attachment connected to the operator’s hands pulls them back if they remain in the danger zone	• Acts even in the event of accidental mechanical repeat • Easy to install • Adaptable to frequent die changes	• Requires effective supervision • Worker resistance (changing old habits) • Must be adjusted to individual operator and operation
Awareness barriers: • Protective shield • Splash guard	• Lathe chucks • Milling machines • Drill presses • Machine tools	• Partial barriers that contain liquids and flying chips or turnings	• Easy to install • Does not impede operation	• Provides limited protection against harmful contact with moving parts

4

Some Common Safeguarding Applications

Power transmission guards

Power transmission parts typically consist of belts, pulleys, chains, sprockets, gears, shafts, and couplings. Contact with these moving parts accounts for a large number of preventable injuries. It is usually a straightforward task to fabricate and install guards for these hazards. Refer to "Design and performance requirements for barrier guards" (page 25) for the do's and don'ts associated with barrier guards.

Two very common machine guards are:

- V-belt/chain-sprocket guard
- PTO (power take-off) drive shaft guard (frequently found in agriculture)

V-belt/chain-sprocket guard

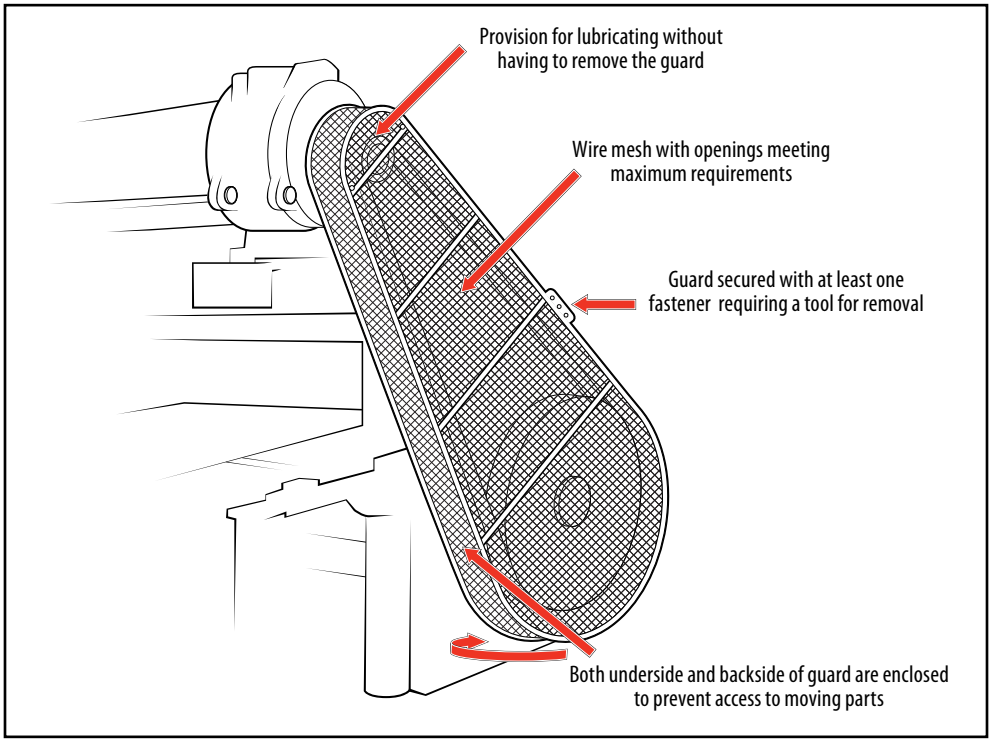


Figure 4.1. Typical fabrication design of the V-belt/chain-sprocket guard.

PTO drive shaft guard

Unguarded PTO (power take-off) drive shafts account for a large number of serious entanglement injuries, especially in agriculture, where they are frequently used with tractors for powering portable machinery such as irrigation pumps. Because the equipment is powered for frequent, short periods there is a tendency to neglect installing guards over these drives. It is a good practice to install a chain or cable tether at each end of the PTO drive shaft guard so that the guard can be readily secured to the tractor or portable equipment when not in use.

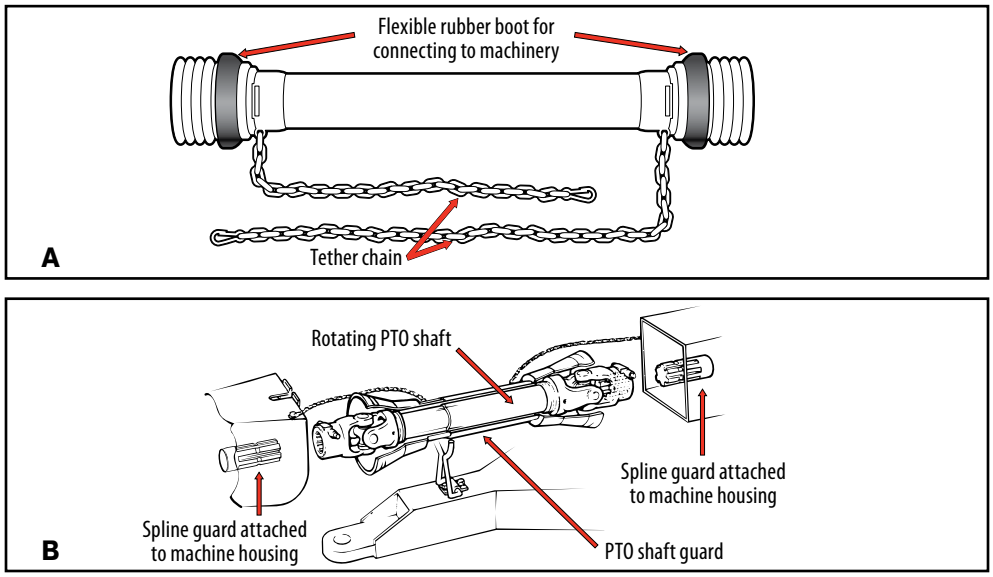


Figure 4.2. PTO drive shaft guards. (A) With tether chain attached to each end of the guard. (B) Cutaway view of PTO drive shaft and typical guard.

Rotating shaft and coupling guard

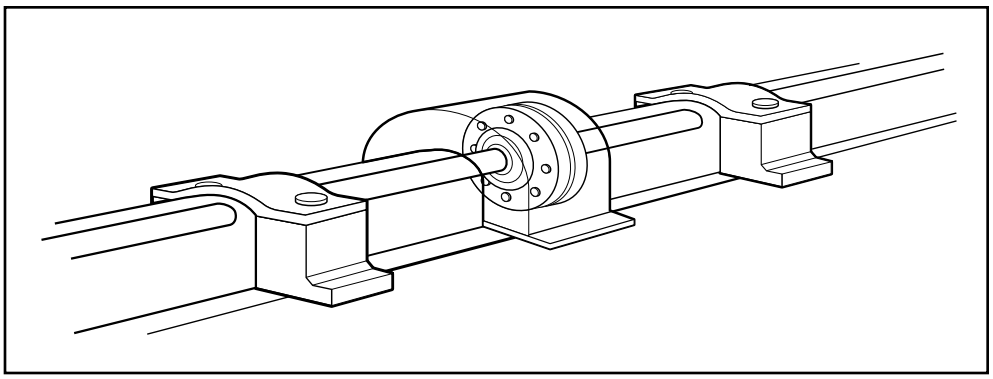


Figure 4.3. Typical design of a rotating shaft and coupling guard.

Conveyors

This section focuses on two common types of conveyors:

- Belt conveyors
- Screw (auger) conveyors

Belt conveyors

Injuries associated with unguarded belt conveyors generally involve one of two moving parts:

- The power transmission drive (V-belt or chain-sprocket drive and transmission)
- The conveyor belt itself where it engages around the head or tail spool (also known as the drum)

Guarding of the power transmission drive is done using the safeguarding methods described earlier for typical power transmission drives. Guarding of the in-running nip point between the running belt and the head or tail spool is achieved by fully enclosing access to the belt and spool for a minimum of 1 metre (3.3 feet) back from the centreline of the spool. In industry, this is often referred to as a "boot." Figure 4.4B shows a typical belt conveyor tail spool boot. The boot must be designed and fabricated to permit tracking adjustments, which must be done when the belt is moving, to be performed without removing the boot.

Where access to the running conveyor belt is not prevented by guardrails or enclosure, a typical safeguarding device consists of an emergency trip wire running the entire length of the conveyor. This safety device must be installed using the safety criteria described under "Grab wire and pull wire devices" (page 41).

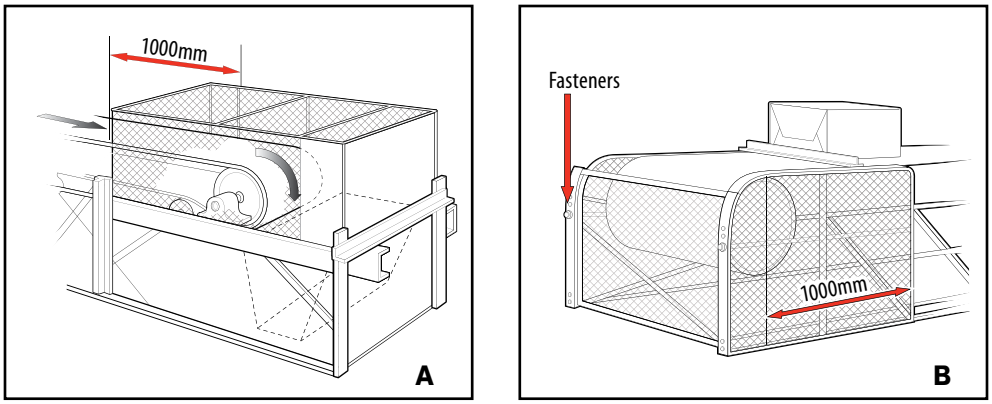
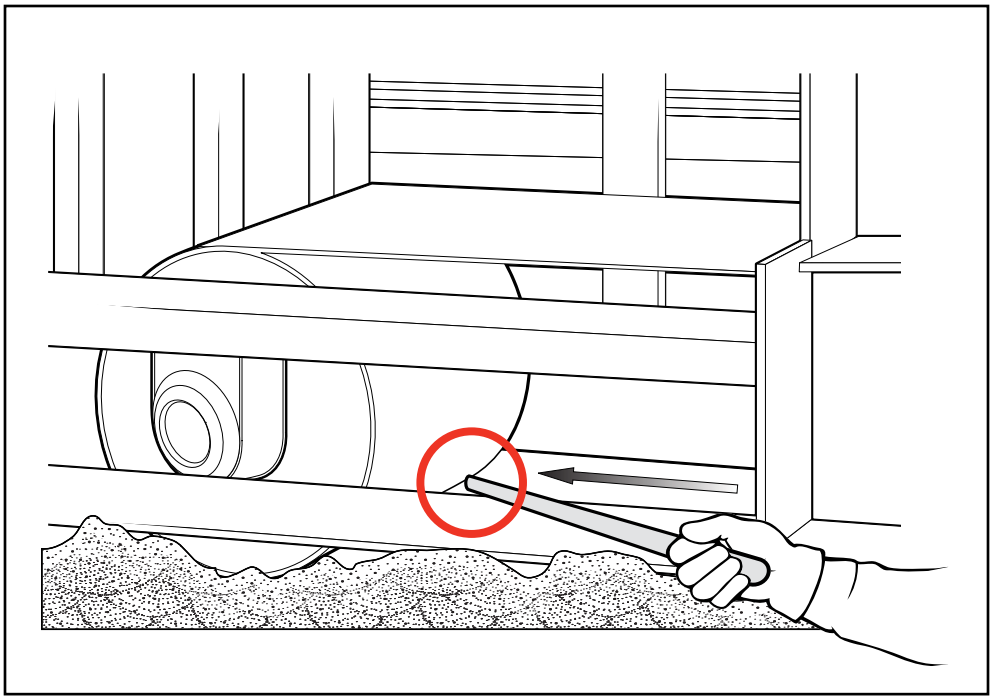


Figure 4.4. Typical belt conveyor boot guards. (A) Head spool guard. (B) Tail spool guard.

Blatant disregard of safety led to an amputation at this belt conveyor:

- The tail spool was not guarded to prevent access.
- The worker used a stick to clear debris from the underside of the belt.

When the stick got caught in the spool, the worker was unable to let go.



Screw (auger) conveyors

Screw conveyors are found in a wide variety of industrial operations, including ice houses, cement plants, pulp mills, grain and feed establishments, and farms. Injuries associated with unguarded screw (auger) conveyors are usually traumatic and extensive, and often result in fatalities from whole-body entrapment.

Think of a screw conveyor as a large meat grinder. It is one of the least forgiving types of powered machinery. As with belt conveyors, there are two main sources of harmful engagement:

- The power transmission drive (V-belt or chain-sprocket drive and associated power reduction unit)
- The rotating auger (also known as the vane), which runs through a trough to move the material

The power transmission drive is guarded using the methods described for typical power transmission drives (beginning on page 51). The auger itself is typically guarded using solid metal covers if no access to the trough is required during operation. When material must be fed into the running auger, such as those located at floor level in ice houses, guarding material such as grating or horizontal members are often used. The following safety measures must be built into the guard design:

- The openings in the guard are small enough to prevent a hand, arm, or foot from engaging the running auger (see "Power transmission guards and enclosures: maximum permissible openings" on page 26).
- The guards are securely bolted in place using fasteners that require a tool for removal. Quick-release latches are not permitted.

Figure 4.5 shows a point-of-operation feed guard for an ice auger located at floor level. Because a worker is present at all times to tend the operation to ensure a flow of ice in the conveyor, the guards may be designed to allow ice to be shovelled onto the conveyor but must prevent any part of the worker's body from touching the moving auger.

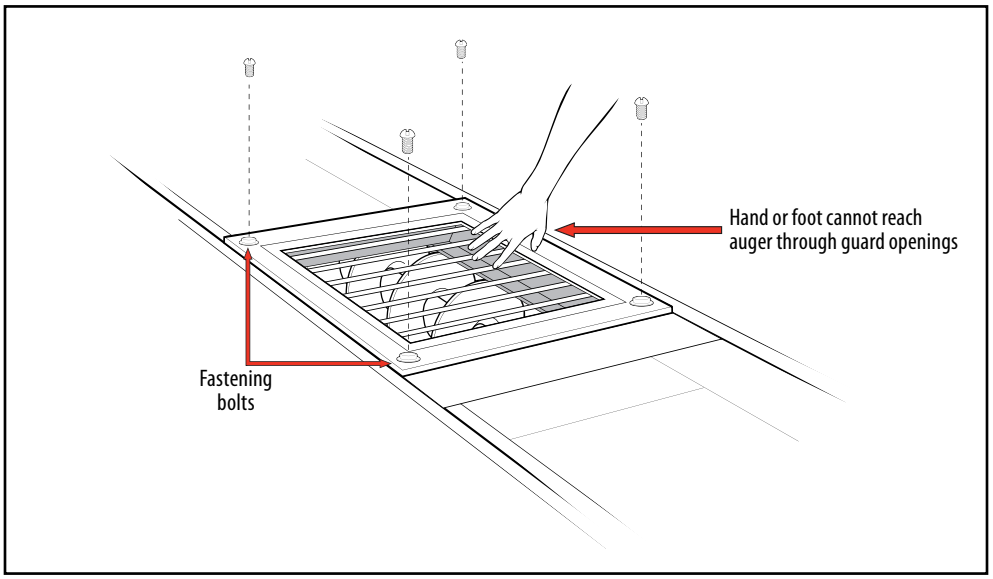


Figure 4.5. Ice auger conveyor with good functional design.

Safety Rules for conveyors

1. Don't perform service on a conveyor until the motor disconnect is **locked out.**
2. Service a conveyor with authorized maintenance personnel only.
3. Keep clothing, fingers, hair, and other parts of the body away from the conveyor.
4. Don't climb, step, sit, or ride on the conveyor at any time.
5. Don't load the conveyor outside of the design limits.
6. Don't remove or alter conveyor guards or safety devices.
7. Know the location and function of all stop/start controls.
8. Keep all stop/start control devices free of obstructions.

9. All personnel must be clear of the conveyor before the conveyor is started.
10. Operate the conveyor with trained personnel only.
11. Keep the area around conveyors clear of obstructions.
12. Report all unsafe practices to your supervisor.

Accidents around conveyors occur most frequently due to:

- Unguarded power transmission parts
- Unguarded nip points
- Unguarded shear points
- Unguarded pinch points
- Unguarded spill points
- Unbarricaded access to areas under counterweights
- Tension take-up points
- Transfer mechanisms
- Absence of safe passage under conveyors

Feed rolls

Safeguarding feed rolls in general

Feed rolls are found in a wide variety of industries, such as paper products manufacturing and sheet metal production. They present a high risk of serious injury because of their high speed of operation. Once a worker is caught in a feed roll, the damage is done quickly, and stopping the equipment will not undo it.

In general, there are two types of feed rolls:

- Those that run material into a machine but do not have to be accessed by workers. These can usually be safeguarded by enclosure or location within the machine.
- Those that are hand-fed as part of the production process. These require closer attention to safeguarding.

Safeguarding design criteria for feed rolls fed by hand

Figure 4.6 provides guidance for designing fixed barrier guards to prevent hands from accessing the nip points created by feed rolls. Please refer to "Point-of-operation (feed) guards: maximum permissible openings" beginning on page 27 for the safe distances for guard placement and guard openings.

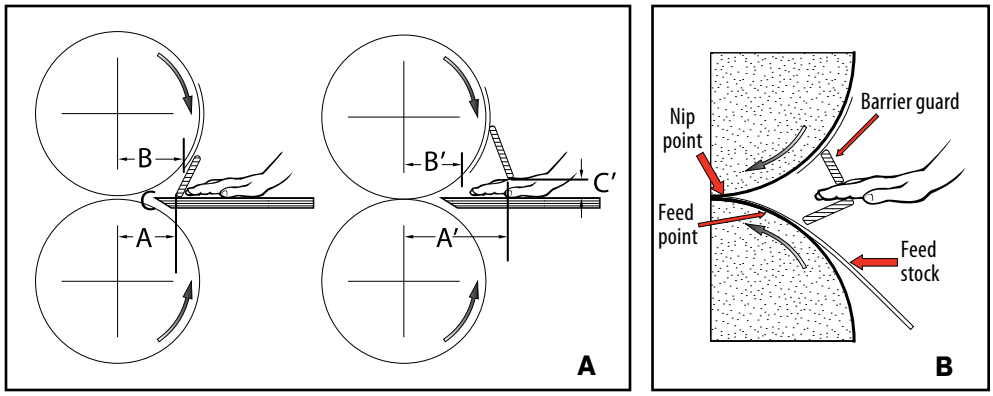


Figure 4.6. Fixed barrier guards for feed rolls. (A) Position of barrier guard relative to feed roll nip point in operation with feed table. Note how the guard feed opening C can be increased to C′ as the guard position A is moved further out to A′ from the nip point, allowing the position of the fingertips (B) to get closer (B′) to the feed point. (B) Barrier guard for operation without feed table.

You can also use the following rule of thumb to determine the maximum safe opening in a feed guard located less than 305 mm (12 inches) from the danger zone:

> Maximum safe opening = 6 mm (¼ inch) + ⅛ of the distance from the guard to the point where the rolls are 9 mm (⅜ inch) apart (the danger zone)

You may have to make a sketch to determine this distance.

Example

A guard is needed for an operator feeding sheet goods into feed rolls 152 mm (6 inches) in diameter and 9 mm (⅜ inch) apart. The guard must be within 102 mm (4 inches) of the centreline of the rolls in order to accommodate the type of material being fed.
How large a feed opening can be allowed under the guard?

Solution

The feed rolls meet at 9 mm (⅜ inch) apart. The distance from the danger zone (in this case, the centreline of the rolls) to the guard is therefore 102 mm (4 inches). The maximum permitted opening is:

> 6 mm (¼ inch) + ⅛ of 102 mm (4 inches) = 6 mm (¼ inch) + 12 mm (½ inch) = 18 mm (¾ inch)

If you have a punch press, you must refer to the CSA Standard Z142, Code for Punch Press and Brake Press Operation: Health, Safety and Guarding Requirements to determine how to safeguard it properly.

Metal-forming equipment

Punch presses

Types of punch presses

A punch press is a machine used for piercing holes or other openings in sheet metal or plate. The tooling or *die set* consists of two parts: the upper male punch and the lower female die. The punch is fitted to a *ram* or *slide,* which moves down and up by mechanical, hydraulic, or pneumatic power. The punch pierces the material and enters the lower die. A punch press can be small and manually operated and hold one punch and die, or be very large and CNC (Computer Numerical Control)-operated, and hold many punches and dies of various sizes and shapes.

Punch presses are manufactured in many shapes and sizes, ranging from 2-ton benchtop models to 500-ton floor models and larger. The **tonnage** of a punch presses refers to the total force between the **dies.** In an oversimplified example, a 100-ton punch press with a 25.4 cm (10 inch) × 25.4 cm (10 inch) die area (645 cm^2 [100 square inches]) will achieve a force of 13,800 kilopascals (1 ton per square inch).

A press that must complete one full revolution before the stroke can be stopped is called **full revolution clutch.** A press equipped with an air-friction clutch, and with a proper control package, is capable of being safely stopped anywhere during its stroke. This type of press is called **part revolution clutch.** The difference is important because it will dictate the types of safeguards that can be used.

Presses can be further classified by the type of power source: **mechanical** (electrical motor and flywheel for energy transfer to the crankshaft) or **hydraulic.**

Figure 4.7 shows the two most common punch presses found in general use.

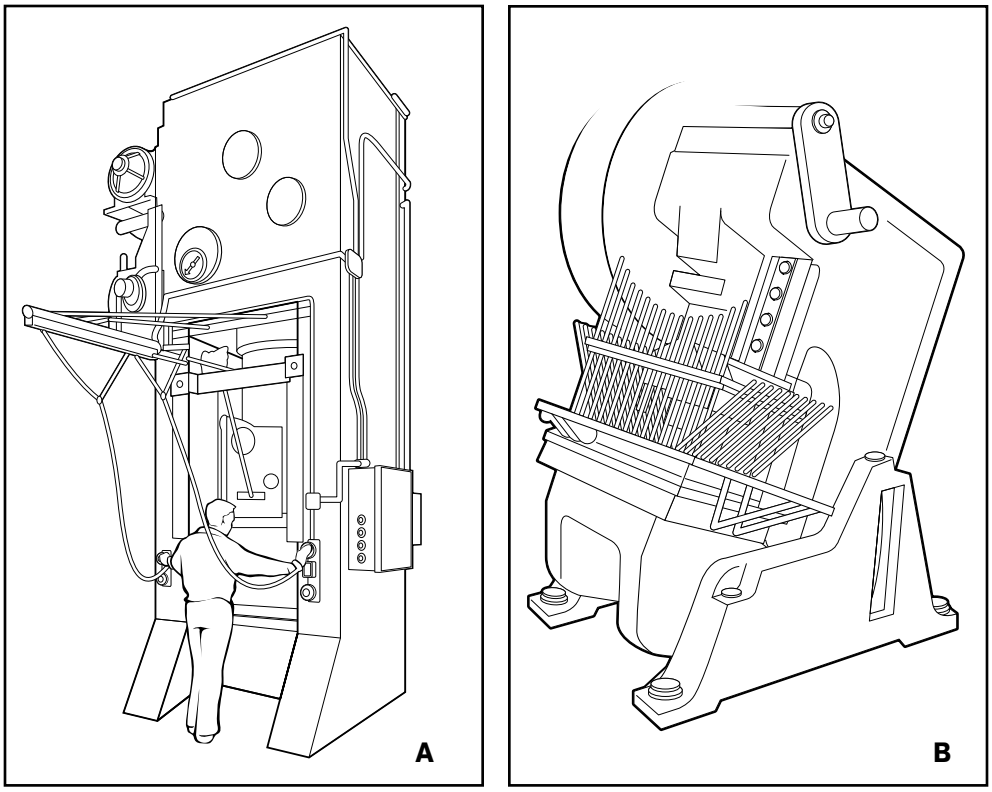


Figure 4.7. Most common punch presses in general use. (A) Straight side hydraulic power press (no flywheel) – press remains in vertical position. (B) OBI (open back inclinable) mechanical punch press – press can be tilted back to allow formed parts to drop out of the back.

Methods of safeguarding

The two critical areas of safety on punch presses are:

- Point-of-operation (feed point) safeguarding
- Control reliability (can the machine come to a safe stop consistently and reliably in the event of an unsafe condition or when an emergency stop signal is given?)

Because a punch press can be used for many different operations (hand feeding, automatic strip/coil feeding, and so on) there are several effective ways to safeguard the point of operation. Figure 4.8 shows the many options available.

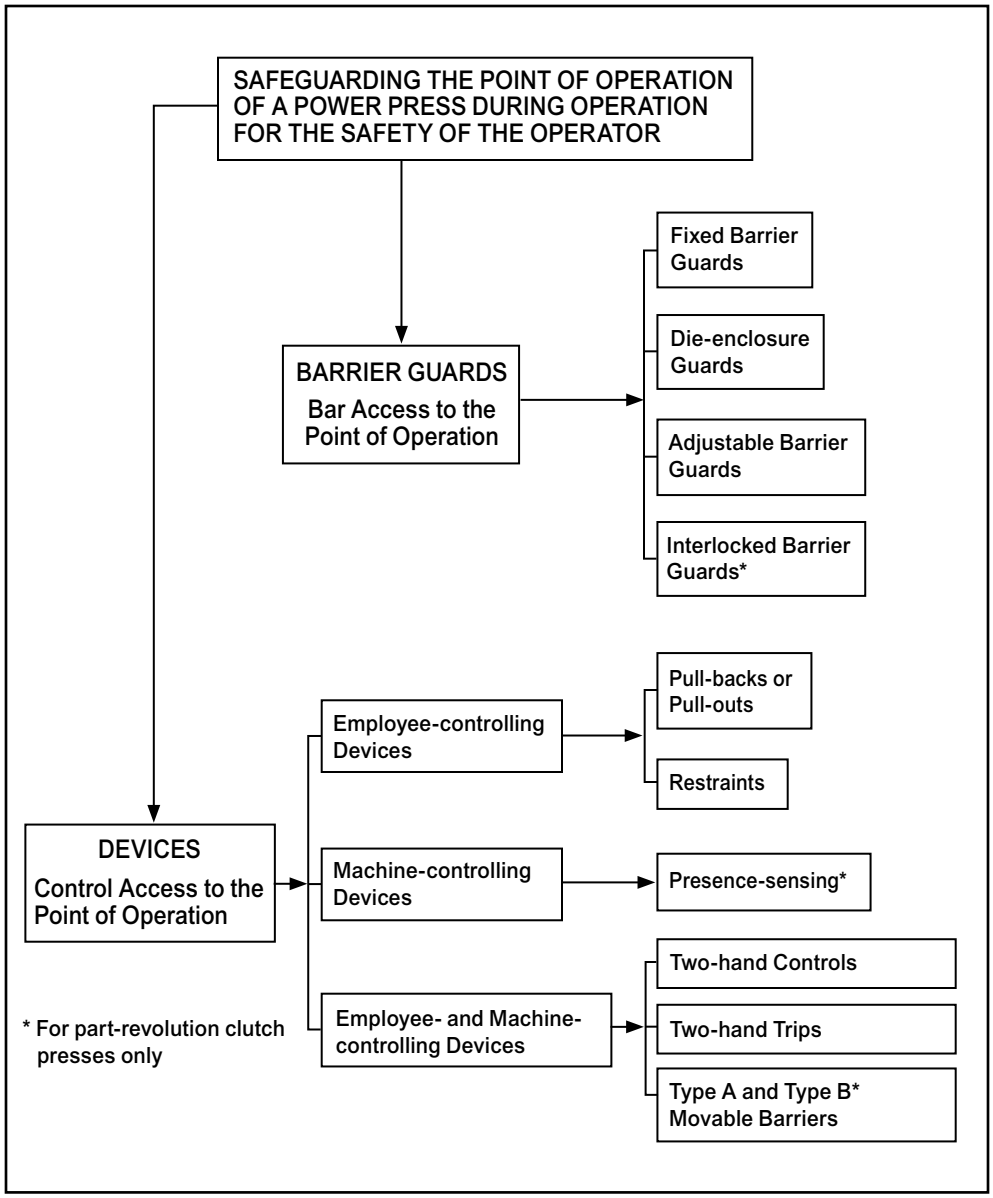


Figure 4.8. Safeguarding options for punch and brake presses.

Brake presses

Types of brake presses

Whereas punch presses are generally used for *piercing* metal, brake presses are used mostly for *bending* sheet or plate metal. Brake presses are generally rated by the length of the press bed. The longer the bend, the longer the piece that can be inserted into the dies. Each cycle of a brake press is called a **stroke.**

Brake presses are normally fed by hand and operated with a foot control, which places them at high risk for amputations. Brake presses have **part revolution clutch** operation; if the foot treadle or electrical control is released, the ram (the part that holds the upper die and moves down and up) either stops or returns to top of stroke.

If you have a brake press, you must refer to the CSA Standard Z142, Code for Punch Press and Brake Press Operation: Health, Safety and Guarding Requirements to determine how to safeguard it properly.

Brake presses are also classified by the type of power source:

- Mechanical (electrical motor and flywheel for energy transfer to the crankshaft)
- Hydraulic
- Hydro-mechanical (a combination of mechanical actuation with hydraulic assist)

Methods of safeguarding

The two critical areas of safety on brake presses are:

- Point-of-operation (feed point) safeguarding
- Control reliability (can the machine come to a safe stop consistently and reliably in the event of an unsafe condition or when an emergency stop signal is given?)

The options for safeguarding the point of operation of a brake press are somewhat limited. This is because the profile of the formed piece is substantially different after the bending process. What goes into a narrow die space as flat stock may have to be removed as a complex shape, so brake press operations generally require a fair amount of open space between the dies. The exception to this would be small-piece parts that can be fed into an open die space of 6 mm (¼ inch) or less (safeguarded by minimum opening) and removed without difficulty. Additional safeguarding is required at the ends of the press.

Besides point-of-operation safeguarding, an **awareness barrier,** usually in the form of a chain or rope with appropriate signage, should be installed across the back of the brake press to deter access by unqualified persons.

Point-of-operation safeguarding is generally limited to three options:

- Light curtain devices that are mounted at either end of the press bed and detect entry of a hand or body part into the die space. These devices can be programmed to recognize the varying profiles of piece parts and selectively mute or blank out the light beam channel(s) that may interfere with the proper functioning of the

light curtain. These devices offer the least interference with normal press operation. They are particularly well suited to hydraulic brake presses. If they are retro-installed on a mechanical brake press, modifications will have to be made to the existing brake and clutch system, and a control-reliable package will have to be installed.

- Two-hand controls coupled with foot switch operation. This type of conversion package uses control-reliable components to enable the operator to bring the ram down to a 6 mm (¼ inch) or less closure using two-hand controls, then change over to foot control operation. The foot control is inoperative during the initial part of the downstroke. This method normally requires the piece part to be supported for productive operation.
- Pull-back or restraint devices. Although not commonly used, they might be considered for some dedicated brake press operations with infrequent die and piece part changes.

Power shears (sheet metal and plate)

The point of operation of a power guillotine shear used for forming sheet metal and plate be safeguarded according to the requirements of *ANSI Standard B11.4, American National Standard for Machine Tools – Shears – Safety Requirements for Construction, Care and Use.* This section summarizes the point-of-operation safeguarding requirements contained in the standard. If you have an unusual application for a shear, you should refer to this standard for specifics on how to safeguard it properly.

The two critical points of operation on a guillotine shear are:

- The blade, which does the actual cutting
- The hold-down clamps or "feet," which hold the work piece in position during the cutting cycle

The hazards posed by the blade and clamps are hidden by the guard (Figure 4.9).

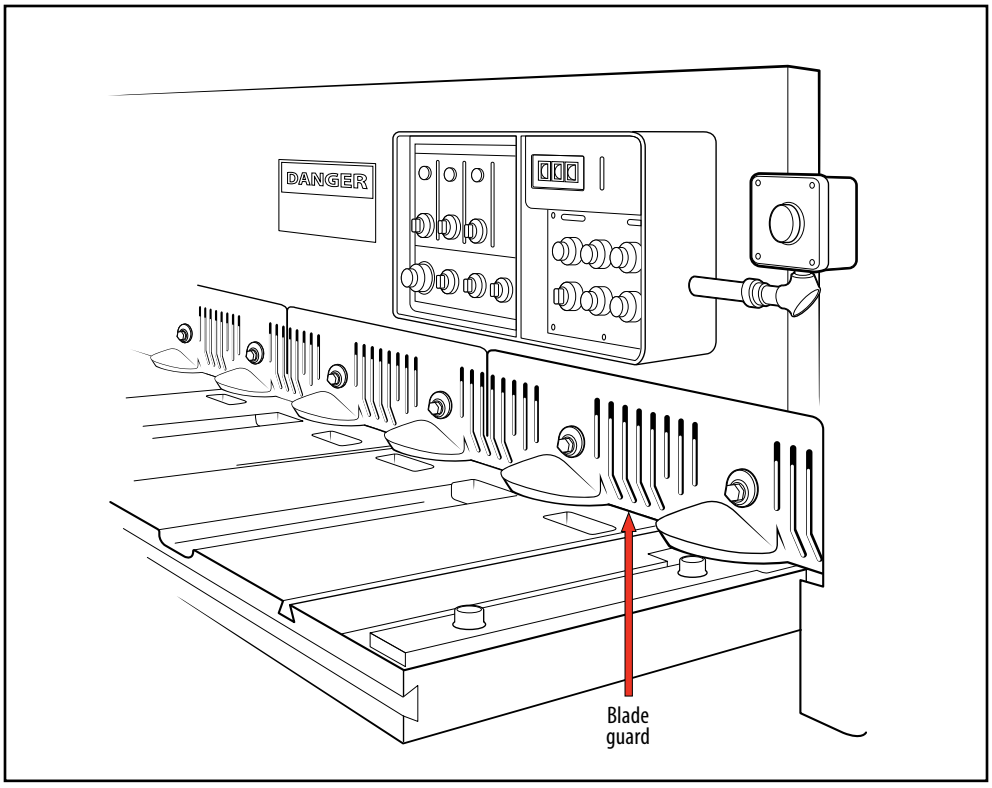


Figure 4.9. Power guillotine shear with point-of-operation safeguarding.

Methods of safeguarding

Three type of safeguards are used to protect the point of operation of shears:

- A fixed barrier guard designed with openings large enough to allow the flat stock into the shear but small enough to keep fingers out
- A fixed barrier guard with an awareness modification that allows larger thicknesses of plate steel (greater than 12 mm [½ inch]) to enter the shear but warns the operator that his or her fingers are approaching the danger area.
- Two-hand controls, which are not common but are found in some specialized cut-to-length operations

Besides point-of-operation safeguarding, an awareness barrier, usually in the form of a chain or rope with appropriate signage, should be installed across the back of the shear to deter access by unqualified persons.

ANSI Standard B11.4, American National Standard for Machine Tools — Shears — Safety Requirements for Construction, Care and Use, provides the dimensions for the maximum openings permitted in and under the guard, and the minimum distances from the guard to the nearest point-of-operation hazard.

ANSI Standard B11.4, American National Standard for Machine Tools — Shears — Safety Requirements for Construction, Care and Use, has a diagram showing the locations of the fixed and movable guards and the dimensions for point-of-operation awareness barrier guards.

Guard design criteria for shears with capacities up to 12 mm (½ inch)

Flat metal stock of 3 mm (⅛ inch) thickness or less is referred to as **sheet metal.** Material of greater thickness is called plate. Shears used for sheet metal and plate up to 12 mm (½ inch) require a **non-adjustable fixed barrier guard** that protects the operator from contact with both the clamps and the blade.

Guard design criteria for shears with capacities over 12 mm (½ inch)

When plate thickness exceeds 12 mm (½ inch), it is not possible to design a guard that will allow material into the cutting area and still keep fingers out. A compromise called an **awareness barrier modification** will alert operators when their hands approach the danger area near the clamps and blade. It consists of a movable section (usually 102 mm [4-inch] segments of high-visibility coloured plastic pipe) mounted on the lowest fixed section of the guard with a warning sign (for example, "Do not extend fingers or hands beyond guard or barrier") displayed.

Iron workers

An iron worker is a multi-purpose powered tool used for punching, shearing, notching, and coping ("nibbling") metal parts. It may be powered either **mechanically** (flywheel) or **hydraulically.** Each machine function is called a **work station.**

The in-feed side of an iron worker station, particularly the structural shearing station, is generally safeguarded by design. Access to the point of operation is limited by the **restrictor,** which holds the work piece in position during punching and shearing operations. Provision must be made, however, to ensure that the offside (blind side) of each machine station is safeguarded to prevent someone other than the operator from accidentally reaching into the point of operation. Guarding usually consists of self-closing guards that are open only when material is in the cutting area. *All the work stations on mechanical clutch iron workers operate at the same time, so any work stations not in use must be guarded.*

The punch station of an iron worker presents a risk of injury to the operator and nearby workers from flying debris if a punch gets broken. The restrictor should always be properly adjusted during punching operations, and some guarding installed to contain flying fragments in the event of a punch failure.

Hand-fed powered metal-forming rolls

Steel fabrication shops make use of equipment for rolling sheet metal or plate into cylinders. These metal-forming machines are often referred to as "pyramid rolls" or "initial pinch offset rolls" (Figure 4.10). They present a unique safeguarding challenge: the point of operation must remain accessible during the entire forming operation. This exposes both the operator and helper to the risk of being drawn into the powered rolls. Safeguarding usually consists of an emergency body contact device such as cable wire or a bumper bar (see "Miscellaneous emergency body contact devices" on page 40) that will be involuntarily activated by the operator or helper in case of entrapment in the rollers.

Because the rolls are under very high operating pressure, the equipment will normally come to a very sudden stop when the emergency stop device is activated. It is important that this device be installed so that both the operator and the helper can access it.

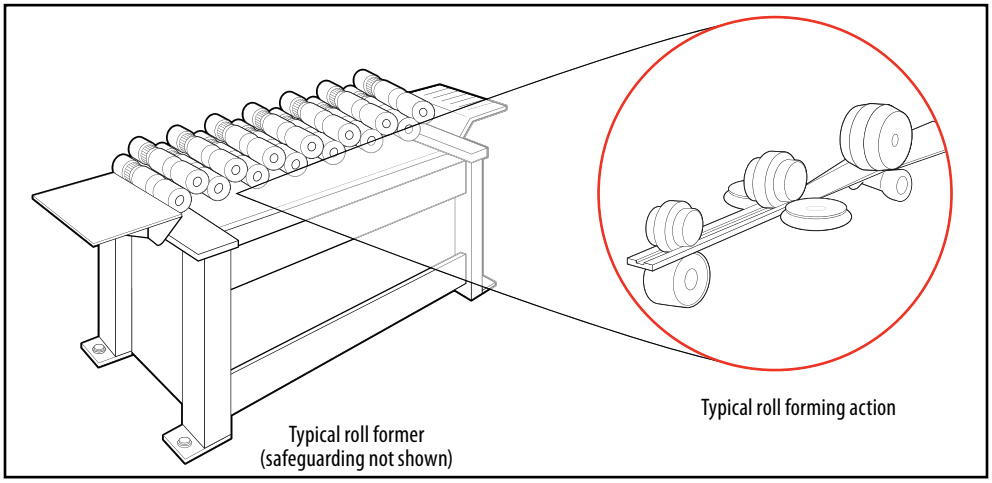


Figure 4.10. Typical metal-forming rolls.

The point of operation of an iron worker must be safeguarded according to the requirements of *ANSI Standard B11.5, American National Standard for Machine Tools — Iron Workers — Safety Requirements for Construction, Care and Use.* This section summarizes the point-of-operation safeguarding requirements contained in the standard. For specific information on how to safeguard an iron worker properly, refer to the standard.

Other powered roll formers

There are a number of production machines that produce formed metal products such as continuous gutters, corrugated roofing panels, steel studs, and so on. They usually consist of a set of rollers through which coil or pre-cut sheet metal stock is fed. Safeguarding these machines is usually accomplished by **barrier guards** that cover the exposed rollers and prevent access to the point of operation. On some production lines, presence-sensing devices such as light curtains or pressure mats could be employed, provided that the technical restrictions associated with these devices can be overcome.

Abrasive wheels and grinders must be used according to the requirements of *ANSI Standard B7.1, The Use, Care and Protection of Abrasive Wheels.* This section highlights the more important safety measures contained in the standard, but is not intended to take the place of a thorough knowledge of the standard, especially for employers and workers involved in high-risk grinding operations.

Abrasive equipment

An abrasive tool uses an abrasive wheel to wear away the surface of a workpiece to change its shape. An abrasive wheel consists of a bonded abrasive material with properties specific to the material being worked; for example, a wheel intended for ferrous material may not be suitable for grinding nonferrous material. There are three common types of grinding machines: bench grinders, pedestal grinders, and portable grinders.

The greatest risk associated with abrasive equipment is **fragmentation** of an abrasive wheel. The size and peripheral speed of the wheel determine the amount of energy that will be released in the event of a failure. The main objective of safeguarding is to contain pieces of the abrasive wheel if a rupture occurs.

There are two important areas where training and safeguarding will prevent serious injury and death:

- Proper storage and handling of abrasive wheels
- Appropriate safeguarding of stationary and portable grinders

Proper storage and handling of abrasive wheels

Wheels (especially vitrified or glass-based wheels) are easily damaged if they are bumped or dropped. That is why it is so important to store and handle them carefully.

- Check all wheels when you receive them and before using them.
- Follow the manufacturer's instructions for storage. Proper sorting and storage of grinding wheels will help ensure easy access, less handling, and less chance of error.
- Store grinding wheels in an area that is dry and protected against damage from impact, solvents, high humidity, and extreme heat or cold.
- Store portable grinders on hooks or in V-shaped racks. Protect racks from damage.
- Arrange grinding wheels so that older ones will be chosen before newer ones.
- Never roll a wheel on its edge; it may absorb oil or dirt from the floor, and get damaged.

Design criteria for abrasive wheel guards

Figure 4.11 illustrates the maximum wheel exposures for guards on two types of abrasive equipment: bench and pedestal grinders (90° exposure) and hand-held angle grinders (180° exposure). When a portable grinder is being used for grinding root passes in welded pipe, the protective hood must cover at least 120° of the wheel periphery and the operator must wear adequate eye and face protection.

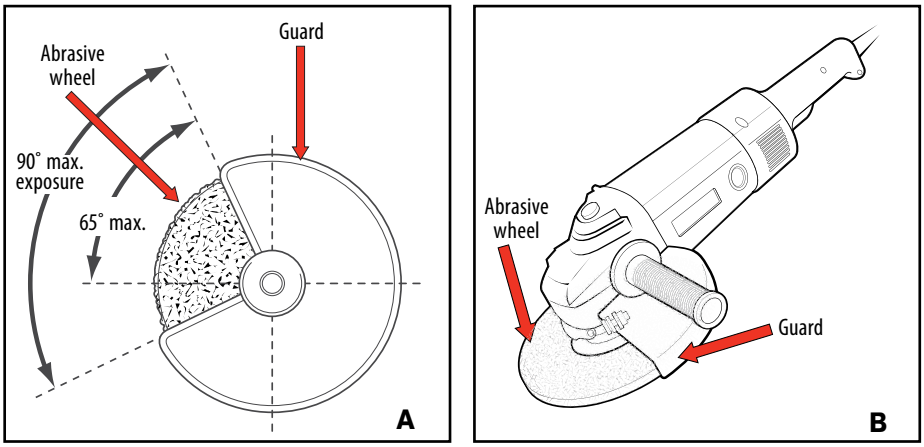


Figure 4.11. Maximum wheel exposures for different types of abrasive wheel guards.

Safety rules for bench and pedestal grinders

- Pedestal grinders must be securely attached to the floor. Bench grinders should be securely fastened to a bench.
- Always check that the rated RPM (revolutions per minute) of the grinding wheel is consistent with the rotational speed of the grinding machine.
- Always wear eye protection (safety glasses or impact-rated face shield).
- Never remove wheel guards from a bench/pedestal grinder. They offer protection in case of wheel failure, and protect hands and fingers from injury.
- Work rests or tools rests must be provided on all machines. The work rest must be securely fixed and adjusted close to the grinding wheel (maximum distance of 3 mm [8 inch]). It should be adjusted as the disc becomes smaller through wear and dressing. Never adjust tool rests while the grinder is running.
- Before commencing grinding, allow the grinding wheel to run at operating speed for at least one minute. Do not stand directly in front of a grinding wheel when it is first started. Do not use a wheel that vibrates.

CSA Standard Z114-M1977, Safety Code for the Woodworking Industry, covers the requirements for safe installation, operation and maintenance of woodworking machinery.

CSA Standard Z432, Safeguarding of Machinery, covers the requirements for design, manufacture, installation, maintenance, operation and safeguarding of industrial equipment.

- When starting a grinding operation, bring the object into contact with the grinding wheel slowly and smoothly. Avoid impact or bumping motions.
- Move the work piece back and forth across the face of the wheel. This prevents "ruts" or grooves from forming.
- Occasionally a new wheel may be cracked or flawed and is likely to shatter as soon as it is used. New wheels should be visually checked and given a "ring" test before being fixed to the spindle. Tap the side of the wheel with a light tool. It should have a clear ring. A dull noise indicates a flaw.
- Ensure that the hole in the grinding wheel fits closely on the spindle.
- When a wheel has been newly fitted, rotate it by hand to check the balance before switching on power to the machine.
- An abrasive wheel can crack and shatter if flanges and blotters are not evenly seated on either side of the wheel before the locking nut is tightened. Avoid overtightening the locking nut, as this can exert hazardous stresses on the wheel.
- If the pores of an abrasive wheel become clogged, or if the wheel loses its cutting effect, exerting force will cause the wheel to overheat and shatter. Dress the wheel with a proper dresser.

Woodworking equipment

Equipment and machinery used in woodworking are dangerous when used improperly or without proper safeguards. The most common injuries to workers are lacerations, amputations of the fingers and hands, and loss of sight. Besides traumatic injuries, workers in this industry can suffer from skin and respiratory diseases from exposure to wood dust and the chemicals used in finishing.

This section describes the principal hazards of woodworking equipment and some methods for controlling these hazards through safeguarding. *It is not a substitute for a thorough knowledge of the Workplace Safety and Health Regulation (MR217/2006).* This section does not cover machinery used in the primary production of lumber and basic wood materials at sawmills and lumber remanufacturing plants.

Safety and health hazards

The main occupational hazards associated with woodworking operations are as follows.

Safety hazards

- Machine hazards (point of operation, power transmission components)
- Kickbacks
- Flying chips and material
- Tool projectiles (unbalanced cutter heads)
- Fire and explosion
- Electrical

Health hazards

- Chemical (sensitization from exposure to finishes, coatings, adhesives, solvents)
- Wood dust (some are carcinogens)
- Noise
- Vibration

Point-of-operation hazards

The point of operation of a woodworking machine is where the stock is cut, shaped, bored, or formed. Most woodworking machines use a cutting and/or shearing action. Here are some examples of how injuries can occur at the point of operation:

- Hands too close to the blade, particularly when working on small pieces of stock. Accidents occur when stock unexpectedly moves or when a worker's hand slips.
- The work piece is not properly supported, a common unsafe work practice with table saws. The worker assumes an awkward handling position, often with hands over or behind the blade. Loss of control or balance causes hands to contact the blade.
- Stock gets stuck in a blade and actually pulls the operator's hands into the machine.
- Operator's gloves get caught in a blade and pull the operator's hands into the machine.
- Machine safeguard is not properly adjusted and maintained. For example, a radial arm saw blade which can overhang the cutting table may snag clothing and pull the worker into the running blade.
- Machine controls are not properly positioned or protected from inadvertent activation.
- A worker reaches in to clean a saw or remove a piece of wood after the saw has been turned off but while it is still coasting or idling. (Saw blades often move so fast that it can be difficult to see if they are actually moving, especially under fluorescent lighting.)

- Contact can occur during repair and maintenance if the machine starts unexpectedly because lockout procedures were not followed.

Kickbacks

Kickbacks occur when a saw seizes the stock and hurls it back at the operator. This can happen when the stock twists and binds against the side of the blade or is caught in the teeth — often caused by a dull blade or one that is set at an incorrect height. Poor-quality lumber (splits, frozen, many knots, foreign objects) will increase the likelihood of kickback.

Kickback hazards are most likely when there is a lack of safeguards such as spreaders, anti-kickback fingers, and gauge or rip fences. Kickbacks occur more often when **ripping** (cutting parallel to the grain) than when crosscutting.

Tool projectiles

Many pieces of woodworking equipment — such as routers, shapers, and moulders — use rotating cutter heads with multiple knives. Cutter heads that are not properly adjusted, or that are poorly mounted or have broken knives, can become unbalanced. Balance is critical for keeping knives secured to a rapidly moving cutter head. The centrifugal forces on an unbalanced cutter head can fling the knives from the tool and severely or fatally injure the operator or other persons nearby.

Using the wrong tool on a cutter head or using a tool at a higher speed than it was designed for can cause the tool to break and create a deadly projectile.

Preventive measures

The following is a summary of preventive measures to control workplace hazards in woodworking shops. Please refer also to the "Hierarchy of safeguarding controls" on page 18.

Engineering controls (guards)

These involve physically changing the machine or work environment to prevent employee exposure to the potential hazard. Examples include fitting the machine with a guard, or using local exhaust ventilation to remove dust and other contaminants at the source. Engineering controls must always be the first consideration.

Safeguarding the point of operation of hand-fed woodworking

machinery presents a challenge: how do you build a guard to allow the stock into the blade or cutter while at the same time keeping fingers out? *The best working compromise is a self-closing guard that effectively prevents the operator from contacting the unused portion of the blade or cutting tool.* Investigation determines time and again that in most incidents, the worker contacted the cutting tool in a manner inconsistent with normal feeding practice.

Administrative controls (safe work practice)

These involve removing workers from the hazard by changing the way they do their job. For example, push sticks and push blocks could be used to guide short or narrow pieces of work through saws and cutting tools. Lockout procedures are another example of an administrative control. Administrative controls always involve training and supervision.

Personal protective equipment

Personal protective equipment encompasses a wide variety of devices and garments designed to protect a worker from injury or disease. Examples include respirators, safety eyewear, face shields, safety footwear, and hearing protection. Workers must **avoid loose clothing, gloves, or long, unconfined hair,** which can become snagged in moving machine parts.

Safeguarding commonly used on woodworking machines

The following are recommended point-of-operation safeguarding techniques and safe work practices for several machines commonly used in the woodworking industry. Personal protective equipment is not specifically covered because its use applies to all industrial machinery. Work practices that apply to all woodworking equipment (such as using a brush for cleaning saws) are not covered either.

Use and operation

Table saws are used for straight sawing. Depending on the blade, they cut either across (crosscut) or with (ripsaw) the grain of the wood. With hand-fed saws, the operator adjusts the height and angle of the blade, then, holding the stock, pushes the stock into the blade. A guide or fence is used to maintain a straight cut at the desired width. Power-feed or power table saws are equipped with feed rollers or a conveyor system to hold the lumber and force-feed it into the saw blade.

Table saw

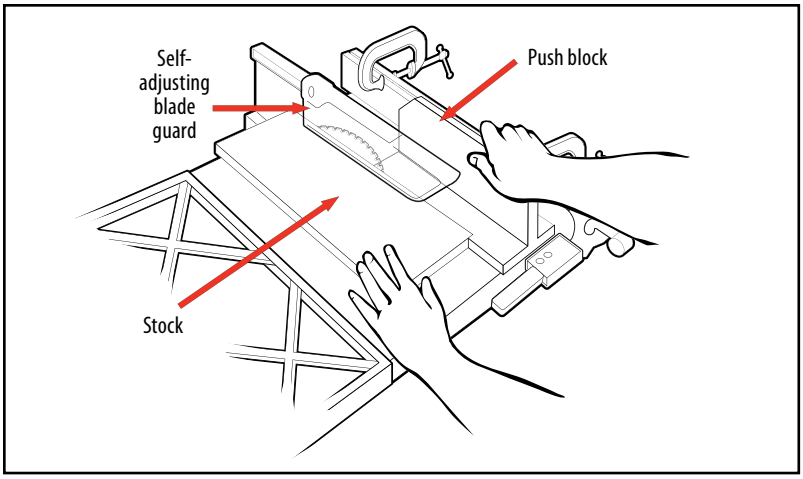


Figure 4.12. Typical table saw.

How injuries occur

An operator's hands can slip while feeding the stock into the saw, or if the hands are too close to the blade. Workers can also be injured when removing scrap or finished pieces from the table.

Kickbacks are another major cause of injury. They are more likely to occur when ripping rather than crosscutting. Kickbacks can occur if:

- Safeguards are not used.
- Poor-quality lumber is cut.
- The blade height is not correct.
- The blade is not properly maintained.

Other sources of injury are unguarded power transmission parts (belts and pulleys) and nip points of automatic feeders. Clothing, hair, or hands may be caught by and pulled into the in-running feed rolls.

Recommended engineering controls

- Ripping and crosscutting – Enclose the portion of the saw above the table with a self-adjusting guard as shown in Figure 4.12. The guard must adjust to the thickness of the material being cut and remain in contact with it. The guard should be hinged so it can be easily moved away for saw changes.
- Ripsaws – Use a spreader to prevent material from squeezing the saw or kicking back during ripping. Use anti-kickback fingers to hold the stock down in case the saw kicks back the material.
- Guard all drive belts and in-running nip points.

- Always ensure that the portion of the blade below the table is guarded from unintended contact.
- Operator controls (Start/Stop) readily accessible by operator.

Recommended safety rules

- Keep hands out of the line of cut.
- Use the proper blade for the cutting action (for example, don't use a crosscut blade for ripping).
- Only trained, competent operators allowed to operate equipment.
- Ensure safe work procedures are in place, understood, and followed by operators.
- Maintain a sharp blade in good condition.
- Stand to one side of the saw blade to avoid injury from possible kickback.
- Use a push stick for small pieces of wood and for pushing stock past the blade.
- Use jigs to support pieces of stock to avoid having to put excessive hand pressure on the work piece.
- Do not attempt to crosscut long boards on a table saw.

Radial arm saw

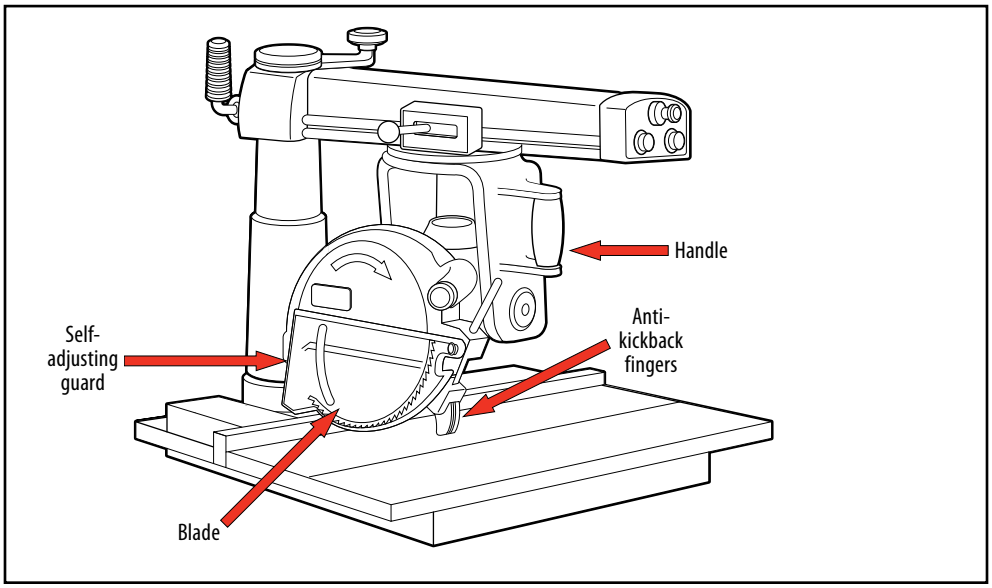


Figure 4.13. Typical radial arm saw.

Use and operation

Radial arm saws are circular saws that rotate downward either with (rip) or against (crosscut) the wood grain. For crosscutting, the wood is

placed against a fence away from the operator and the blade is pulled into the stock. For rip cuts, the blade is set parallel to the fence and the stock is pushed through.

Radial arm saws have features that make them more versatile than table saws. The saw arm can be raised and lowered and swung to the side to adjust the depth and horizontal angle of the cut. The blade can be replaced with shaping cutters, disk or drum sanders, or other accessories.

Radial arm saws are the preferred choice for cut-to-length operations when other saws are not available.

How injuries occur

The principal types of injury from radial arm saws are cuts to the arms and hands, or amputation of fingers from contact with the blade or from flying wood chips. Kickback can also occur; workers nearby can be seriously injured if stock that is fed in the wrong direction (especially when ripping) is flung out of the saw.

Injuries can also occur when the leading edge of the blade extends beyond the front of the cutting table; an operator's clothing or body can be snagged by the saw blade.

Recommended engineering controls

- Enclose the upper half of the saw (from the blade down to the end of the saw arbor) with a fixed hood. Guard the lower half with a self-adjusting, floating guard that rises and falls with the stock.
- Make sure the saw has a return device. The front end of the unit should be slightly higher than the rear so that the cutting head will return to its original position when released by the operator. This will also prevent the cutting head from rolling or travelling due to gravity or vibration.
- Set the end travel stop to prevent the forward travel of the blade from overhanging the cutting table.
- Operating controls readily accessible by operator.
- Exhaust – ie: sawdust extraction system.
- Fence – proper height, hold product up against.

Recommended safety rules

- During crosscutting, operate the saw on the side of the table with the handle.
- During ripping, make sure the stock is fed in the correct direction to avoid serious kickback hazard.
- Clearly mark the direction of saw rotation on the protective hood (guard).
- Measure boards using an end stop gauge. If measuring by rule, turn off the saw.
- Wait for the blade to stop before making measurements.
- Before performing angular cuts, check the intended direction of the saw blade (for example, compound 45° cuts).
- Clean level table top.
- Only trained, competent workers/operators to use equipment.
- Ensure safe work procedures are in place, understood and followed by operators.

Band saw

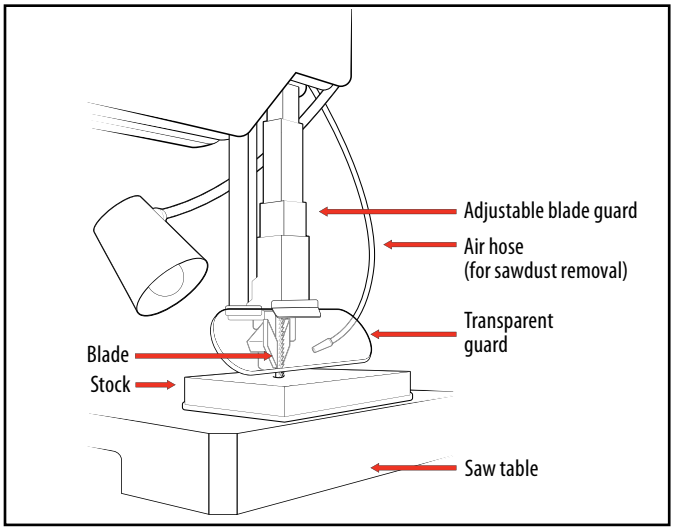


Figure 4.14. Typical band saw.

Use and operation

Band saws are used both for straight sawing and for cutting curved pieces. The band saw uses a thin, flexible, continuous steel strip with cutting teeth on one edge. The blade runs on two pulleys, one driven and the other an idler, through a hole in the work table on which stock is fed. The operator hand-feeds and manipulates the stock against the blade to saw along a predetermined line.

How injuries occur

The most common injury is caused by contact with the blade. Contact with the blade at the point of operation occurs in two ways:

- The operator's hands may come close to the blade during cutting. A band saw cannot be completely guarded; the portion of the blade used for cutting is always exposed.
- The operator may contact the unused portion of the blade if it is not guarded (for example, when removing a cut piece).

Recommended engineering controls

- Guard the blade entirely except at the point of operation (the working portion of the blade between the bottom of the guide rolls and the table).
- Use a self-adjusting guard for the portion of the blade between the sliding guide and the upper saw so that it rises and lowers with the guide.
- Properly adjust the blade guide post to fit the thickness of the stock and to provide additional guarding.
- Fully enclose the band wheels.
- Guard feed rolls if they are used as a method of feeding the saw.
- Consider installing a braking system on one or both wheels to minimize the potential for coasting after the saw has been shut off; otherwise, do not remove material until the blade has stopped.
- Make sure the saw includes a tension control device to indicate proper blade tension.

Recommended safety rules

- Use a blade of an appropriate size and type. For example, do not force a wide saw to cut on a small radius.
- Set the guard to just clear the stock being cut.
- Never stop the saw too quickly or thrust a piece of wood against the cutting edge of the teeth after the power has been shut off.
- Periodically inspect blades; remove cracked or defective blades immediately.
- Make cuts only when the power is on and not when the saw is coasting.
- Use a push stick to control the stock when it is clearing the blade.
- Use a special jig or fixture when cutting small pieces of stock.
- Only trained, competent workers/operators to use equipment
- Ensure safe work procedures are in place, understood and followed by operators.

Jointer

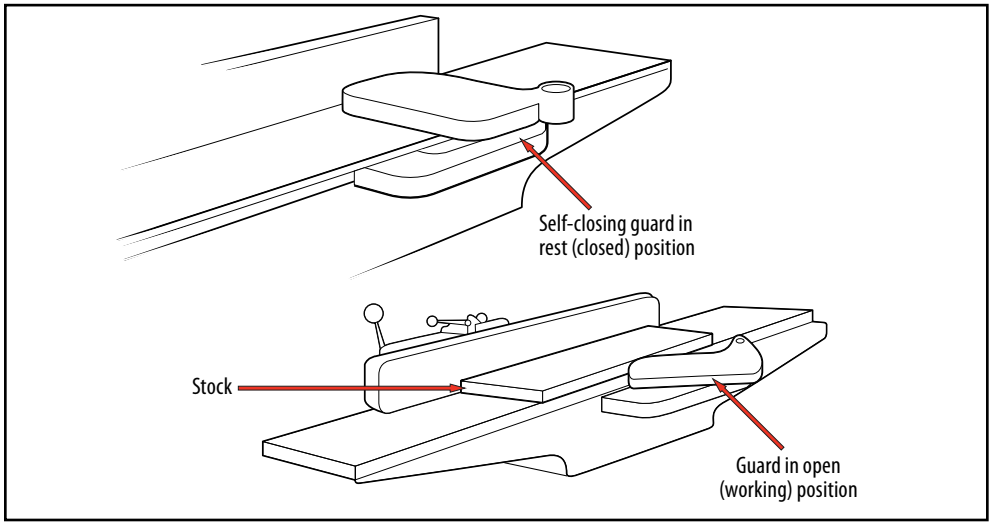


Figure 4.15. Typical jointer.

Use and operation

Jointers face or flatten wood and are primarily used to joint small pieces of material. The operator passes stock over a cylindrical, multi-knife cutter head while keeping the stock flush against a guide (fence). The depth of the cut is achieved by adjusting the front table.

There are two types of jointers:

- Hand-fed jointers with a horizontal cutting head (Figure 4.15)
- Wood jointers with a vertical head

How injuries occur

Hand-fed jointers are dangerous woodworking machines. Injuries can occur if the operator's hands and fingers come in contact with the knives. This can happen when the operator is jointing narrow lengths of stock, particularly if a jig or other holding device is not being used. Injuries can occur when the operator allows fingers to ride along the surface of the jointer behind the stock as it is fed though. Sometimes stock may be accidentally kicked away, exposing the operator's hands to the cutter head.

Recommended engineering controls

For **horizontal** hand-fed jointers:

- Enclose the cutter head with an automatic (spring-loaded, self-enclosing) guard that exposes the cutter head only when the stock is being fed. The guard must automatically adjust to cover the unused portion of the head, and it must remain in contact with the

material at all times.

- Adjust the cylindrical cutter head so that the knife projects no more than 3 mm (8 inch) beyond the cylindrical body of the head.
- Adjust the cutter head so that the clearance between the path of the knife projection and the rear table is no more than 3 mm (8 inch).
- Keep the clearance between the table and the head as small as possible.
- Only trained, competent workers/operators to use equipment
- Ensure safe work procedures are in place, understood and followed by operators.

For **vertical** head jointers:

- Completely enclose the cutter head, except for a slot to apply the material for jointing. This guard can be part of the local exhaust system.

Recommended safety rules

- Use a hold-down push block when jointing wood.
- Avoid deep cuts. They increase the likelihood of kickbacks and require a larger table opening.
- As a general rule, avoid jointing short pieces. Never joint pieces of material that are shorter than four times the width of the bed opening.
- Check knives regularly for proper setting and adjustment, but only when the power is shut off.
- Only trained, competent workers/operators to use equipment
- Ensure safe work procedures are in place, understood and followed by operators.

Shaper

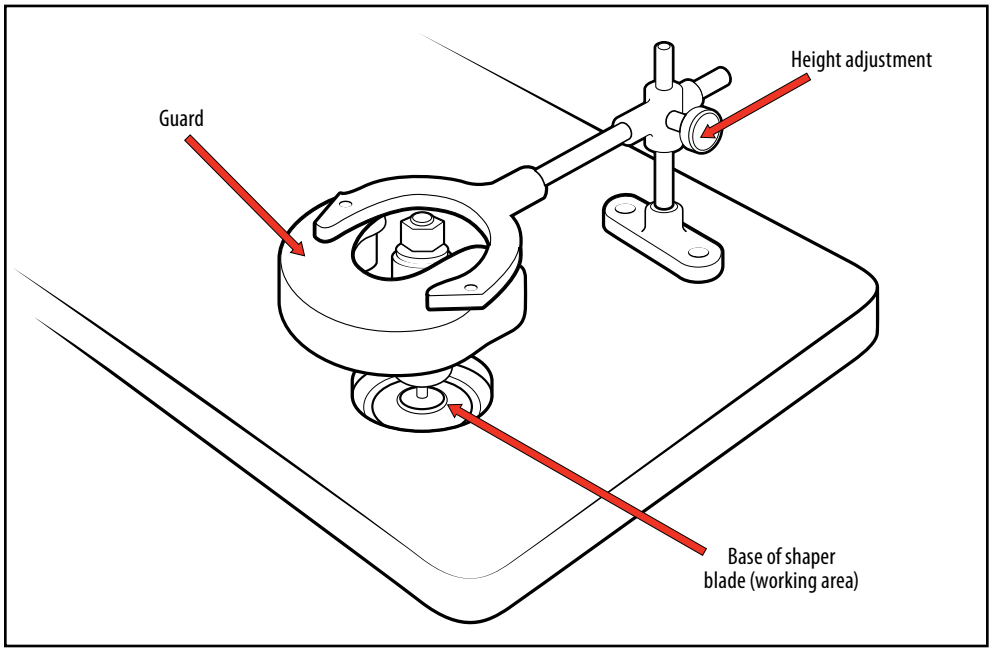


Figure 4.16. Typical shaper.

CSA Z114-M (3.3.6)

Guarding of shapers – the cutting heads of the wood shapers, hand fed panel raisers, or other similar machines not automatically fed shall be enclosed or guarded to keep the operator's hands away from the cutting edge.

Use and operation

Shapers are most commonly used to shape the edges of stock. The operator feeds the stock from any direction against a vertical rotating cutter mounted on a spindle. The spindle rotates at a high speed. Some machines have multiple spindles. Guidepins hold the stock for curved shaping, and fences hold it for straight-line shaping.

How injuries occur

Injuries occur when the operator's hands or fingers contact the revolving knives. Workers can also be seriously injured or killed by tool projectiles resulting from unbalanced cutter heads. Shapers are difficult to guard, but a number of guards are available to protect the operator's hands.

Recommended engineering controls

For horizontal hand-fed shapers:

- Figure 4.16 shows a spindle enclosed with an adjustable guard or cage. For straight-line shaping, the fence frame should include the guard. The fence should contain as small an opening as possible for the knives, and should extend at least 457 mm (18 inches) on either side of the spindle. Split adjustable fences are useful for guarding when the entire edge of the stock is to be shaped.

The Workplace Safety and Health Regulation (MR217/2006) requires that robots and robotic systems be safeguarded according to the requirements of *CSA Standard Z434, Industrial Robots and Robot Systems — General Safety Requirements.* If your operation uses robots or robotic systems, you must refer to this standard to determine how to safeguard them properly.

The information in this section is provided for general application. Safeguarding of robots and robotic systems should be done only by qualified and experienced persons with a thorough knowledge of the applicable standard.

- Guard automatic feed rollers where present.
- Ensure that double-spindle shapers have a starting and stopping device for each spindle.
- Use a safety collar to minimize the potential for tool projectiles.

Recommended safety rules

- Maintain the knives. Make sure they are precision-ground to apply uniform pressure, and that they are balanced and fit properly.
- Train operators to listen for "chatter" indicating that knives are out of balance. To start the machine, operators should apply the power in a series of short starts and stops to slowly bring the spindle to operating speed.
- Use templates, jigs, and fixtures to distance the operator's hands from the point of operation. Featherboards may be clamped to the fence for straight-line shaping.
- Whenever possible, cut in the direction opposite to the spindle's rotation.
- Only trained, competent workers/operators to use equipment
- Ensure safe work procedures are in place, understood and followed by operators.

Industrial robots and robotic systems

The use of robots and robotic systems in manufacturing has become mainstream in large manufacturing operations such as the automotive industry, and their use in small manufacturing plants and niche operations will increase. Unauthorized entry into the working envelope of a robot exposes a worker to the potential for serious impact or crushing injuries from the unexpected movement of the robot.

The safeguarding of robots requires a **systems approach** to safeguarding. It typically uses a combination of fixed barrier fences, interlocked gates, and presence-sensing devices such as safety mats and light curtain devices. Figure 4.17 shows a typical robot work cell safeguarding system.

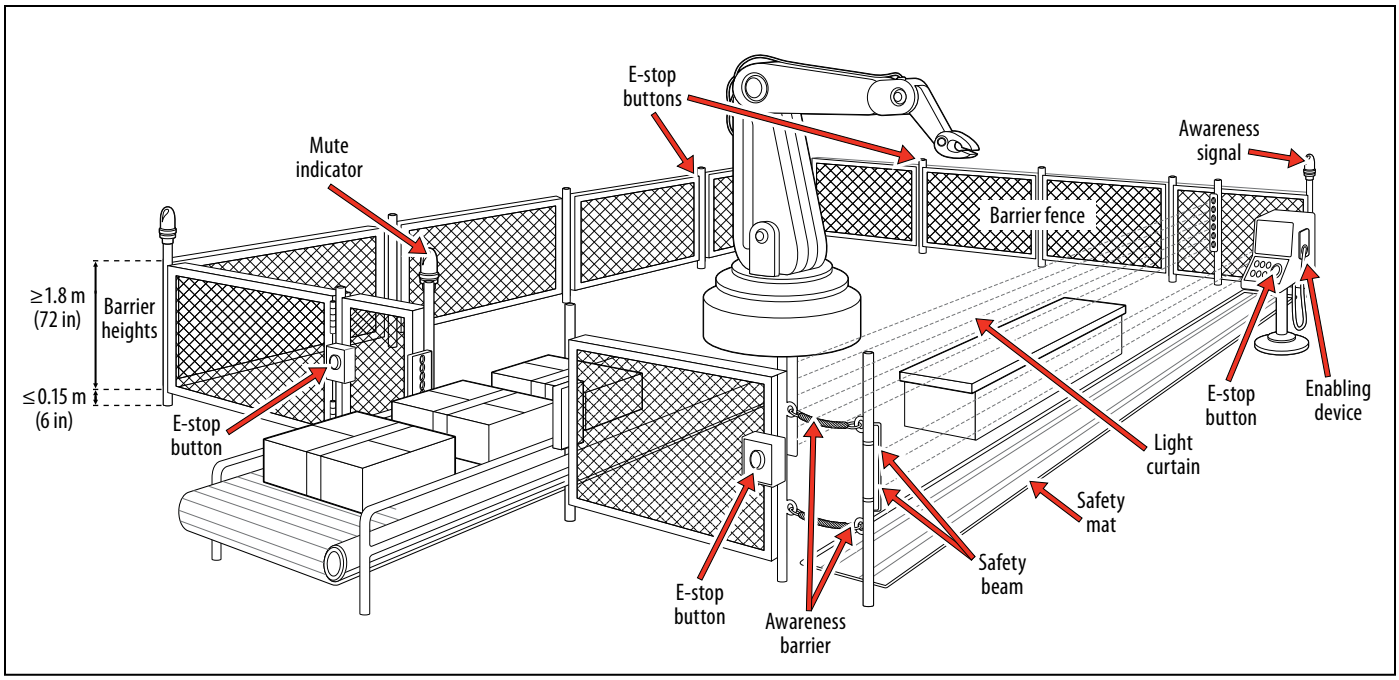


Figure 4.17. Typical robot work cell safeguarding system.

Appendices

Appendix 1 – Maintenance and Repair

Appendix 2 – Personal Protective Equipment

Appendix 3 – Machine Risk Assessment Survey

Appendix 4 – Safeguarding Checklist

Appendix 5 – Standards References

Appendix 1 – Maintenance and Repair

A good maintenance and repair program can contribute significantly to the safety of machine operators and other workers in the area of machine operation. Good maintenance and repair safe work practices and procedures ensure maintenance workers are also protected. However, the variety and complexity of machines to be serviced, the hazards associated with their power sources, and the special dangers that may be present during machine breakdown can make safe maintenance and repair work difficult. Employers must ensure that maintenance workers are provided adequate time and resources to safely maintain and repair the equipment without creating additional hazards.

Training and aptitude of people assigned to these jobs should make them alert to the intermittent electrical failure, the worn part, the inappropriate noise, the cracks or other signs that warn of impending breakage or that a safeguard has been damaged, altered, or removed. By observing machine operators at their tasks and listening to their comments, maintenance personnel may learn where potential trouble spots are and give them early attention before they develop into the sources of accidents and injury. Sometimes all that is needed to keep things running safely is machine lubrication and/or adjustment. Any damage observed or suspected by workers must be reported to the supervisor; if the condition impairs safe operation, the machine must be taken out of service for repair. If maintenance workers observe or suspect damage and do not have the authority to immediately rectify the situation, they must also report the condition to the supervisor. Safeguards that are missing, altered, or damaged also should be reported so appropriate action can be taken to protect the worker.

If possible, machine design should permit routine lubrication and adjustment without removal of safeguards. When safeguards must be removed, maintenance and repair personnel must never fail to replace them before a job is considered finished.

In some circumstances, machines need to be maintained or serviced while running. When these situations occur, safe work practices and procedures must be developed and implemented to ensure the safety of the maintenance personnel while performing the job. Additional safeguards must be considered when developing the safe work procedures. When it is not imperative that a machine run to be serviced or repaired, a lock out procedure must be used to ensure the machine is de-energized so that accidental start up cannot occur. Warning signs and tags are inadequate insurance against the start up of a machine, but can be used as part of a lockout procedure.

1. Lock-Out Procedure

Lock-out means ensuring that a machine, tool, pipe, or other equipment is not able to start or transmit energy when it is being maintained, serviced, repaired, or adjusted. When a machine or piece of equipment is locked-out, starting it in any way should be impossible – directly by an on/off switch or indirectly by a main power switch. The machine or equipment must be in a zero-energy state.

Zero-energy means that there is no energy of any kind left in the machine, tool or line. For example, a tool that uses compressed air would have the air line drained of any pressure and disconnected or blocked from the air source. An electrical panel would have the electricity shut off. It means the machine or equipment cannot be operated – intentionally, by using the switch, or by mistake because some energy was left in the system.

When a machine or piece of equipment is locked out, it must be physically locked out by a lock-out device. A lock-out device is anything that keeps the energy source away from a machine. This could be as simple as a lock that makes a switch impossible to reach or to turn on. If the lockout system used is a lock and key system, a separate lock and key must be issued to each worker that is required or permitted to work on the machine. The lock that is issued to the worker must have only 2 keys – one issued to the worker, and one duplicate key. The duplicate key must only be accessible to a designated worker and can only be used in the case of an emergency or if the original worker is not available and all precautions have been taken to ensure it is safe to remove the lock and activate the machine. In the case of a duplicate key being used to unlock the machine, a log book must be kept so that you can keep track of when duplicate keys are being used. In all normal situations, the lock-out device can only be removed by the person that installed it, and only once all precautions have been taken to ensure that the piece of equipment or machine is safe to reactivate.

A lock-out tag cannot be used on its own to lock out a piece of equipment because it does not provide a means of physical lock out. It can be used in conjunction with your lock-out system to provide additional information. For example, it can let other workers know who has locked out the machine, that it cannot be started or operated, and a brief explanation as to why the machine has been locked out. As for the physical qualities of a lock-out tag, you will need to assess the equipment and area of the lock out. If it is to tag an electrical lock-out, it should not readily conduct electricity, for example.

What should a lock-out procedure cover?

a) *A lock-out procedure should say:*
   - How you can safely bring and keep a machine at zero energy
   - Where and how to place appropriate lock out devices and tags on the machine
   - How to verify lock-out effectiveness and test for zero energy state
   - How to let people know the lock-out has happened
   - How to make sure that all persons near the locked-out machine are clear of the area until the machine is repaired and re-energized again (if required)
   - How to re-energize the machine after the lock-out

b) *Things to consider when writing a lock-out procedure:*
   - Job objectives and equipment involved
   - Detailing the energy sources for each machine and lock-out procedures
   - Steps for shutting down and securing machinery
   - Steps to verify lock-out effectiveness and test for zero energy
   - Procedures for applying lock-out devices and tags
   - Procedures for restarting
   - Employees authorized to do lock-out
   - Circumstances for the alternative person to remove a lock-out device

c) *Training for lock-out procedures:*
   - All employees must understand what equipment lock-out is, what the tags mean, and the procedures to follow if they want to operate the equipment
   - The person responsible for lock-out must be trained in the written procedure and fully knowledgeable of the hazardous energies related to the equipment
   - All employees that are reassigned to alternate equipment must be fully trained in the safe work procedures for that equipment
   - If contracted employers or self employed persons are called in to service equipment or machinery, employees that come into contact with them must be trained on their lock-out procedures and they must be trained on the internal lock-out procedures

2. Preventative Maintenance Programs

Preventative maintenance programs not only protect the equipment that you use in your workplaces, they can protect workers by revealing hazards and unsafe conditions before incidents happen. Preventative maintenance programs save on repair costs because when equipment is maintained regularly, fewer breakdowns occur. Also, when there are fewer breakdowns, unintentional downtime is avoided. To establish a preventative maintenance program in your workplace, you need to follow these steps:

a) Inventory – make an inventory of all machines and equipment you want to include in your preventative maintenance program. All equipment that you have in your workplace should be included, but depending on the complexity of the equipment, it may be a large component of your program or a small component.

b) Documentation – review any documentation you have that can assist you with determining what maintenance each piece of equipment needs. Good documentation to review includes manufacturer's operating manuals, safe work procedures developed at your workplace, and your safety and health program which will outline scheduled inspections, for example.

c) Developing your plan – once you have determined what type of maintenance is recommended for each piece of equipment, you need to develop a written plan of action. Some workplaces use computerized programs or written action calendars as tools to help organize the maintenance required. Dependant on the type of equipment in your workplace, maintenance plans should include items such as:
   - Lubrication times
   - Replacing gears
   - Changing pumps
   - Calibrations
   - Outside inspections
   - Safeguards

Appendix 2 – Personal Protective Equipment

Personal protective equipment (PPE) is an important consideration at every workplace. PPE should always be considered as a last resort, or as additional safeguarding against a hazard, because if the protection fails at this stage, there will be nothing protecting the workers. Dependant upon the type of workplace you work in, you may need different types of PPE. Also, the type of PPE required depends on the material you are using. If PPE isn't properly fitted to the task or to the worker, it can create additional hazards by getting caught in moving parts of equipment, or causing the worker to have less control over the product.

Part 16 of the Workplace Safety and Health Regulation lists the requirements when PPE is required. This part requires employers to develop and implement safe work practices and procedures when it comes to PPE that is required in the workplace. PPE must be provided to the worker at no cost, except in the case of protective footwear (unless the worker's feet may be exposed to hot, corrosive, or toxic substances) and protective headwear on a construction site. PPE must be stored in a clean area that the worker can access when required, repaired or replaced if it is defective, and replaced when contaminated by a hazardous substance. Workers must be fitted for and trained in how to wear the PPE to ensure that it is effective. If there is a requirement for PPE to meet a certain standard (CSA or ANSI for example), the employer must ensure that the PPE meets that standard.

Common types of protection workers wear when working with machines include:

1. Vests/Aprons

Vests or aprons are sometimes used to prevent a worker from being exposed to hazardous liquids or materials that can "splash" onto them. Vests or aprons can also be used to prevent a worker from being injured by projectile parts or materials. In this case, the material in the vest or apron acts as a cushion so that if material is ejected from the machine and hits the operator, the vest or apron absorbs the energy and the operator is not injured.

2. Eye and Face Protection

Eye and face protection is commonly used in areas where machines and equipment are used. Eye or face protection must be worn wherever there is a chance of injury to a worker's eyes or face from:

- Flying objects or particles
- Splashing liquids or molten metals
- Ultraviolet, visible, or infrared radiation
- Any other material, substance, or matter

3. Hearing Protection

In most workplaces where machines are used, hearing conservation programs must be implemented. Where noise levels exceed 85dBA, sound control measures should be implemented to try and reduce the noise level to below 85dBA. Where that is not practical, the employer must implement a mandatory hearing protection policy. Hearing protection can be in the form of ear muffs or ear plugs, and must reduce the worker's exposure to below 85dBA.

4. Foot Protection

A worker is responsible for providing their own protective footwear to protect against the risk of foot injury at work. The employer is responsible for determining what hazards a worker might be exposed to, and then informing the worker. For example, falling objects, rolling objects, vehicular traffic. In the situation where a worker's feet are exposed to hot, corrosive, or toxic substances, the onus is on the employer to provide the appropriate foot protection to protect the worker.

5. Respiratory Protection

In some workplaces, respiratory protection for workers will be required because of the airborne contaminants present in the workplace or the specific job or task the worker is engaged in. Where the airborne contaminants cannot be controlled by ventilation or other engineered controls, respiratory protection is required. In these situations, the employer must ensure the respiratory protection is appropriate to protect the worker against the contaminant they are exposed to. Also, the employer must ensure that the worker is fit-tested for the respirator to ensure that it is effective in protecting the worker. All respiratory protection must be kept in an area that is sanitary and convenient for the worker to access.

Appendix 3 – Machine Risk Assessment Survey

The main purpose of a risk assessment is to decide which machine should be given priority, and which parts of the machine should be safeguarded first.

Machine Risk Assessment Survey				
Company Name	**Date of Survey**	**Survey done by:** 1. 2. 3.		
Machine Name	**Machine Function**			
Identify and describe *every* hazardous machine motion or harmful condition to which the worker's body parts are exposed (e.g., rotating shafts, in-running nip points, shearing parts, reciprocating parts, punching action, impact hazards, flying debris, abrasive surfaces, electrical hazards, hot/toxic fluids, vapours, emissions, radiation). Be as descriptive and detailed as possible.	**Describe the worst injury that would reasonably occur due to each hazard.** Use the following descriptions as a guide: • **Fatal** • **Major** (normally irreversible: permanent spinal damage, loss of sight, amputation/crushing, respiratory damage) • **Serious** (normally reversible: loss of consciousness, burns, fractures) • **Minor** (bruising, cuts, light abrasions)	**Estimated severity of injury:** Minor = 1 Serious = 5 Major = 7 Fatal = 10	**Estimated likelihood of injury** (see Note 1): Unlikely = 1 Possible = 5 Probable = 7 Certain = 10	**Estimated level of risk** (see Note 2): Estimated severity × estimated likelihood
1.				
2.				
3.				
4.				

Note: Gathering this information may require repeated observations, especially when determining what the worker does when normal production flow is interrupted.

Recommended safeguarding to eliminate or reduce the risk to an acceptable level (see Note 3)	
1.	3.
2.	4.

Note 1. The following factors may be useful when estimating the likelihood of injury:

- Machine cycle speed
- Hand feeding with foot control
- Operator training and experience
- Boredom factor (repetition)
- History of jams and misfeeds resulting in frequent access to danger areas of the machine
- Previous injuries on this machine or machines of this type

Note 2. Use the estimated level of risk to set the priority for implementing safeguarding measures. The higher the estimated level of risk, the more urgent it is to implement safeguarding solutions.

Note 3. Always follow the hierarchy of safeguarding controls regardless of the perceived level of risk.

Appendix 4 – Safeguarding Checklist

Photocopy this checklist. Use it to analyze all of the moving machinery in your workplace.

MACHINE GUARDING CHECKLIST

Guarding Requirements

1. Do the guards prevent workers' hands, arms, and other body parts from making contact with dangerous moving parts?

   Yes ☐ No ☐

2. Are the guards firmly secured and not easily removable?

   Yes ☐ No ☐

3. Do the guards ensure that no objects will fall into the moving parts or explode out?

   Yes ☐ No ☐

4. Do the guards permit safe, comfortable, and relatively easy operation of the machine?

   Yes ☐ No ☐

5. Can the machine be oiled or greased without removing the guard?

   Yes ☐ No ☐

6. Does the machine automatically shut down when the guard is removed?

   Yes ☐ No ☐

7. Can the existing guards be improved?

   Yes ☐ No ☐

Mechanical Hazards

The point-of-operation:

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

   Yes ☐ No ☐

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

   Yes ☐ No ☐

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

   Yes ☐ No ☐

4. Could you suggest a more practical, effective guard?

   Yes ☐ No ☐

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

   Yes ☐ No ☐

Power transmission apparatus:

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

   Yes ☐ No ☐

2. Are there any exposed belts or chain drives?

   Yes ☐ No ☐

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

   Yes ☐ No ☐

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

   Yes ☐ No ☐

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

   Yes ☐ No ☐

Other moving parts:

1. Are guards provided for all hazardous moving parts of the machine, including auxiliary parts?

   Yes ☐ No ☐

Education and Training

1. Do operators and skilled trades workers have the necessary education and training in how to use the guards?

   Yes ☐ No ☐

2. Does the education include examples of workers in your workplace or elsewhere who might have lost their life or their limbs from lack of machine guarding?

   Yes ☐ No ☐

3. Have production workers and skilled trades workers been trained in where the guards are located, how they provide protection, and what hazards they protect against?

   Yes ☐ No ☐

4. Have production workers and skilled trades workers been trained in how and under what circumstances guards can be removed?

   Yes ☐ No ☐

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

   Yes ☐ No ☐

6. Do skilled trades workers have the necessary education and training in how to build the safety aspects of guards?

   Yes ☐ No ☐

Protective Equipment and Proper Clothing

1. Is protective equipment required?

   Yes ☐ No ☐

2. If protective equipment is required, is it appropriate for the job, in good condition, kept clean and sanitary, and stored carefully when not in use?

   Yes ☐ No ☐

3. Is the operator dressed safely for the job (no loose fitting clothing or jewelry)?

   Yes ☐ No ☐

Machinery Maintenance and Repair

1. Have skilled trades workers received up-to-date instructions on the machines they service?

   Yes ☐ No ☐

2. Do skilled trades workers lock out the machine from all of its energy sources before beginning repairs?

   Yes ☐ No ☐

3. Is the maintenance equipment itself properly guarded?

   Yes ☐ No ☐

Source: CAW Health and Safety Department, "Blowin' in the Wind – Machine Guarding Prevents Death" (used with permission).

Appendix 5 – Standards Referred to in the Safeguarding of Machinery and Equipment Guideline

The Workplace Safety and Health Regulation (MR217/2006) requires that health and safety requirements of specific standards be followed. Many other machine safety standards have been developed by organizations and industry associations. Although such standards are not referred to in the Workplace Safety and Health Regulation (MR217/2006), they provide specific guidance for safeguarding nearly any type of manufacturing equipment or inductrial process. Below you will find listed some of the standards referred to in the Workplace Safety and Health Regualtion (MR217/2006) as well as the other standards that refer to safety and health requirements for specific equipment or processes.

Type of equipment	Standards referred to in the OHSR
Abrasive equipment	*ANSI Standard B7.1, The Use, Care and Protection of Abrasive Wheels*
Automotive lifts and supports	*ANSI Standard ANSI/ALI B153.1, American National Standard for Automotive Lifts – Safety Requirements for the Construction, Care, and Use* *ANSI Standard ASME PALD, Portable Automotive Lifting Devices*
Chain saws	*CSA Standard Z62.1, Chain Saws*
Conveyors (all types)	*ANSI Standard ANSI/ASME B20.1, Safety Standards for Conveyors and Related Equipment*
General machinery safeguarding	*CSA Standard Z432, Safeguarding of Machinery*
Industrial robots	*CSA Standard Z434, Industrial Robots and Robot Systems – General Safety Requirements* *ANSI Standard ANSI/RIA R15.06, American National Standard Industrial Robots and Robot Systems – Safety Requirements*
Iron workers	*ANSI Standard B11.5, American National Standard for Machine Tools – Iron Workers – Safety Requirements for Construction, Care and Use*
Marking physical hazards	*CGSB Standard CAN/CGSB-24.3, Identification of Piping Systems* *CSA Standard CAN/CSA-Z321, Signs and Symbols for the Workplace* *ANSI Standard Z535.1, Safety Color Code* *ANSI Standard Z535.2, Environmental and Facility Safety Signs* *ISO Standard 3864, Safety Colours and Safety Signs*
Power-actuated tools	*ANSI Standard A10.3, American National Standard for Construction and Demolition Operations – Safety Requirements for Power-Actuated Fastening Systems*
Power presses and brake presses	*CSA Standard Z142, Code for Punch and Brake Press Operation: Health, Safety and Guarding Requirements*
Sheet metal and plate shears	*ANSI Standard B11.4, American National Standard for Machine Tools – Shears – Safety Requirements for Construction, Care and Use*
Welding	*CSA Standard W117.2, Safety in Welding, Cutting, and Allied Processes* *CSA Standard W178.1, Certification of Welding Inspections Organizations*

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