NSW GOVERNMENT

MACHINE SAFETY STARTS WITH YOU.

GUIDE TO MACHINE SAFETY

SAFEWORK NSW

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1. INTRODUCTION

There are many kinds of machines used in NSW workplaces the *Work Health and Safety Act (2011)* has requirements for Person Conducting Business or Undertaking (PCBU) to manage risks associated with the use of plant.

The Guide to Machine Safety provides information to help you to manage risks with using machinery (plant) in your workplace.

The guide uses a range of examples and will help you to:

- identify the hazards;
- understand how you can reduce or remove risks using various controls; and
- check responsibilities with new and old machines.

It is important to have a workplace culture of safety where people can speak up about safety in the workplace, report and monitor near misses.

Icons used in this guide represent the following:


Do this


Stop


Calculate or measure


Allow time


Caution


Check


Stop doing / Don't do


Information

2. IDENTIFY COMMON HAZARDS AND MACHINE PARTS THAT NEED SAFEGUARDING

Safeguarding machinery must prevent an operator's or a passer-by's access to danger areas or prevent the risk of machine (plant) parts being ejected.

Typical hazards or the dangerous parts of machines, include:

- In running rollers that 'draw you in'
- Shear points
- Flying ejected parts
- Moving parts that can bump and knock
- Hot and cold surfaces

The risk:

- Impact and crushing
- Cutting
- Entanglement
- Stabbing
- Abrasion

Machine parts that are hazardous which require safeguarding include:

- Belts and pulleys
- Gear wheels
- Shafts and spindles
- Flywheels
- Slides and cams
- The tools and dies of power presses
- Blades of guillotines
- Milling cutters
- Circular saws
- Drills and chucks

3. REMOVE THE HAZARD AND/OR CONTROL THE RISK (SAFEGUARD CONTROLS)

The most effective way to manage the risk is to **remove the hazards**.

For example, an in-running nip can sometimes be eliminated by moving the rollers further apart or by running one roller in the opposite direction.

Where eliminating the hazard is not possible, the risks must be controlled or safeguarded, so far as is reasonably practicable.

Bypassing or disabling of the guarding, whether deliberately or by accident, must be made as difficult as is reasonably practicable. Guards must be kept in an effective state that prevents access to the dangerous parts of the machine.

Four main ways to safeguard machines are:

- **barriers** that physically prevent access to the hazard or the hazard reaching a person;
- **presence sensing devices** which removes the hazard, for example, by the stopping when a person is accessing the hazardous area;
- **designing machine operator controls** that prevent the operator reaching the hazardous area; and
- **administrative controls** if other types of controls are not practicable.

In most cases, a combination of controls is used to control the risks.

3.1 BARRIERS

3.1.1 Permanent guard (inherently guarded)

Permanent guards are integrated into the design and cannot be removed.

For example, a metal sheet welded onto the machine to form a barrier or the housing between the motor and the gear box. The motor shaft would not be accessible when assembled.

Figure 1: Motor Shaft

Motor shaft is exposed

Motor shaft is not accessible when assembled

3.1.2 Fixed and interlocked guards

Often, using permanent guards is not practicable as the hazardous areas need to be accessed for various reasons, including cleaning, setting up and maintenance.

If frequent access to the danger area is necessary during operation and isolation of the energy is not practicable, interlocked physical guards should be fitted. The machine will not operate until the guard is fully closed. They can be electrical, mechanical, pneumatic or hydraulic.

If frequent access is not required, **fixed guards** may be fitted.

Fixed guards should not be able to be removed without using tools. Tools used to remove the guard should only be available to workers who are authorised to remove the guard or maintain the machine.

Moving parts of some machines continue to run even after the power is removed. The guards of these machines should remain locked, after the action is taken to deactivate the dangerous function until the moving parts comes to a standstill.

Generally, danger areas should not be accessed without isolating the power to the machine and removing the stored energy (from gravity, compressed air or accumulators).

Sometimes the machine should be run to undertake cleaning, setting up or fault tracing. To do these activities, these machines should be able to run at a slower speed and operate only by pulsing or using a hold-to-run control. The interlocking system could automatically switch the machine into safer mode when the guard is opened.

A key operated service switch to change the running mode may be appropriate in some situations.

If you find a fixed guard has been removed or interlock has been defeated, investigate the reason for not fitting it back or defeating the system. In most cases these arise from the need to frequently access the area to rectify a problem. Based on the findings, implement a long-term solution to the problem or install an interlocked guard where appropriate.

Make regular checks of the functions of the interlock system.

Reliability

The level of reliability of presence sensing or interlocking system (safety integrity level or the performance level) should be in line with the level of the severity of the possible injury.

3.1.3. Tunnel guards

Tunnel guards are used typically when material being processed needs to flow through the machine. The guard should be long enough to prevent a person reaching the danger point. This concept is similar to the approach distances in the section on reach.

3.1.4 Fences and protection by distance

Distance fences or perimeter fences or other means which can prevent persons accessing the danger zones can be used. Reach distances are shown further below in the guide.

Figure 2 – Examples of fences

Distance guard where a worker cannot reach over the guard and reach the rotating item

A perimeter fence for an area where the movement of items is due to automatic activation

3.1.5 Adjustable guards

Adjustable guards are used when the entire danger areas could be isolated, for example, an opening is required to feed the work piece, into a band saw or a table saw.

The guard should be adjusted for the minimum possible gap for each job being processed.

Figure 3 – Examples with and without guard

Table saw **without** the top guard

Adjustable top guard with integrated dust extractor

3.1.6 Self-closing guards

Self-closing guards open: The cutting edge of a drop saw or circular saw only opens to the extent necessary to cut the workpiece.

Figure 4– Examples of drop saws with and without guard

Drop saw **without** a self-closing guard

Drop saw with a self-closing guard

3.1.7 Combination guarding

Sometimes a combination of control measures is the most effective way of providing the necessary protection. This could be a combination of fixed guarding, presence-sensing, distance fencing or perimeter fencing.

3.1.8 Design considerations of guards

Materials	Guards may be made from imperforated sheets, particularly if parts to be guarded do not need to be ventilated or seen. Where visibility or ventilation is necessary, rods, bars, mesh or transparent material can be used. Rods and bars should be fitted parallel to the direction of movement of the parts to be observed by the operator. The guard must be of solid construction and securely mounted so, as to resist impact or shock and avoid using light brittle material. Where there is a risk of flying or ejected parts, the strength of the material should be sufficient to contain the parts.
Opening size	If mesh, rods or perforated sheets are used, workers should not be able reach the danger point through the openings. Make sure the size of openings and clearances take ergonomic factors into account. While the reach distances in this guide will help you do this, the main aim is to prevent a person reaching the danger point. For example, the danger point should be more than the length of the arm away from the mesh if the arm could be inserted through the openings.
Access	Make sure that guards allow maintenance workers to safely get access to the machine. Guards should be designed so that routine maintenance procedures (such as lubrication) can be carried out without removing the guards.
No new hazards	Make sure that new guards do not create a new hazard. For example, fixed guards should not have sharp or jagged edges.
Not harder to operate	Make sure that guards allow the operator to carry out normal duties comfortably. A guard that makes the machine more difficult to operate is usually removed or disabled.

3.2 PRESENCE SENSING DEVICES

When permanent or fixed guards are not practicable, interlocked presence sensing devices may be used.

Presence sensing devices detect a person or a body part approaching the danger zone and stops the dangerous operation of the machine.

Presence sensing devices and their associated safety systems take time to bring the danger area to a safe state. When using presence sensing devices, place the sensors far enough away from the danger zone (approach distance), to allow time for the system to respond.

Presence sensing devices include pressure sensing mats, light screens and configurable scanners.

Check the functions of the presence-sensing safeguarding system on a regular basis.

3.3 TWO HAND OPERATIONS

Where the use of guards or presence sensing devices is not practicable to isolate all danger areas, two hand operation may be implemented to prevent the hands of the operator reaching the danger area. Both operator controls should be activated at the same time, typically within half a second (0.5 sec).

Figure 5 – Example of control switches for two handed operations

Green switches need two hands to operate

Two hand operation can protect only the operator; other workers could approach the danger zones and be at risk. The risks to other persons should be controlled by other control measures, procedures and supervision.

3.4 ADMINISTRATIVE CONTROLS

Administrative controls are the least preferred way of managing risks as human behaviour is not reliable. These controls involve procedures, training and supervision and includes setting up adjustable guards.

4. HOW TO KEEP A SAFE DISTANCE FROM MACHINES (DANGER ZONES)

Overhead danger areas may not be guarded if they cannot be reached. These areas are usually higher than 2700 mm (2.7 metres).

Guidance on reach distances beyond a fence that is shorter than a person is not straight forward. A fence up to the height of a hip allows a person to bend and reach longer horizontal distances than when leaning against a taller fence.

See the data in this guide on reach distances for fixed guards if a person is reaching up, down/around, in, through and around a barrier. The aim is to prevent people reaching the danger parts.

The illustrations and tables will help you assess where and what sort of fixed guarding you need to keep a danger point on a machine safely out of reach.

4.1. REACHING UP

If a person can reach 2700 mm, they are at a higher risk of overhead danger.

Figure 6 – Reaching up

The reach upwards from a standing position with the body stretched is taken to be;

Reaching overhead protective structures,

Low Risk 2500 mm

High Risk 2700 mm

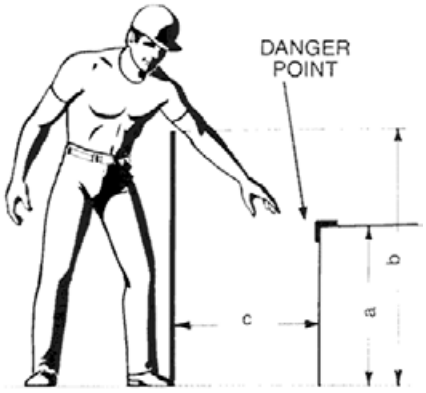
Note: for further information refer to AS4042.1801:2042

4.2. REACHING DOWN AND OVER

Barriers should be high enough and far away enough to keep people safe.

See table 1 to assess how high to make a barrier. For example: if the danger point is 1600 mm above the floor (a – 1600) and 500 mm from where the barrier is (c = 500), then the barrier should be 2000 mm high (b = 2000).

Figure 7 – Reaching down and over



In table 1:

a = the distance of the danger points from the floor or working surface.

b = the height of the barrier.

c = the horizontal distance from the edge of the barrier to the danger points.

Table 1 – How high to make a barrier

Note: Barrier heights of 1200 & 1000 mm may not be suitable in applications where the barrier could be stepped over.

Height of hazard Zone 'a' mm	Height of edge of barrier 'b'									
	1000	1200	1400	1600	1800	2000	2200	2400	2500	2700
	Horizontal distance 'c' from danger point in mm									
2700	0	0	0	0	0	0	0	0	0	0
2600	900	800	700	600	600	500	400	300	100	0
2 400	1100	1000	900	800	700	600	400	300	100	0
2 200	1300	1200	1000	900	800	600	400	300	0	0
2000	1400	1300	1100	900	800	600	400	0	0	
1800	1500	1400	1100	900	800	600	0	0		
1600	1500	1400	1100	900	800	500	0	0		
1400	1500	1400	1100	900	800	0	0			
1200	1500	1400	1100	900	700	0	0			
1000	1500	1400	1000	800	0	0				
800	1500	1300	900	600	0	0				
600	1400	1300	800	0	0	0				
400	1400	1200	400	0	0					
200	1200	900	0	0	0					
0	100	500	0	0						

Note: This table is from the Australian Standard AS4042.1801:2014. For further information refer to this standard.

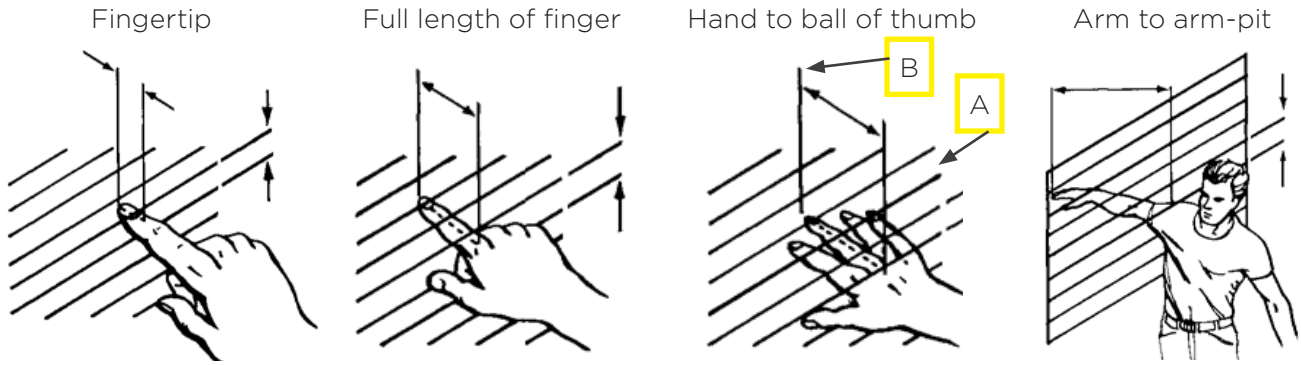
4.3 REACHING IN AND THROUGH

These illustrations below show how to determine the safe distance allowances necessary to prevent someone gaining access to a danger point either by reaching through a grille, or by reaching through square or circular apertures.

If you can touch the danger point through the grille or aperture then the aperture "a" need to be reduced to ensure the reduction in the measurement "b".

4.3.1 reaching in and through a grille

Figure 8 – Reaching in and through a grille

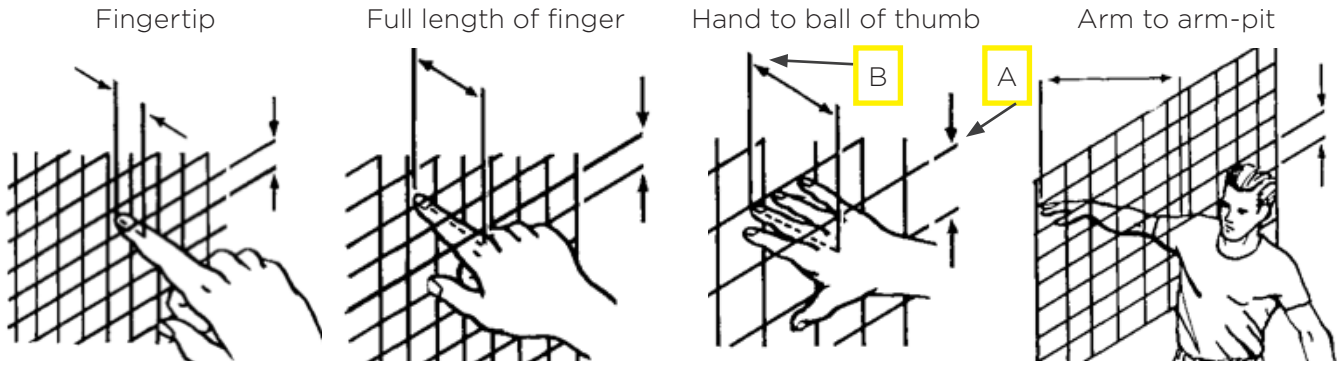


A = the vertical width of the space between the grilles (in mm).

B = the horizontal safety distance from the danger point (in mm).

4.3.2 Reaching in and through square or circular apertures

Figure 9 – Reaching in and through a square or circular aperture



A = the vertical width of the space between the grilles (in mm).

B = the horizontal safety distance from the danger point (in mm).

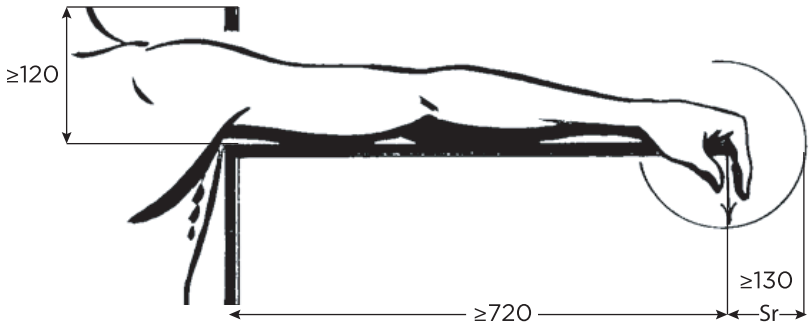
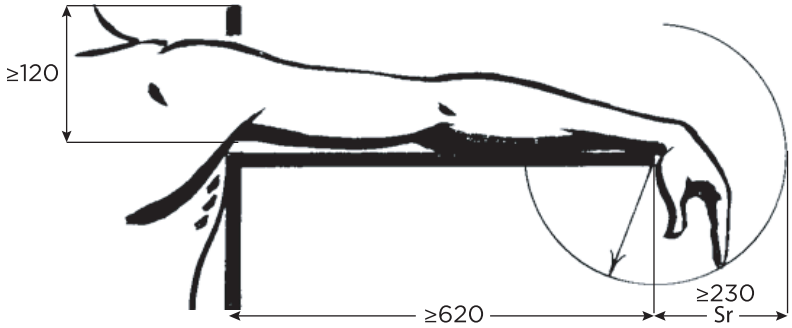
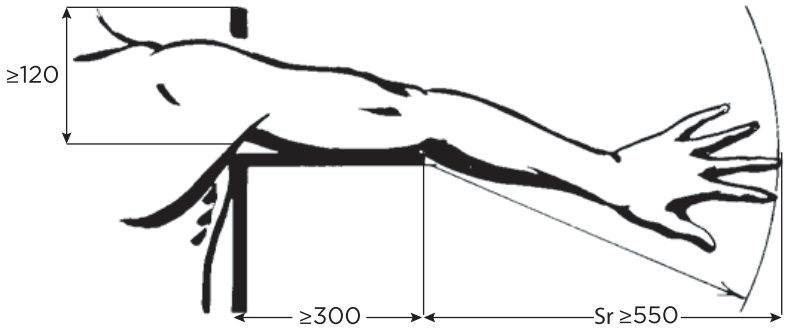
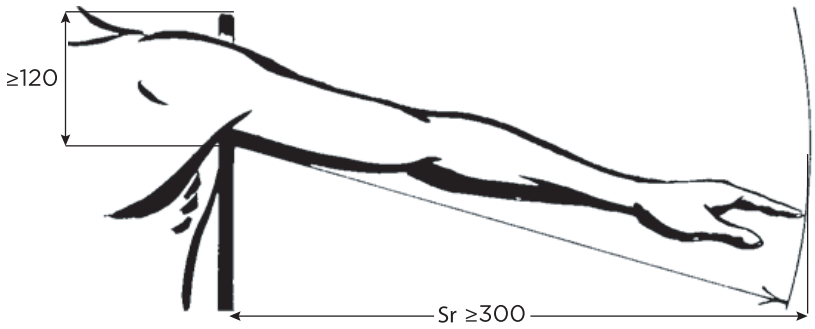
Please note: Further information to assist and clarify figures 8 & 9 can be obtained from the Australian Standard - AS/NZS 4024.1801:2014 – Safety of machinery – Part 1801: Safety distances to prevent danger zones being reached by upper and lower limbs.

4.3.3 Reaching around

In Figure 10 the minimum safe distance allowance for the reach of an arm and hand in any position is given.

This is based on the assumption that the arm cannot move closer to the danger point.

Figure 10: Safe distances to prevent reaching around a barrier

Limitation of movement	Illustration showing the Safety distance (sr)
Arm and hand supported up to knuckle joint	
Arm supported up to wrist	
Arm supported up to elbow	
Armpit to finger tip	

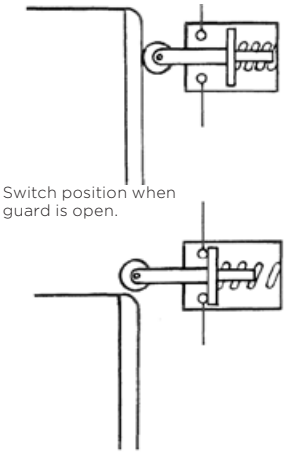
Please note: Further information to assist and clarify figures can be obtained from the Australian Standard - AS/NZS 4024.1801:2014 – Safety of machinery – Part 1801: Safety distances to prevent danger zones being reached by upper and lower limbs.

5. EXAMPLES OF GUARDS AND BARRIERS

5.1 **EXAMPLE 1** - ELECTRICAL INTERLOCK

The figure below shows how this particular type of electrical interlock guard operates. The top switch in the figure shows the switch in the open position whereby the machine can't operate. The bottom switch in the figure shows the switch in the closed position allowing the machine to operate.

Figure 11: One switch system



Interlocked guards are connected to the operation of a machine so that:

- The machine will not operate until the guard is closed.
- The guard will not close until any body part is removed from the danger zone.
- Either the guard remains locked until all dangerous movements have ceased, or opening the guard disengages the machine drive and stops all movement.

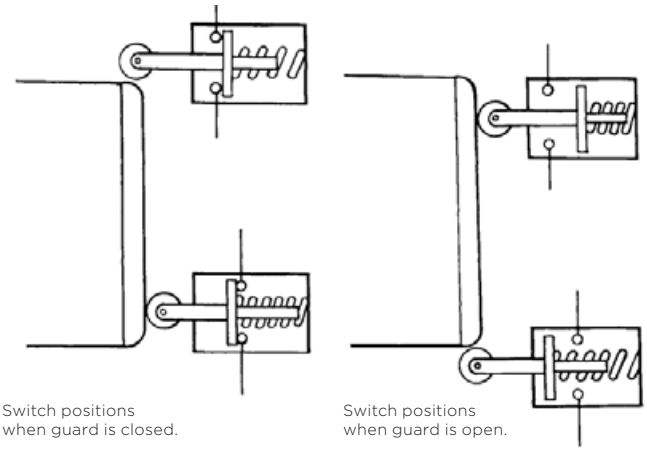
Electrical interlocked guards

Electrical interlocked position switches should be designed to fail to a safe state. The machine remains in this state until the fault detected by the system has been corrected.

How does it work?

In figure 11 the linear cam depresses the stem when the guard is open, removing the power source from the moving machine parts. This is an example of a fail to safe guard. However, there is still a possibility that the switch in figure 11 could fail if not properly maintained.

Figure 12 – Two switch system



Making it safer

Figure 12 shows how to further reduce the possibility of failure of the safety system by using more than one switch. Keep in mind though that in a two-switch system the failure of one switch will not be noticed unless the circuits in which the correct functioning of the switches that are used are monitored.

5.2 **EXAMPLE 2** – MECHANICAL INTERLOCK

How does it work?

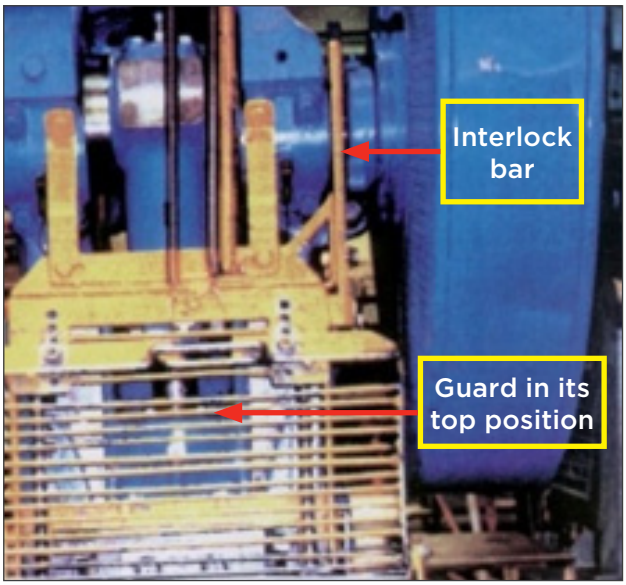


Photo A – shows the mechanical interlock bar that prevents the clutch plate from engaging, which in turn prevents the machine operating.

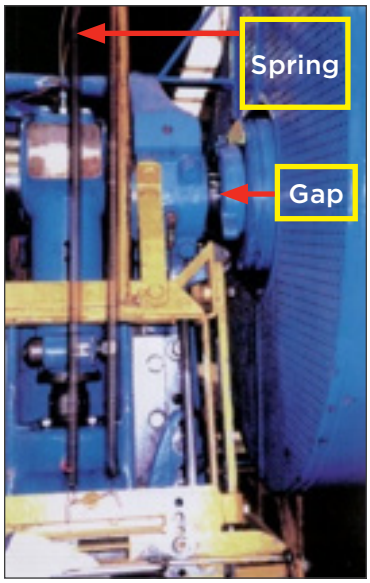


Photo B – shows the gap that has been created when the guard is closed and the interlock created a gap. This allows the clutch to move to the left to engage and the machine to operate.

Photo A shows the mechanical interlock bar (yellow bar) of a power press. The bar is connected to the front movable guard below which moves up and down with the bar. The spring shown in photo B raises the guard when released preventing stroking (press cycle).

To operate the press, the guard is lowered which in turn lowers the interlock bar as shown in photo B. The pedal is pressed to operate the press though one cycle. This allows the clutch to engage the stroke by sliding across the gap where the interlock bar was allowing the press to stroke.

Raising the guard to remove the workpiece will automatically re-insert the mechanical interlock bar into the gap preventing further stroking.

5.3 **EXAMPLE 3** - PRESENCE-SENSING SYSTEM

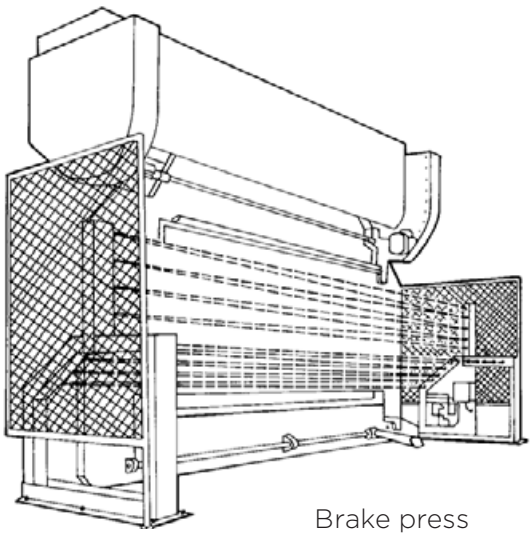
How does it work?

Presence-sensing systems, which include light curtains, safety mats and laser scanners, are connected to the control system of the machine so that it will not operate if the beam of light is broken (e.g. by the operator's hand reaching into the danger zone).

The response time of the presence-sensing system should be shorter than the time a body part takes to reach the hazard from the sensing zone.

Brake press as shown on right, shows presence-sensing system in the operator area of a press brake and fixed guards on the sides.

There should also be rear guarding in place.



Brake press

5.4 **EXAMPLE 4** - PARTIAL GUARDING

In some cases, it may not be possible to fully guard a machine. In such cases, the machine should be guarded as completely as is possible. In the illustration below, a table saw is guarded as much as possible.

Table saw

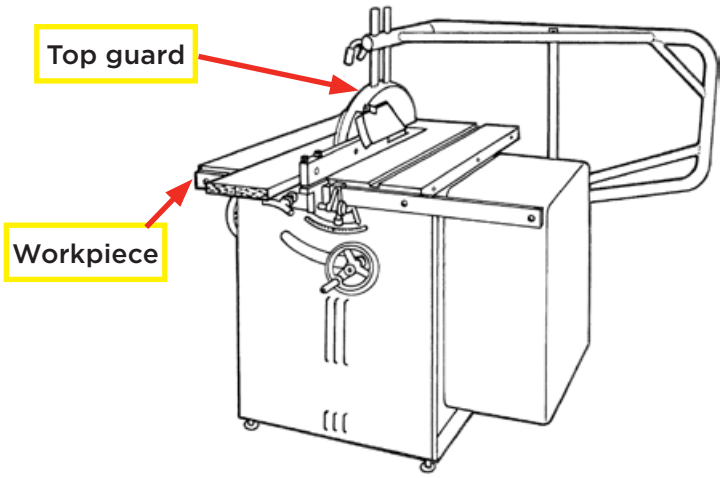


Table saws as shown above presents many hazards. These include nip points on belt drives, over heating the electric motor when covered with saw dust, cuts from the cutting blade, inhaling saw dust and noise particularly when the material is cut.

This is an example where a combination of control measures is used to manage different hazards associated with one machine. Table 2 below shows some examples of the hazards and possible control measures.

Table 2 – Hazards and possible control measures of table saws

Hazard	Control measure
Nip points on the belt drive	Install fixed guards
Overheating dust covered motor	Clean the motor area regularly
Fixed guards are difficult to remove and takes time to remove and replace. These difficulties may discourage the operator from cleaning	Interlock the access door to the belt drive
Need to get into an awkward posture to reach the motor to clean	Use a brush with a long handle
Using the brush makes the operator maintain an awkward posture for a long time	Use a vacuum cleaner
Saw dust reaching the breathing zone of the operator and other around the saw	Fit a mechanical dust extractor
	Extractor may reduce the amount of dust settling in the area thereby reducing the intervals of cleaning of the motor area
Saw dust settling on walls and roof which can cause dust explosion	Fit a mechanical extractor that can collect the dust
Operator can reach the cutting edge of the blade from the top	Fit an adjustable guard. Train and supervise the operator
Operator's hand gets closer to the blade when cutting the operator end of the workpiece	Provide a push stick, train and supervise the operator
	Provide a location on the machine for the push stick
Blade shatters when the push stick hits the blade	Use a push stick made from soft material such as plastic or timber
Workpiece kicking back	Install a riving knife slightly wider than the width of the blade, behind the blade
	Operator to stand away from line of workpiece feeding
Noise generated when cutting	Wear hearing protection

6. BUYING AND SELLING MACHINES

The Manufacturer or Importer or Supplier as a PCBU have specific legal obligations in the WHS Act where it requires that a Manufacturer of Importer or Supplier must ensure, so far as is reasonably practicable, that plant is without risk to health and safety of persons who at the workplace use the plant for the purpose it was designed or manufactured.

For further information see the following sections of the WHS Act (2011); s.23 for Manufacturers, s.24 for Importers and s.25 for Suppliers.

6.1 BUYING A NEW MACHINE

Buy new machines that have proper guards. Check for risks and control them after you have installed the machine, and before you start using it for production.

Guards 'designed into' equipment are usually more effective than guards fitted after the machine has been installed.

6.2 BUYING AN OLD MACHINE

When buying an old or second-hand machine, ensure the supplier provides appropriate guarding for the machine as required by the legislation. Check this before installing and/or commissioning the machine.

After the machine is installed and before using the machine you should assess the machine to identify any further hazards. If you identify any hazards, implement control measures for the risks from those hazards before placing the machine into production.

6.3 SELLING OLD MACHINES

If you sell an old machine to another PCBU, you can be deemed a supplier unless you sell it for scrap.

As previously stated s.25 Supplier in the WHS Act the PCBU must ensure, so far as is reasonably practicable, that plant is without risk to health and safety of persons who at the workplace use the plant for the purpose it was designed or manufactured. Clause 199 and 200 of the WHS Regulation 2017 prescribe the specific requirements.

For further information on the meaning of "supply" refer to Section 6 of the *Work Health and Safety Act (2011).*

7. OTHER CONTROL MEASURES

As well as fixed guards, interlocked guards, presence-sensing safeguarding system, two-handed push button controls and partial guarding, more examples of controls are:

- Distance guard
- Trapped key
- Specific types of controls for in-running rollers

Other issues

These are not guarding issues but, should be considered and controlled when machines are installed and used:

- Noise
- Hazardous chemicals
- Airborne contaminants
- Falls
- Electrical
- Lighting
- Hazardous manual tasks
- Hazardous atmospheres
- Falling objects

7.1 SAFETY PROCEDURES

Consult supervisors and operators when preparing any safety procedures for machines and tasks.

7.2 TRAINING

PCBU's must train their workers /operators about the hazards of machines they operate and about safe working procedures. Training is particularly important if it is only possible to partially guard a machine.

7.3 ADMINISTRATIVE MEASURES

The PCBU should, on a regular basis, inspect guarding, maintain guards and maintain machinery in a safe and effective condition.

7.4 PERSONAL PROTECTIVE EQUIPMENT

If the guarding system does not completely control the hazard then protective equipment, such as eye protection, must be provided.

Make sure that:

- It complies with Australian Standards and has the "Standards Australia" symbol on it
- It fits comfortably and gives adequate protection
- Provide training in how to use it correctly
- It is properly maintained
- It is used properly.

Operators should avoid wearing gloves when working with machinery with moving parts (such as lathes) as the gloves may get caught in the machine or make it more difficult to operate controls.

7.5 MAINTENANCE WORK PROCEDURES

Isolation procedures must be used when maintenance workers enter the danger zone to carry out repair work.

Before they enter the danger zone each maintenance worker must 'lock out' or 'tag out' the machine to prevent it being accidentally switched ON while anyone is working on it. This includes electrics, hydraulics and pneumatics.

8. THE LAW

The Work Health and Safety Act (WHS Act & Regulation) has requirements for Person Conducting Business or Undertaking (PCBU) to manage risks associated with the use of plant.

The *Work Health and Safety Act 2011* states that:

- worker and others are not placed at risk while at work,
- the provision and maintenance of safe plant,
- the provision and maintenance of safe system of work,
- the safe use, handling and storage of plant,
- the provision of adequate facilities,
- the provision of any information, training, instruction or supervision,
- the health of workers and the conditions at the workplace are monitored.

The Work Health and Safety Regulation 2017 clauses of note:

- c.203 Management of risks to health and safety,
- c.205 Preventing unauthorised alterations to or interference with plant,
- c.206 Proper use of plant,
- c.207 Plant not in use,
- c.208 Guarding,
- c.210 Operational controls,
- c.211 Emergency stops,
- c.212 Warning devices,
- c.213 Maintenance and inspection of plant,
- c.222 Industrial Robots,
- c.223 Lasers,
- c.226 Plant with presence-sensing safeguarding system – records must be kept for 5 years.

9. CONTACTS AND RESOURCES

For further information contact SafeWork NSW on 13 10 50 or visit www.safework.nsw.gov.au

RESOURCES

SafeWork NSW's *Code of Practice - Managing the risk of plant in the workplace (WC03838) July 2014* in particular, clauses;

- 4.1 Guarding of plant
- 4.2 Operator controls
- 4.3 Emergency stops
- 4.4 Warning devices
- 4.5 Isolation procedures

AS/NZS.4024.1201:2014 Safety of machinery: General principles - Basic terminology and methodology

AS/NZS.4024.1401:2014 Safety of machinery: Ergonomic principles - Design principles - Terminology and general principles

AS.4024.1501:2006 (R2014) Safety of machinery: Design of safety related parts of control systems - General principles

- 6.2 Stop function
- 6.3 Emergency stop function
- 6.4 Manual reset
- 6.5 Start and restart
- 6.6 Response time
- 6.7 Safety-related parameters
- 6.8 Local control functions
- 6.9 Muting
- 6.10 Manual suspension of safety function
- 6.11 Fluctuation, loss and restoration of power source
- 7 Categories
- 11 Maintenance

AS/NZS.4024.1601:2014 Safety of machinery: Design of controls, interlocks and guarding - Guards - General requirements for the design and construction of fixed and movable guards

- Fixed movable and interlock guards

RESOURCES

AS/NZS.4024.1602:2014 Safety of machinery: Interlocking devices associated with guards - Principles for design and selection.

- Appendix 'B' – Trapped-key interlocking device

*AS/NZS.4024.1604:2014 Safety of machinery: Design of controls, interlocks and guarding - **Emergency stop** - Principles for design*

*AS/NZS 4024.1801:2014 – Safety of machinery – Part 1801: Safety distances to prevent danger zones being **reached by upper and lower limbs***

*AS.4024.2601:2008 Safety of machinery - design of controls, interlocks and guarding - **two-hand control devices** - functional aspects and design principles*

AS.4024.2801:2008 Safety of machinery - safety distances and safety gaps - positioning of protective equipment with respect to the approach speed of parts of the human body

- 8.4 Two-hand control devices

AS.4024.4:1998 - Safeguarding of machinery - Installation and commissioning requirements for electro-sensitive systems - Pressure-sensitive devices.

NO MATTER WHAT YOU DO, SAFETY STARTS WITH YOU.

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