

# Safe Use of Machinery

**MAY 2014**



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**This guideline is aimed at employers, engineers, designers, manufacturers and distributors of machinery. WorkSafe New Zealand has also developed a set of factsheets for specific machinery. Though relevant to employers, these factsheets are mostly aimed at operators and employees.**

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# 01/

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## INTRODUCTION

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### IN THIS SECTION

- 1.1 Australian Standard AS 4024
- 1.2 Using the flowcharts in the guideline

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***The Best Practice Guidelines for the Safe Use of Machinery*** outlines the hazards that come with using machinery in the workplace, potential injuries and how best to control these hazards. It gives duty holders advice on how to use machinery safely and meet their duties under the Health and Safety in Employment Act 1992 (HSE Act) and the Health and Safety in Regulations 1995 (HSE Regulations). When using this guideline, consider the unique demands of your workplace and industry; there may be other hazards and risks not covered in this guideline.

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The HSE Act and HSE Regulations place responsibilities on many different persons, including machinery and plant designers, manufacturers, suppliers, installers and operators, employers and owners of machinery. These people are called 'duty holders'. Duty holders must take all practicable steps to make sure machinery in the workplace is designed safely and is adequately guarded to reduce the risk of injuries or harm.

Machinery can injure people by:

- > crushing
- > cutting
- > shearing
- > puncturing
- > abrading
- > burning
- > tearing
- > stretching.

Common injuries include:

- > amputation
- > crushing
- > electric shock

- > hearing loss
- > ill health from hazardous chemicals or lack of oxygen.

WorkSafe New Zealand has identified a number of trends where employers have been prosecuted for injuries and fatalities to staff and contractors through using machinery. These trends are:

- > no guarding on machines at all – letting operators reach into dangerous parts of the machine
- > guards not securely fastened and easily removed while the machine is in use
- > openings in the guards where the operator can easily reach through to dangerous parts
- > operators able to remove guards for maintenance and not replacing them
- > interlocked guards that can open while parts are still moving or running down
- > mechanisms from interlock switches can be removed to override the guards
- > single light beam safeguard devices can be switched off
- > closed limit switches which are not used, causing interlock switches to be overridden
- > interlock guards used as a shortcut to start the machine

- > ineffective lock-out and isolation of power systems
- > supporting systems failure, such as when pneumatic or hydraulic systems lose pressure and allow a ram to fall.

### **1.1 AUSTRALIAN STANDARD AS 4024**

Duty holders should use the Australian Standard AS 4024 *Safety of machinery series* as the standard that gives the current state of knowledge for the safeguarding of machinery and plant. It should be referred to by duty holders as the primary standard against which to benchmark. Employers, suppliers, manufacturers and designers can work to other standards, but they need to show that they can reach the same level of safety, or better, in the circumstances in which they are used.

Employers must make sure anyone they engage for advice on machine guarding and safety is a competent person and is experienced at working with and using AS 4024 or equivalent or higher standards.

Based on key information from AS 4024, this guideline advises employers and other duty holders on managing machinery hazards. This guideline is the key reference for what safety looks like when using machinery.

This guideline is part of a suite of guidance for the use of machinery. For further information refer to WorkSafe NZ's *Safe Use of Machinery* page at [www.worksafe.govt.nz](http://www.worksafe.govt.nz).

### **1.2 USING THE FLOWCHARTS IN THE GUIDELINE**

This guideline has a series of flowcharts that cover the key concepts around machinery safety. The flowcharts work through the processes for commissioning, manufacturing or purchasing machinery and how hazards can be eliminated at this point.

The design stage is the best time to control the hazards associated with machinery. Whether commissioning or designing a new machine, or changing an existing machine – this is the chance to get rid of significant hazards. WorkSafe NZ recommends eliminating hazards at the start of the commissioning or purchase process.

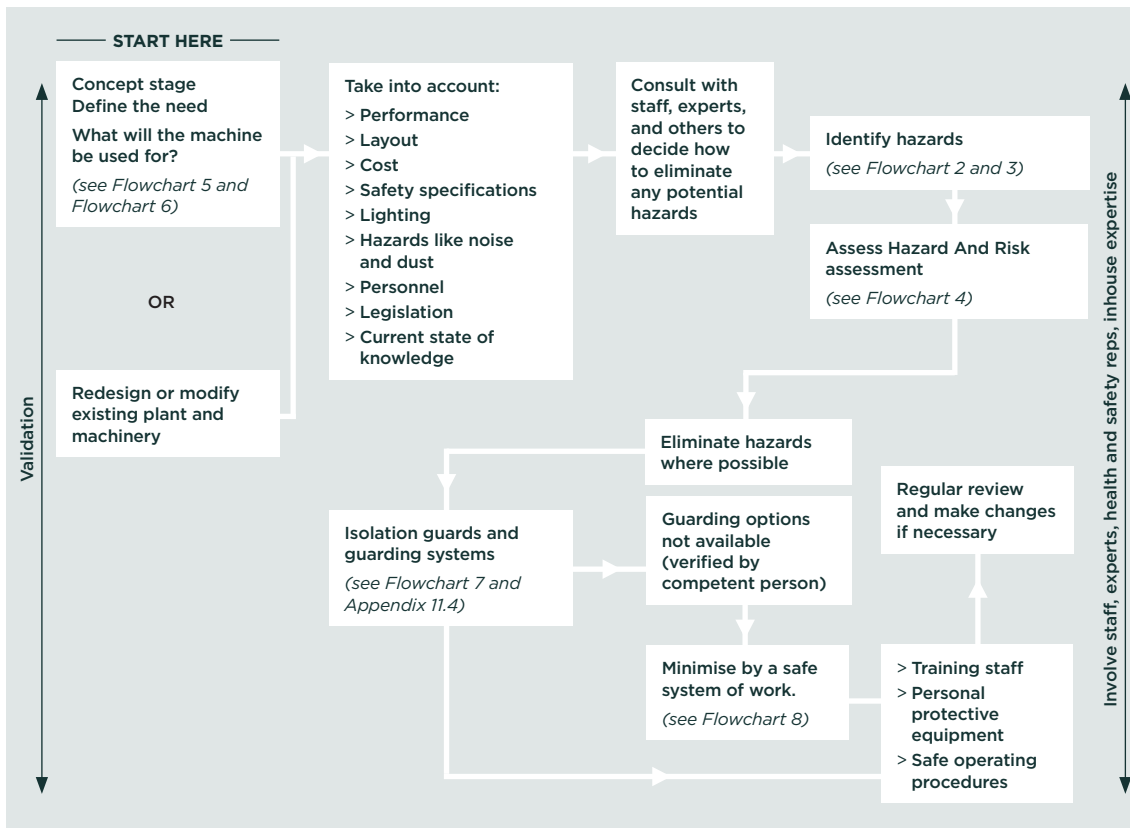
The flowcharts also cover identifying hazards, risk assessments, choosing appropriate guarding and how to develop a safe system of work. The aim is to create a safe working environment and safe systems of work for anyone working with or near machinery.

Use the individual flowcharts to scope the design or to modify of a piece of machinery. The key is identifying and assessing all hazards caused by the machine and its use, which then must be eliminated, isolated or minimised. If you cannot eliminate or isolate them, work through the hierarchy of guarding options (see section 5 of this guideline) before moving to minimising the hazard.

Minimisation includes:

- > using personal protective equipment
- > monitoring employee health and the environment
- > using safe operating procedures
- > training
- > using safe systems of work.

The flowcharts are collated together in section 11.6 and also appear in the appropriate section of this guideline.



**Flowchart 1:** Get it right from the start – overview of safe use of machinery guideline

## 1.2.1 SUMMARY OF FLOWCHARTS

### Flowchart 1: Get it right from the start

> This flowchart shows the overview of safe use of machinery process. It summarises the process and shows how each flowchart links with the others.

### Flowchart 2: Common machinery hazards

> A summary of the common machinery hazards.

### Flowchart 3: Identify operational hazards to use machinery safely

> The common operational hazards are identified in this flowchart.

### Flowchart 4: Assess hazard and risks – eliminate hazards where possible

> Flowchart 4 offers a method of assessing the risk each hazard poses so appropriate control measures can be developed.

### Flowchart 5: Building health and safety into the business case

> A thorough safety and hazard assessment at the concept stage can eliminate many hazards. This flowchart works through the basics of including health and safety into a business case.

### Flowchart 6: Validation of machine safety

> This flowchart works through the process of validation, making sure that all required steps of the safety life cycle are tested.

### Flowchart 7: Choosing a guard

> The flowchart gives the hierarchy of machine guarding using the standard AS 4024 *Safety of Machinery* series.

### Flowchart 8: Developing and maintaining a safe system of work for specific tasks

> This flowchart describes the minimum needed to put a safe system of work in place for a specific task or set of tasks.



# 02/

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## **RESPONSIBILITIES AND DUTIES FOR MACHINERY**

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### **IN THIS SECTION**

- 2.1 Design and manufacturing - get it right from the start**
- 2.2 Duties of manufacturers and suppliers of machinery**
- 2.3 Supplying machinery**
- 2.4 Choosing and buying**
- 2.5 Installing machinery**
- 2.6 Use of machinery - the employer**
- 2.7 Inspection and maintenance**
- 2.8 Modifying machinery**
- 2.9 Decommisioning machinery**
- 2.10 Use of machinery - the employee**

Designers, manufacturers, suppliers and employers all have responsibilities to ensure machinery is safe to use. Figure 1 shows who has health and safety responsibilities for each phase or aspect of the machine's life cycle.

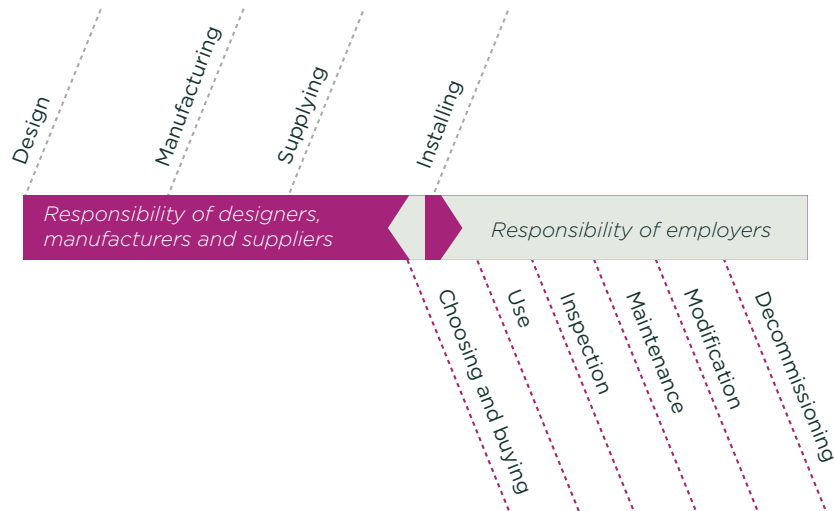


Figure 1: Division of health and safety responsibilities during a machine's life cycle

## 2.1 DESIGN AND MANUFACTURING - GET IT RIGHT FROM THE START

The best time to make machinery safe is at the design stage. Designers of machinery must take all practical steps to ensure that what they design does not become a hazard to anyone building, installing, using, maintaining or repairing it.

Designers, manufacturers and suppliers of machinery and personal protective equipment have legal duties; these are explained in HSE Regulations 66 to 69.

Equipment designs should meet relevant New Zealand and international standards.

Figure 2 summarises the designer's responsibilities which are to ensure machinery:

- > is ergonomically sound
- > has conveniently placed power controls
- > will not be a source of harm
- > meets relevant New Zealand and overseas standards
- > will be safe for its intended purpose during manufacture and during its operating life
- > is safe when it is decommissioned and disposed of.

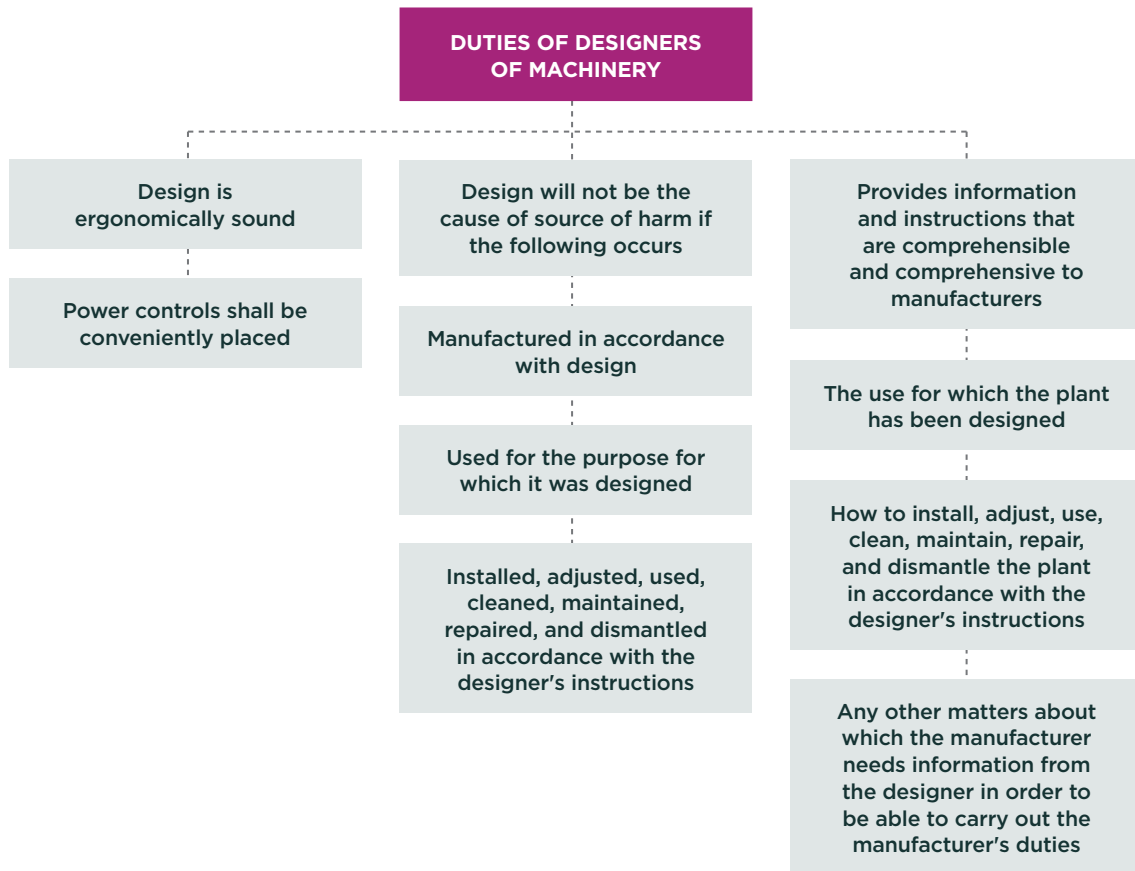


Figure 2: Summary of the duties of designers of machinery

Designers should provide thorough and easy-to-understand information and instructions to the manufacturer about how to build the machine so it meets the design criteria. The designer also needs to give information on the right way to install, operate, adjust, maintain and repair the machine.

## 2.2 DUTIES OF MANUFACTURERS AND SUPPLIERS OF MACHINERY

Manufacturers and suppliers of machinery should take all practicable steps to make sure it is designed, manufactured and tested so it will not harm anyone during:

- > installation
- > use
- > repair
- > dismantling
- > cleaning.

Manufacturers and suppliers are responsible for:

- > safety in design (eg if they cannot find the parts specified by the designer, they must find others of the same standard)
- > building the machine to meet the design requirements
- > testing the machinery.

HSE Regulations 67 describes the duties of manufacturers and suppliers of plant.

## 2.3 SUPPLYING MACHINERY

Under section 18A of the HSE Act, a person who hires, leases, sells or otherwise supplies another person with a machine to be used in a workplace has legal duties.



People who hire, lease or loan machinery must find out whether it will be used in a workplace, and if so, how it will be used. They must ensure that the machinery has been designed, made and maintained to be safe for its intended use.

People who sell or supply machinery that can be used in a workplace must take all practicable steps to make sure it has been designed, made and maintained to be safe for any known intended use or any reasonably expected use. If a seller or supplier agrees to install or arrange a machine, section 18A(3) of the HSE Act says they must take all practical steps to install or arrange the machine so it is safe for its intended use.

Health and safety legislation requires people to make sure others are safe at work. It also protects people using machinery and equipment.

### 2.3.1 INFORMATION FOR SUPPLIERS AND PURCHASERS/HIRERS

Manufacturers and suppliers must give thorough and easy-to-understand instructions on how to use the machine safely (see HSE Regulations 67(3) & (4)). People who make and supply protective clothing and equipment have similar duties (see HSE Regulations 69(4) & (5)).

Any instructions must explain:

- > hazards linked to the machine
- > how to install the machine safely
- > how to operate the machine safely
- > safe ways to clean and adjust the machine
- > how to maintain and repair the machine
- > regular replacement of parts of the machine that wear
- > how to safely take the machine out of service and take it apart
- > any other relevant matters.

The supplier, or the purchaser or hirer, must understand and follow the information.

## 2.4 CHOOSING AND BUYING

Machinery that is designed from the outset to remove hazards should reduce costs for employers due to less need to:

- > purchase personal protective equipment
- > install extraction systems for fumes or particles
- > install extra guarding.
- > Buyers and hirers can include conditions about the safety of the machinery in the purchase contract. Examples include:
  - > Goods/machinery will meet all relevant New Zealand safety laws.
  - > Goods/machinery will meet the following standards: (eg *AS 4024 Safety of Machinery series*).

For more information, see WorkSafe NZ's *Position Paper for the Safe Use of Machinery*.

Exceptions to section 18(A) of the HSE Act are goods that are second-hand or sold 'as is'. 'As is' means without promises or warranties as to quality, durability or fitness, with the buyer carrying all risks. Buyer beware!

## 2.5 INSTALLING MACHINERY

The installer must thoroughly identify and assess all hazards and determine the machine's limits using the latest AS 4024.1, or other equivalent standard.

An engineer must decide what safety category the machine falls into and what guards it needs so it meets AS 4024. The engineer needs relevant experience and knowledge of machine guarding and the requirements of AS 4024.

The manufacturer must validate that the design of all safety features in control components and control systems meet the standards of sections 1501 and 1502 of AS 4024. If the manufacturer cannot do this, an engineer (with relevant experience and knowledge) must inspect the machine and validate that it meets AS 4024.

The machinery must be installed according to the manufacturer's instructions. If the person selling or supplying machinery agrees to install it, the law says they must take all practicable steps to install or arrange the machinery so it is safe for its intended use (HSE Act section 18A(3)).

## **2.6 USE OF MACHINERY - THE EMPLOYER**

Employers are responsible for the health and safety of their employees and any other people who can be harmed by the actions or inactions of their employees. Employers must, as far as practicable:

- > keep workers safe from hazards at work by identifying and managing hazards
- > make sure work done is safely
- > provide protective clothing and equipment
- > train and supervise workers so they can work safely
- > provide an accident reporting system and follow up on any accidents, injuries or near misses
- > develop procedures for dealing with emergencies.

If an employer can only minimise a hazard, they must monitor the environment and the health of employees.

### **2.6.1 TRAINING AND SUPERVISION OF MACHINE OPERATORS**

The employer or person in control of the workplace must not let anyone use a machine unless they have had training on:

- > the actual and potential hazards of the machine

- > all the precautions to be taken.
- > Unless the machine operator can operate the machine safely, then the employer or person in control should have the operator closely supervised by someone with the skills.

**Employees must be supervised and trained by a competent person (section 13 HSE Act).**

When training people to use machinery, a trainer must explain:

- > how to check and adjust the machine before starting it
- > how to stop and start the machine
- > how the machine works
- > what the machine does
- > location and operation of other controls
- > actual and potential hazards and appropriate ways to control them
- > purpose of guards and other safety devices
- > correct use and adjustment of guards
- > correct work methods to be used
- > how to recognise faults that could cause harm
- > limitations and capabilities of the machine
- > emergency procedures.

Take manufacturer's instructions into consideration when developing training programmes for operators.

### **2.6.2 SAFE USE OF MACHINERY RESPONSIBILITIES - RESTRICTIONS FOR YOUNG PEOPLE**

Employers must take all practicable steps to stop anyone under the age of 15 years old working or helping with work with machinery.

No one under the age of 15 years old should be in an area where:

- > goods are being prepared or manufactured for trade or sale
- > construction work or forestry work is done.

Unless they are:

- > in a public access area
- > under the direct supervision of an adult
- > on a guided tour of the area
- > in an area only used for the sale of goods or services.

**Minimum ages in health and safety legislation:**

- > 12 years old for trained drivers of agricultural tractors and implements (HSE Regulation 61)
- > 15 years old for most duties except those in retail or office areas (HSE Regulations 54 to 60)
- > 16 years old for work between 10pm and 6am, unless special conditions apply (HSE Regulations 58 and 58F)
- > 18 years old to operate amusement devices (Amusement Devices Regulations 1978 20(a)).

## 2.7 INSPECTION AND MAINTENANCE

The employer or principal must have an inspection and maintenance programme in place. This programme must ensure a competent person regularly inspects, tests and maintains the machine's guards and safety control system. This ensures the safety system's reliability and integrity.

When developing maintenance and repair programmes, refer to the manufacturer's instructions.

Maintenance and repair programmes should specify:

- > where servicing is needed
- > how much servicing is needed
- > what type of servicing is needed
- > how often it needs to be serviced
- > who is responsible for maintaining repair and maintenance programmes

- > how defects will be fixed
- > what standards are used for performance testing and evaluation.

Programmes should be reviewed regularly to ensure their effectiveness. Develop, implement and maintain an accurate record of maintenance done and maintenance programmes.

### 2.7.1 CLEANING AND MAINTENANCE OF MACHINERY

Employers should take all practicable steps to make sure any hazardous machinery has stopped before any cleaning or maintenance is done. HSE Regulation 17 requires employers to make sure machinery is safe to clean, maintain and repair. Procedures must be put in place for these activities to be performed safely and workers must be trained to follow them.

Isolation, tag out cards and lock-out devices should also be used as described in section 8.1.11 of this guideline.

Any other hazard present should also have the appropriate control applied to stop people being harmed.

If it is essential for the cleaning, maintenance or repair procedure that the machine stays in operation, then employers should:

- > only have power going to the part of the machine that must be in motion
- > adequately train anyone working in this hazardous situation
- > establish and follow a safe work system
- > regularly review any safe work systems
- > reduce the speed of any dangerous parts to as slow as practical with reduced power/force, or step-by-step operation with a limited movement control device
- > restrict access to and control of danger areas to one person
- > have emergency stop controls within immediate reach

- > use a portable inching control with E-stop or local inching allowing full sight of controlled elements and danger area.

Mid-position pendants are better than jogging or inching machinery using a hold-to-run control. The machine should run at the slowest practical operating speed for cleaning, loading and setting up. The inching control should be a hold-to-run type, so the machine stops immediately when the control is released.

Employers should maintain and keep machinery in sound operating condition at all times. They can manage the maintenance using:

- > preventive maintenance schedules
- > regular inspections
- > unsafe condition reports
- > ask for employee feedback.

## **2.8 MODIFYING MACHINERY**

The manufacturer's and designer's instructions should be referred to before modifying any plant.

Modifications should be only be completed by a competent person who has knowledge and experience of AS 4024 and the type of machine or plant.

Any modifications must be validated so the design of all safety features in control components and control systems meet the standards of sections 1501 and 1502 of AS 4024. If the manufacturer cannot do this, an engineer (with relevant experience and knowledge) must inspect the machine and validate that it meets AS 4024.

## **2.9 DECOMMISSIONING MACHINERY**

Any decommissioning and dismantling of machinery must be undertaken as per the manufacturer's instructions and completed by a competent person.

## **2.10 USE OF MACHINERY - THE EMPLOYEE**

When using machinery an employee is responsible for:

- > their own health and safety
- > not harming others through their actions or inaction
- > following any safe work procedures their employer has in place
- > identifying and reporting hazards - and controlling them where possible
- > using all guarding
- > keeping their work areas clear, clean and tidy
- > wearing and using all protective equipment and clothing
- > alerting their supervisor to any machinery faults or maintenance needs
- > telling their supervisor about any illness or condition that could stop or limit their ability to work with machinery - to keep others safe and help supervisors allocate work.

Machine operators should:

- > check that the machinery they use is in sound working order
- > report immediately any problems to their supervisor
- > use any safety devices, guards, appliances, protective devices and any other methods used to make the machinery safe.

Where there is a risk of entanglement with machinery, people should:

- > tie long hair back close to the head
- > not wear loose clothing.

### **2.10.1 EMPLOYEE PARTICIPATION IN HEALTH AND SAFETY**

Employees are often in the best place to know the hazards of their job and how they could be injured. For example, product might back up in the machine and need clearing, which could be hazardous if the machine is still running.

Everyone benefits when employees are involved in developing health and safety systems, and when those systems are part of the daily life in the workplace.

The HSE Act gives employees the right to participate in health and safety issues at work and gives them access to information and training.

Employees may elect a health and safety representative for their workplace. The health and safety representative is someone that staff can go to and discuss any problems around health and safety. The health and safety representative will work with the employer to find a solution.

In larger workplaces, employees' representatives may be elected onto the health and safety committee that also includes representatives of the employer. Where employee health and safety representatives are elected, they are entitled to paid leave to attend approved training courses.

If an employee has genuine concerns about health and safety, they have the right to refuse unsafe work (HSE Act section 28A). This should only happen when other avenues to deal with the problem have not been successful. During the time the employee's concerns are being investigated, he or she may need to perform other duties in the workplace.

For more information see WorkSafe NZ's factsheets:

- > *Health and safety representatives*
- > *Employers must involve employees in health and safety*
- > *Employees have to help ensure and safe and healthy workplace.*



# 03/

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## **IDENTIFY, ASSESS AND CONTROL HAZARDS**

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### **IN THIS SECTION:**

- 3.1 Hazard management**
- 3.2 Identify hazards**
- 3.3 Machinery hazards**
- 3.4 Mechanical hazards**
- 3.5 Ergonomic hazards**
- 3.6 Chemicals and fumes**
- 3.7 Organisational hazards**
- 3.8 Electrical safety of machinery**
- 3.9 Environmental and occupational health hazards**
- 3.10 Other hazards**
- 3.11 Operational hazards**

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Making sure hazards do not cause harm or injury is the basis of health and safety in any workplace. This section covers the basics of hazard management and the common hazards that are found when working with or near machinery.

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### 3.1 HAZARD MANAGEMENT

Planning a safe approach to a job can help identify the hazards of working with machinery. The hazard management process includes:

- > hazard identification
- > hazard assessment – decide if the identified hazards are significant
- > hazard control – either by eliminating, isolating or minimising the hazard
- > a safety plan or hazard register documenting this information
- > hazard monitoring, including workplace exposure monitoring or health monitoring of workers
- > a schedule to update the safety plan.

### 3.2 IDENTIFY HAZARDS

The first step in the hazard management process is to identify hazards – anything that could injure or harm someone.

Do a workplace inspection to identify all machinery used. Include common items that may not normally be thought of as ‘machines’. Also consider how other workplace items such as chairs and heaters can affect the use of machinery.

Sections 7–10 of the HSE Act outline the process to identify, assess and control hazards.

#### 3.2.1 HAZARD IDENTIFICATION METHODS

Once you have identified all machinery, you can identify their hazards.

A good hazard identification process is key to hazard management. You can identify hazards using:

- > **Physical inspections.** Inspect the machinery and assess where someone could get injured or caught in the machinery.
- > **Task analysis.** Identify the hazards involved in each task. This should include what happens when there is a blockage or the machine needs cleaning or maintenance.
- > **Process analysis.** Identify hazards at each stage of the production process.
- > **Best practice guidelines and standards.**
- > **Hazard and operability analysis (HAZOP).**
- > **Accident investigation analysis.** Identify hazards and causes of harm from investigations involving similar types of work.

Hazard identification and management should be completed and monitored regularly to make sure control measures are working and no new hazards have been introduced. See Appendix 1 for a sample hazard checklist.





Figure 3: Processes are used together to identify hazards

Critically inspect each piece of machinery and how it is used to identify where someone could be harmed by:

- > any parts (moving and stationary)
- > processes
- > procedures
- > workplace activities
- > related danger zones.

For more information see:

- > the machinery factsheets on WorkSafe NZ's *Safe Use of Machinery* page at [www.worksafe.govt.nz](http://www.worksafe.govt.nz)
- > Flowcharts 2 and 3 in this guideline
- > Figure 3 above for an example of one process to identify hazards.

### 3.3 MACHINERY HAZARDS

In this guideline hazards are split into two categories: mechanical hazards and operational hazards. This section covers the main hazards caused by the machinery itself.

Many pieces of machinery use force and motion to cut, bend, join or shape materials. This force and motion can harm people. Some of the ways people can be hurt are covered in this section.

Machines and machinery parts in the figures section are unguarded to show the hazards and danger zones. Flowchart 2 shows the most common types of machinery hazards.

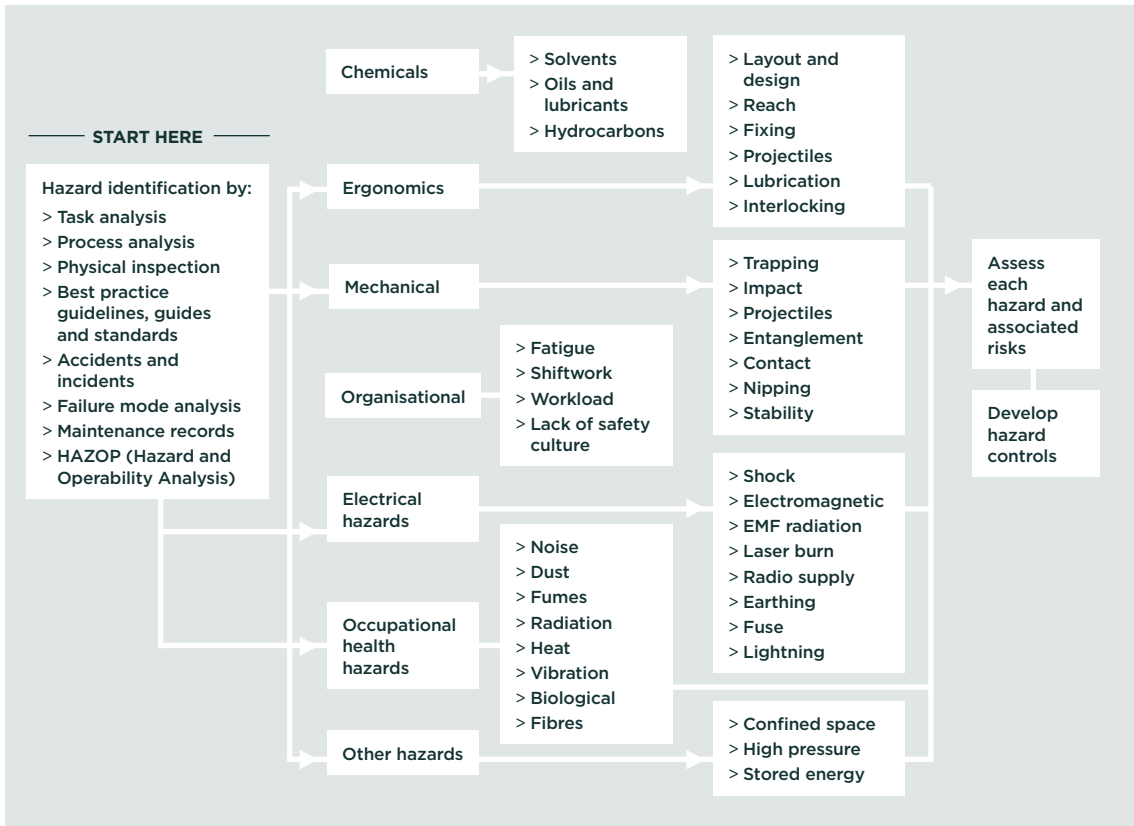
## 3.4 MECHANICAL HAZARDS

### 3.4.1 PRIME MOVERS

Prime movers are devices that turn energy into motion to power a machine. Prime movers include:

- > water turbines
- > electric generators
- > electric motors
- > electric rotary converters
- > the head and tail race of water wheels
- > motors powered by burning fuel, such as coal, petrol or natural gas.

Every flywheel directly connected to a prime mover and every moving part of a prime mover should be securely guarded, unless it is safe because of its position or construction. It must be safe for everyone in the workplace. Prime movers also include motors powered by burning solid, liquid, or gas fuels such as coal, petrol or natural gas.



Flowchart 2: Common machinery hazards

**3.4.2 TRANSMISSION MACHINERY**

Transmission machinery takes energy from a prime mover to the part of a machine where it is used. Every part of any transmission machinery should be securely fenced unless, because of its position or construction, it is safe. Figure 4 shows some ways operators can be injured by this type of machinery.

Transmission machinery can include gears, shafts, pulleys and belts, chains and sprockets, or friction drives.

All transmission machinery should have a device in every room or workplace to cut the power to the machinery.

**Key for arrows:**



*Solid red arrows* = where a part of the body could be drawn into a nip-point



*White or grey arrows* = movement of machine parts

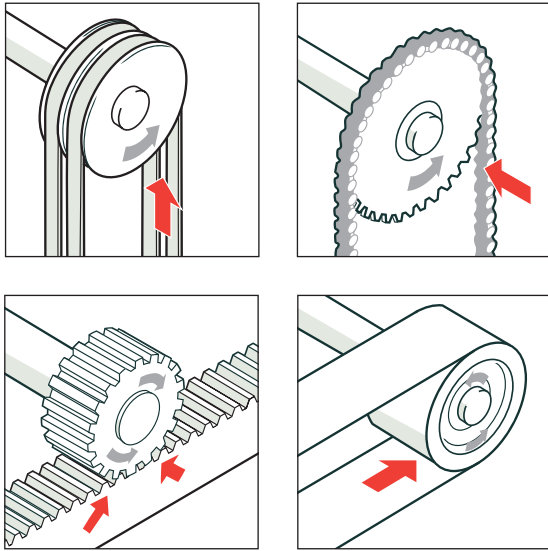


Figure 4: Examples of where operators can be injured by unguarded transmission machinery

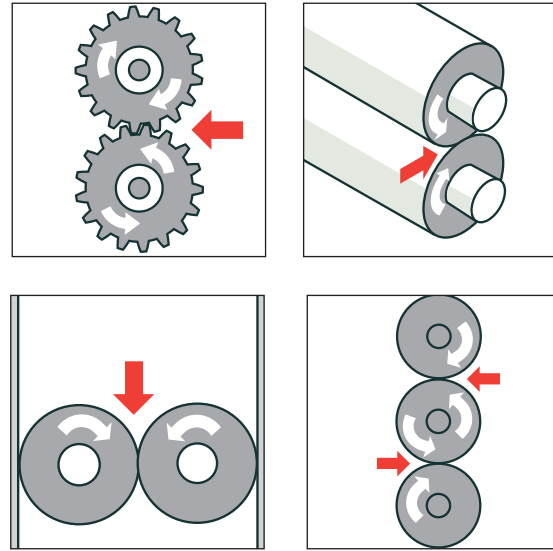


Figure 5: Drawing-in hazards between counter-rotating parts

### 3.4.3 DRAWING-IN OR TRAPPING HAZARDS

Injuries can be caused when a part of the body is drawn into a 'nip-point'. Figure 5 shows some ways operators can be injured by drawing in and trapping hazards, such as:

- > in-running nips between two counter-rotating parts (like meshing gears, rolling mills, mixing rolls, press rolls)
- > in-running nips between a rotating surface and another surface moving along it (such as a power transmission belt and its pulley, a chain and its chain wheel, a rack and its pinion)
- > running nips between a rotating surface and another surface moving along it where material (like metal, paper, cable, rope) runs onto a reel, drum or shaft
- > nips between rotating and fixed parts, which can shear, crush or abrade, such as spoked hand-wheels, flywheels and screw conveyors.

### 3.4.4 CRUSHING HAZARDS

Figure 6 shows some ways operators can be injured through crushing hazards that can happen when part of the body is caught:

- > between a fixed and moving part of a machine (such as the bed and tool of a power press)
- > between two moving parts of a machine (such as the support arms of a scissor lift platform)
- > between a moving part of a machine and a fixed structure (such as a counterweight and the floor).

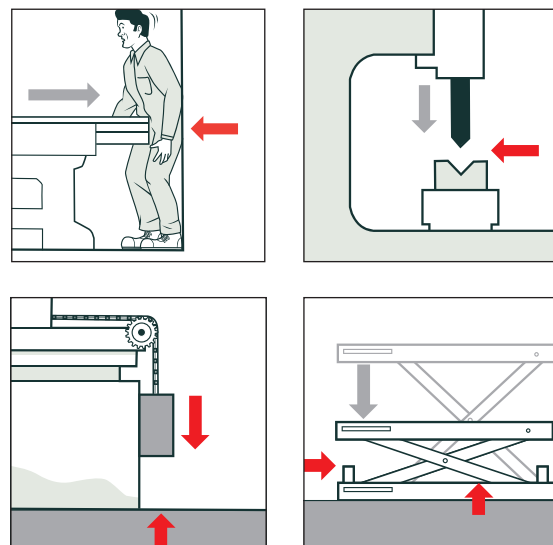


Figure 6: Examples of crushing hazards

### 3.4.5 IMPACT HAZARDS

Impact hazards are caused by objects that strike the body, but do not enter it.

Figure 7 shows some ways operators can be injured by impact hazards. Examples include the rotating arm of a robot, the reciprocating bed of a metal planing machine and the arms of a wool-scouring machine.

Impact hazards are different from crush hazards even though the machines involved may be the same. Impact hazards involve the inertia of the body while crush hazards involve trapping the body between two machine parts or between a machine part and a fixed structure.

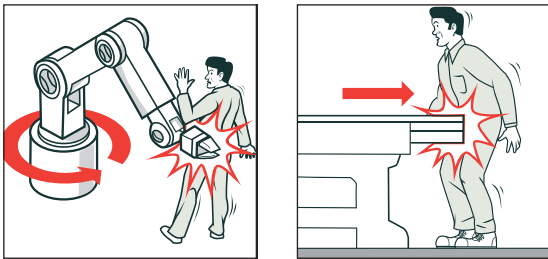


Figure 7: Examples of impact hazards

### 3.4.6 FRICTION AND ABRASION HAZARDS

Friction burns can be caused by smooth parts operating at high speed. Figure 8 shows some ways operators can be injured by friction and abrasion hazards. Examples of friction or abrasion hazards include:

- > the sides of a grinding wheel
- > the belt of a belt sanding machine
- > material running onto a reel or shaft
- > a conveyor belt and its drums
- > pulleys and fast-moving ropes or belts.

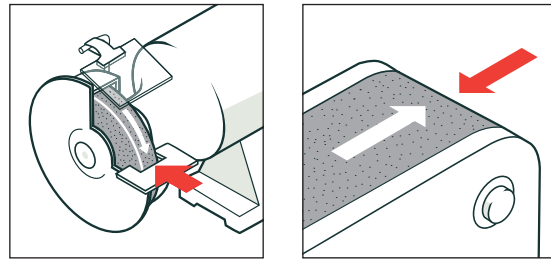


Figure 8: Friction and abrasion hazards

### 3.4.7 ENTANGLEMENT HAZARDS

Entanglement is when someone is caught in a machine by loose items (such as clothing, gloves, ties, jewellery, long hair, cleaning rags, bandages or rough material being fed into the machine).

Figures 9, 10 and 11 show some ways operators can be injured by entanglement with machinery. Contact that can lead to entanglement includes:

- > touching a single rotating surface (such as plain shafting, couplings, spindles, chucks, lead screws, mandrels or rotating work pieces including plain bar material)

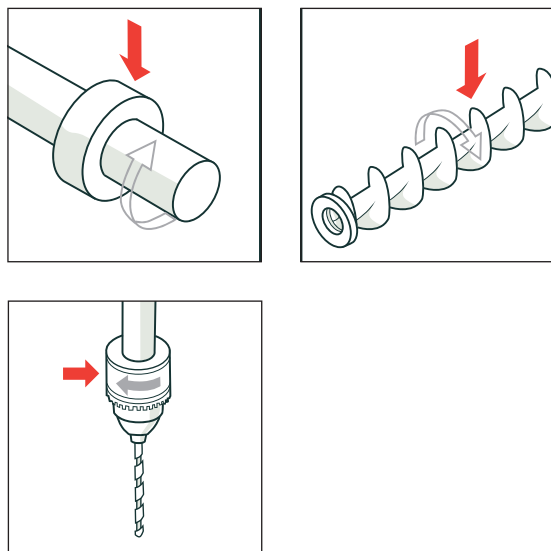


Figure 9: Contact with single rotating surface

- > catching on projections or in gaps. Belt fasteners and other projecting items (such as keys, set screws and cotter pins) are typical projection hazards. Fan blades, spoked wheels (such as pulleys, sprockets, gear wheels and flywheels), mixer and beater arms and spiked cylinders create gap-related hazards

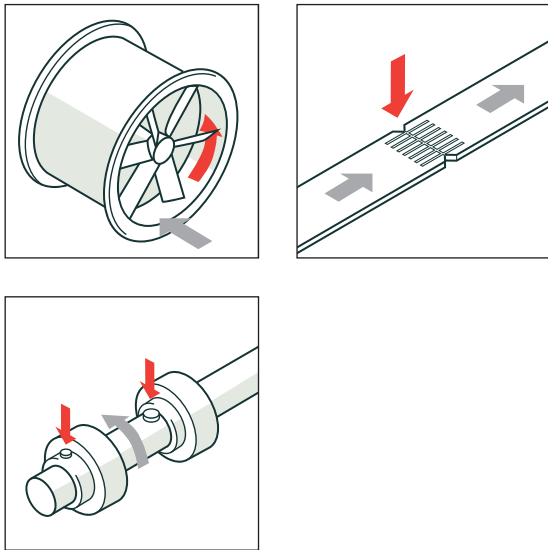


Figure 10: Catching on projections or in gaps

- > touching moving materials in motion (such as in centrifuges, tumble driers and dough mixers or swarf)
- > reaching between counter rotating parts (such as gear wheels, rolling mills)
- > reaching between a rotating part and another part moving along it (such as a power transmission belt and its pulley, a chain and chain wheel, a rack and pinion, a conveyor belt and any of its pulleys, a rope and its storage reel)
- > reaching between rotating and fixed parts (such as flywheels and the machinery bed, screw or worm conveyors and their casings, mixers, extruder screw and barrel, the edge of an abrasive wheel, or an incorrectly adjusted work rest).

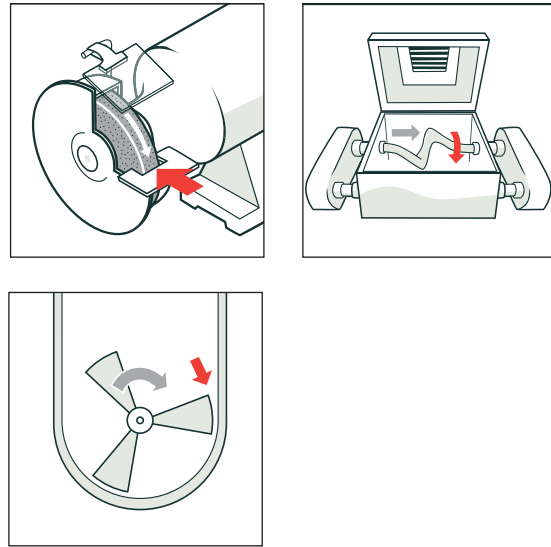


Figure 11: Catching between rotating and fixed parts

### 3.4.8 SHEARING HAZARDS

Shearing trims or shears metal (or other material) with a powered knife or slide. Shear points are found where stock is inserted, held and withdrawn. Figures 12 and 13 show some ways operators can be injured by shearing hazards.

Parts of the human body can be sheared:

- > between two machine parts, such as:
  - > the table of a metal planing machine (shaper) and its bed
  - > the table and blade of a guillotine or power press
  - > nip-points between connecting rods or links and rotating wheels or between parts that move back and forth)
- > between a machine part and a work piece, such as the tool of a broaching machine and the part being broached.

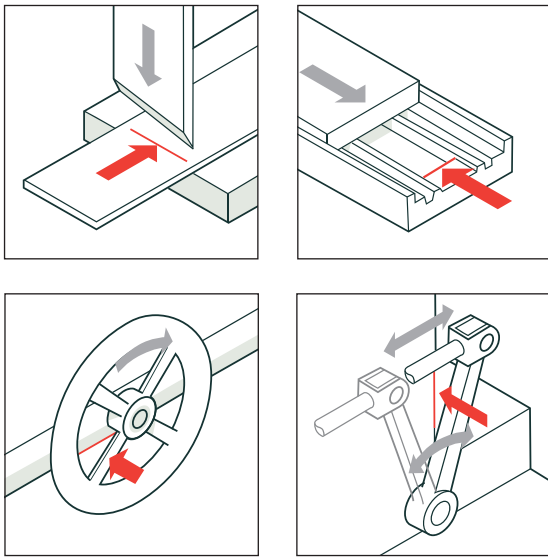


Figure 12: Shear hazards between two machine parts

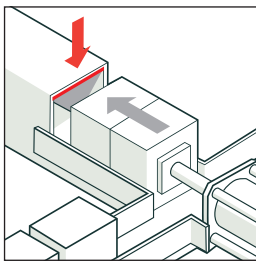


Figure 13: Shear hazards between a machinery part and a work piece

### 3.4.9 CUTTING HAZARDS

Cutting hazards exist at the point where wood, metal or other materials are cut. Figure 14 shows some ways operators can be injured by shearing hazards.

Many kinds of tools create cutting hazards:

- > band and circular saws
- > boring or drilling machines
- > planing and tenoning machines
- > milling machines
- > cutting edges of milling tools water jet cutting
- > high energy lasers

- > moving sheet material in a machine
- > abrasive wheels
- > cutting edges of endless-band cutting machines
- > reciprocating knives and saws
- > revolving cutting tools.

Cutting hazards may involve rotating, reciprocating or sideways motion. Danger exists at the cutting point, where a finger, arm or body part can be injured. Flying chips or scrap material can strike the head, particularly in the eyes or face. The danger is worse if the person caught cannot move away from the cutter.

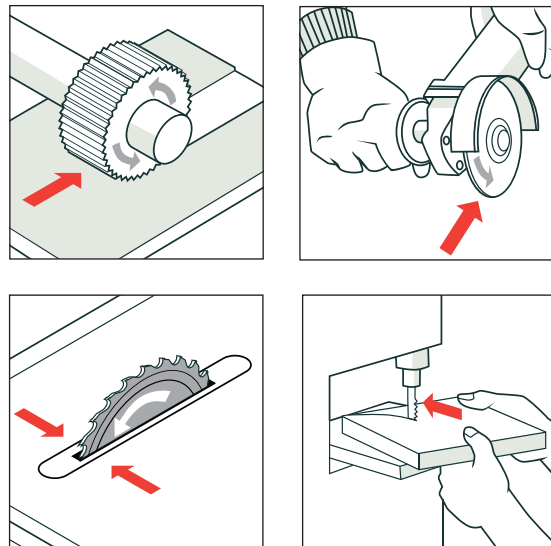


Figure 14: Examples of cutting hazards

### 3.4.10 STABBING AND PUNCTURING HAZARDS

The human body can be pierced by flying objects. Figure 15 shows some ways operators can be injured by stabbing and puncturing hazards. For example:

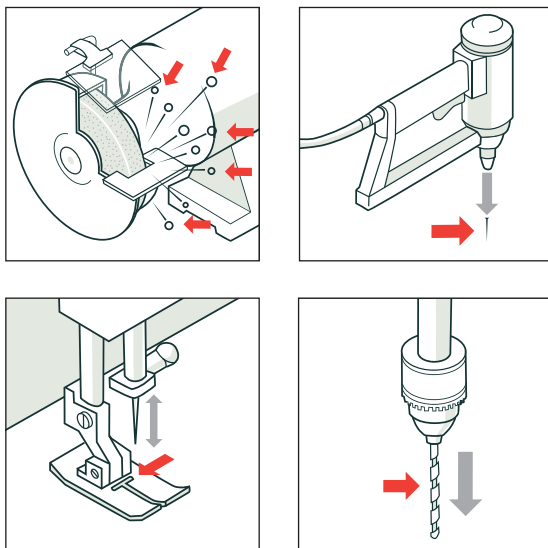
- > a loose tool in a lathe
- > broken tooling on a press
- > an abrasive wheel breaking up
- > swarf

- > timber from a bench saw
- > molten metal from a die-casting machine
- > sparks from welding
- > a bolt from an explosive powered tool
- > debris thrown by rotary mowers and hedge cutters.

The human body can also be pierced by rapidly moving parts of machinery or pieces of material. For example:

- > the needle of a sewing machine
- > the drill of a drilling machine
- > the arm of a robot.

Injection of fluids through the skin can cause tissue damage similar to stabbing.



**Figure 15:** Examples of stabbing and puncture hazards by flying objects or moving parts of machinery

### 3.5 ERGONOMIC HAZARDS

Ergonomic hazards come about through the way the operator interacts with the machine. Sometimes machinery is not always designed for how an operator must use the machine. For example, operators may have to overreach, reach above shoulder height, hold awkward postures, and use repetitive or forceful movements. Having to work this way can cause damage to nerves, muscles and tendons.

Ergonomic hazards can cause serious harm to operators, but they do not need to. These hazards can be removed at the design stage.

#### 3.5.1 MANUAL HANDLING

By considering how and when a machine is used, you can reduce the risk of injury. This includes:

- > how well the working environment is set up – are frequently used displays, instruments or control panels where operators can reach safely while keeping correct posture?
- > what type of machinery is used – does the equipment expose anyone to too much vibration, noise or emissions or does it need physical force to work?
- > how work is organised – how much work needs to be done? How urgent is the work? How many breaks do operators get? How long are the breaks?
- > what physical demands are put on the person using the machinery – is the work repetitive? Does it require awkward movements or postures? Does the operator have to work in extreme temperatures?

Check whether tasks require repetitive movement or there is a risk of musculoskeletal injuries and gradual process disease.

More information can be found in WorkSafe NZ's *Code of Practice for Manual Handling*.

### 3.5.2 LAYOUT AND DESIGN

Good layout makes any guarding better at keeping people safe. Machines that are poorly placed or too close together can be unsafe, even if guarded.

When designing layout:

- > avoid congestion points or worker movements near hazardous machinery
- > make sure people can use, clean and maintain the machinery without being harmed
- > make space for any waste materials to gather before they are cleared (they should not clutter walkways or work areas)
- > note the movements of trucks, materials and people
- > mark out walkways and create vehicle movement areas
- > mark out 'no-go' areas, so people can stay away from dangerous machinery.

Check how close moving parts are to other machinery and fixtures in buildings.

### 3.5.3 REACH AND GUARDING

The main point of machine guarding is to stop workers reaching past the guard into the machine. When deciding on the best way to guard a machine, consider how a worker uses and interacts with a machine (ergonomic principles).

More information on ergonomics is in section 7.2 of this guideline.

## 3.6 CHEMICALS AND FUMES

Many chemicals used with machinery can harm workers. Assess all chemicals for hazardous health effects. Put appropriate controls in place to stop or control people's exposure. In some cases, you may need to monitor the environment or workers' health to make sure exposure to the chemicals is not affecting their health.

For more information refer to the substance's safety data sheet, available from your supplier.

### 3.6.1 CONTROL OF AIRBORNE HAZARDS - VENTILATION

Protect workers at all times from inhaling steam, fumes, dust and other airborne contaminants in the workplace. You can use ventilation, filtration and/or mechanical extraction. Remove any contaminants made as part of the work at the source.

Any mechanical extraction must pull contaminants away from workers' breathing zone, not through it.

If it is not practical to completely remove or isolate the hazardous substance, you must minimise any risk of harm to the employee.

To minimise a hazard's effects, an employer can:

- > monitor employees' exposure to the hazard
- > monitor employees' health (with their informed consent)
- > provide protective clothing and equipment (such as breathing equipment or dust masks) and make sure they are used.

## 3.7 ORGANISATIONAL HAZARDS

For machine guarding to work well, employers must:

- > understand how materials move through the site
- > understand all safe operating procedures for the machinery
- > develop instructions on how to use machinery safely, including maintenance and cleaning
- > train workers to work safely.

New technology, new machinery or changes to machinery can introduce new hazards. At these times, always complete a hazard assessment and consult with workers.



### 3.7.1 FATIGUE AND SHIFT-WORK

Employers must take measures to prevent fatigue causing harm, such as when employees must drive or use dangerous machinery.

Employers are not responsible for anything outside work that reduces an employee's ability to cope or leads to fatigue. But they must have systems to identify and deal with such factors when they can affect workplace safety.

Shift-work can be hazardous because it disrupts normal rest patterns. Employees need enough recovery time outside work so they can be safe and productive at work.

Along with enough sleep, breaks during work hours are important to maintain an employee's physical and mental well-being. See WorkSafe NZ's *Stress and Fatigue: Reducing Their Impact - Advice for Employers and Employees* guide for more information.

## 3.8 ELECTRICAL SAFETY OF MACHINERY

The wiring and fittings of machinery connected to the mains (or similar) must meet all legal requirements and must be installed by a registered electrician.

A certified, professional third party must do all tagging and testing in line with electrical regulations.

All portable or handheld machinery that gets power from electricity should be used with an isolating transformer or residual current device, where needed. Get specific advice from the electricity supplier on the best device to use.

## 3.9 ENVIRONMENTAL AND OCCUPATIONAL HEALTH HAZARDS

When reviewing machinery for non-mechanical hazards, consider how machinery can affect the area around it.

A thorough hazard identification process needs to consider the effect environmental factors (such as lighting, heat, and cold) have on workers when using machinery.

### 3.9.1 WORKING AT HEIGHT

People need a suitable work platform to reduce the risk of falling from machinery.

Working safely at height may need:

- > fixed or permanently installed access platforms
- > mobile elevating work platforms
- > temporary platforms.

For more information, see WorkSafe NZ's *Best Practice Guidelines for Working at Height in New Zealand*.

### 3.9.2 LIGHTING

Make sure the work area is well lit. Poor lighting can be a hazard. Sometimes the machine or guards can block normal lighting so extra local light is needed. Also put local lighting in regular maintenance areas that are poorly lit, such as inside some electrical compartments where electrical isolation is needed for access.

For more information refer to *AS/NZS 1680.2.4 Interior lighting - Part 24: Industrial tasks and processes*.

### 3.9.3 NOISE

Employers must take all practicable steps to reduce any risk of harm to people from machinery noise. Machinery noise should be eliminated, or through isolation kept to a level that does not damage hearing.

Where this is not practical, employers should isolate people from excessive noise.

Where neither option is practical, employers must put systems in place to make sure people exposed to the noise are unlikely to suffer harm.

For more information on controlling noise, refer to *WorkSafe NZ's Approved Code of Practice for the Management of Noise in the Workplace*.

Noise limits for an 8-hour day, peak noise levels and protective measures are in HSE Regulation 11.

### 3.9.4 OPERATING SPEEDS AND DANGEROUS VIBRATION

No machine should be driven or used at an unsafe speed. Where a designer or manufacturer recommends a working speed for a machine, do not go any faster.

Maintain machines so there is no dangerous vibration when the machine is working or when moving parts and cutters are run at idle or full speed.

### 3.9.5 MACHINERY STABILITY AND SECURITY

All machinery must be secured to the floor or other structure so that it cannot tip, become unstable or create any other hazards, unless it is designed to be portable.

### 3.9.6 WEIGHT OF GUARDING

Large machinery may need a lot of guarding, which needs to be removed for maintenance access. Design guards to come off easily and be handled by one person. Well-placed handles make removing, lifting and handling easier and reduce the risk of manual handling injuries.

Where practical, use cranes or other lifting devices to move heavy guards.

## 3.10 OTHER HAZARDS

### 3.10.1 ACCESS HAZARDS

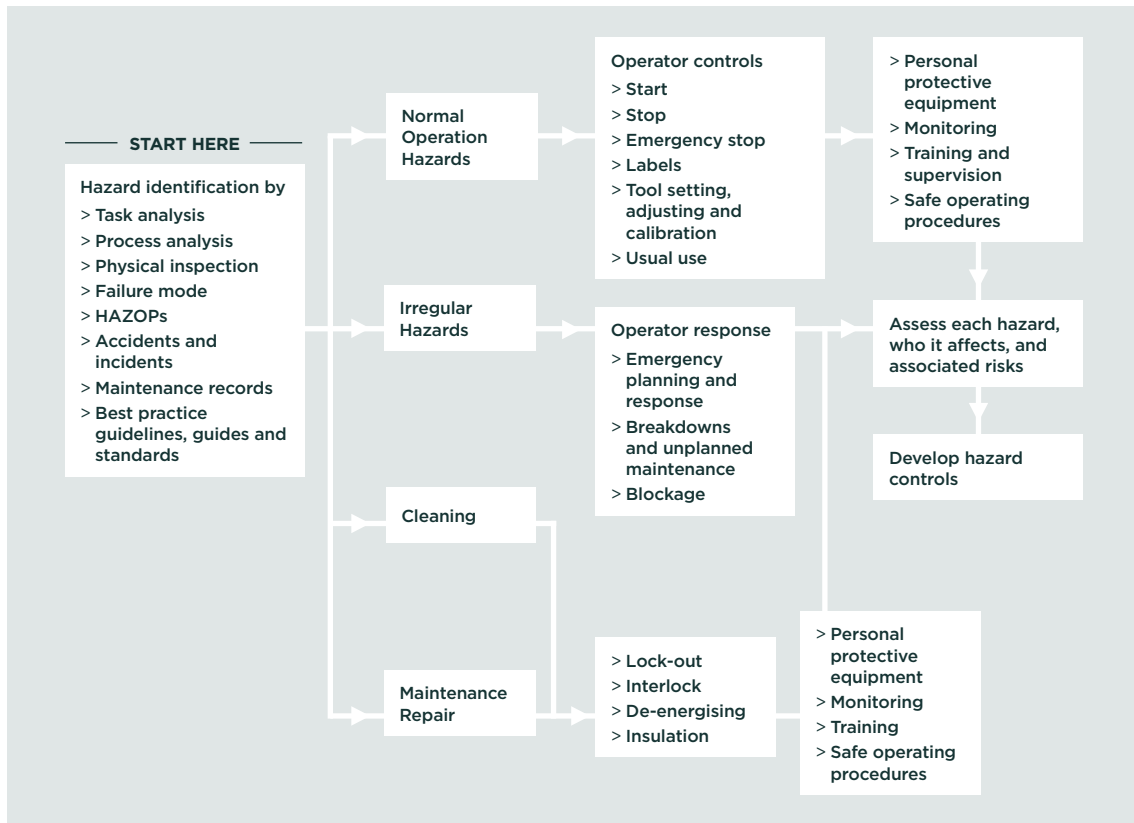
Operators and employees need safe access into, on and around machinery. Workers need a stable work platform that is right for the work they need to do. The operator should be able to keep good posture while working. The platform must give a sure footing, a safe working environment and prevents falls if it is at height.

When designing safe access to machinery, think about who, what, where, when and how.

- > Who will be working on or around the machinery?
- > Do people need to work in enclosed areas where the atmosphere could be harmful (such as pits, tanks or storage vessels)?
- > What equipment or materials need to be carried to do the job?
- > Where and when is access needed to use, maintain and clean the machine?
- > How will people get safe access (such as from a walkway, gantry, elevated work platform, ladder)?
- > What work will be carried out with the machine?
- > Will people be near or exposed to any mechanical or non-mechanical hazards when they access the machine?
- > Has consultation occurred with employees or contractors about how they intend to gain access, and what equipment and work platform or structure is best suited for the intended task?

### 3.10.2 CONFINED SPACE

Larger machinery and equipment can have enclosed areas that are difficult to get to. In confined spaces, oxygen levels may be low or there may be harmful levels of gas, vapour or dust.



Flowchart 3: Identify operational hazards to use machinery safely

For more information, refer to the Australian Standard *AS 2865 Confined spaces*.

### 3.10.3 HOUSEKEEPING

Mess can cause slips, trips and falls. Avoid injuries by:

- > keeping work areas, walkways and other access paths clear and clean
- > clearly marking walkways and no-go areas
- > preventing spills, which can cause slips.

Design machinery and work processes to minimise oil loss or spillage. Clean up spills as soon as possible and avoid any oily residues on the floor. Provide a rough anti-slip floor where this is not practical.

### 3.11 OPERATIONAL HAZARDS

Flowchart 3 shows the more common hazards associated with machine operations. Apart from the hazards associated with the normal running of the machine, the flowchart also covers hazards associated with cleaning, maintenance and repair, along with irregular hazards.

To keep people safe during inspections, cleaning, repairs, maintenance and emergencies:

- > use isolation procedures whenever people need to enter the danger area around machinery for maintenance and repair
- > make sure workers understand cleaning, repair, maintenance and emergency procedures

- > put in place a regular inspection regime to identify any problems with machinery and guards
- > identify and assess any other hazards specific to inspections, cleaning, repair, maintenance and emergencies
- > take special precautions when workers cannot be seen or where there are multiple operating switches
- > if dangerous parts need to move while a guard is open (for example: setting, fault finding, or maintenance), use safe operating procedures (such as speed as slow as practical, and two-hand hold-to-run inching controls with pendant) to minimise hazards and the risk of injury.

**HSE Regulation 17 requires employers must make sure machinery is safe to clean, maintain and repair. Procedures must be put in place for these activities and workers trained to follow them.**



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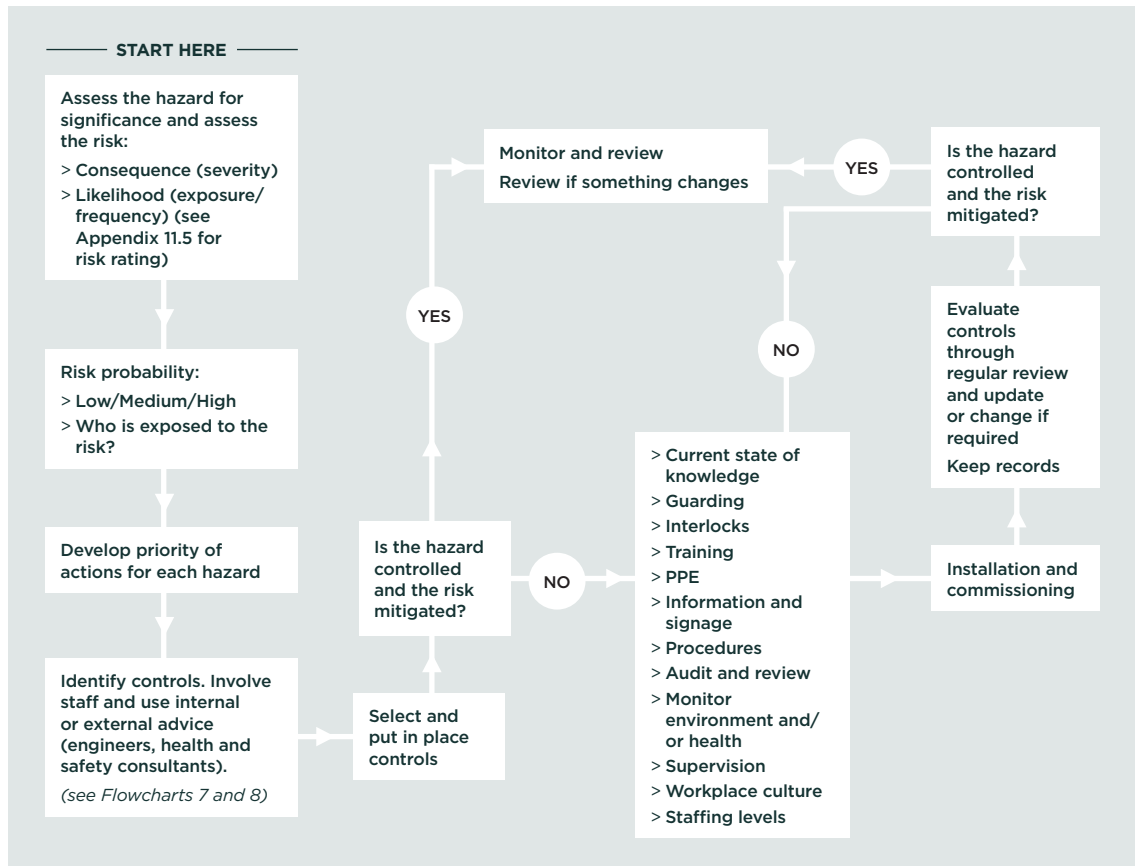
## HAZARD AND RISK ASSESSMENT

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### IN THIS SECTION:

- 4.1 Risk assessment
- 4.2 Adequate information,  
knowledge and experience

Hazard and risk assessment is a process to determine how significant a hazard is and what harm it could cause.



Flowchart 4: Assess hazard and risks – eliminate hazards where possible

Every identified hazard must be assessed to see if it is a significant hazard – something that could cause serious harm. If it is a significant hazard, it must be controlled using the hierarchy of controls. A significant hazard should be eliminated, if it can't then isolated, and if that isn't practicable, controls should be put in place to minimise the hazard. If it is not a significant hazard the employer must still take all practicable steps to ensure the equipment is safe for employees to use.

#### 4.1 RISK ASSESSMENT

Use flowchart 4 to work through the hazard and risk assessment process. This is the process to assess hazards, select controls and to assess whether these methods have reduced or eliminated the risk of harm occurring.

To manage risks effectively, an assessment of how likely a hazard is to cause harm must occur and, if it does, how badly someone can be hurt. This helps prioritise which hazards need to be dealt with first.

Any risk assessment should cover:

- > where, which and how many workers could be injured or harmed
- > how often this is likely to occur
- > how serious any injuries might be.

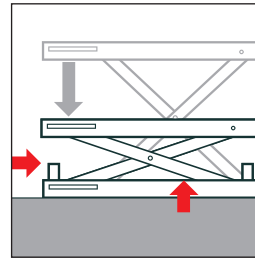
For example, with hazards from moving, rotating or reciprocating machinery, first assess how likely it is that a worker could get caught, entangled or nipped, and then determine how serious any injury might be.

Risk factors to consider during the risk assessment include:

- > visibility – how easy is it to see the hazard?
- > orientation – for example, a feed screw that is low and horizontal could entangle hair, ties and jewellery. A screw in a different place or angle would pose a different risk.
- > anticipated work practices, including less obvious ones such as:
  - > maintenance, inspection, repair and cleaning practices (for example, a screw conveyor is behind closed panels, but when it jams, a worker may open the panel and stick their hand in)
  - > infrequent or one-off tasks required on the machine.

When assessing the risk, take into consideration:

- > whether the danger zone can be reached
- > the likelihood of a worker putting fingers, hands, arms, feet or legs into places where they do not normally go when the machine is running.



**Figure 16:** An example of visibility risk factor. When the top part of the machine lowers, it comes to rest on supports on each corner, so only a small area on the underneath of the top may be a hazard.

**Key for arrows:**



*Solid red arrows* = where a part of the body could be drawn into a nip-point



*Grey arrows* = movement of machine parts

## **4.2 ADEQUATE INFORMATION, KNOWLEDGE AND EXPERIENCE**

Risk assessment is not an absolute science – it is a ‘best estimate’ made on the basis of available information. As such, the people doing risk assessments need the right information, knowledge and experience of the work environment and work processes. They need to talk to workers and health and safety representatives, who can advise on the particular hazards and risks for different machinery.

The *AS 4024 Safety of machinery series* has more information on risk assessment factors and methodology – see AS 4024.1301 and AS 4024.1501 in particular.



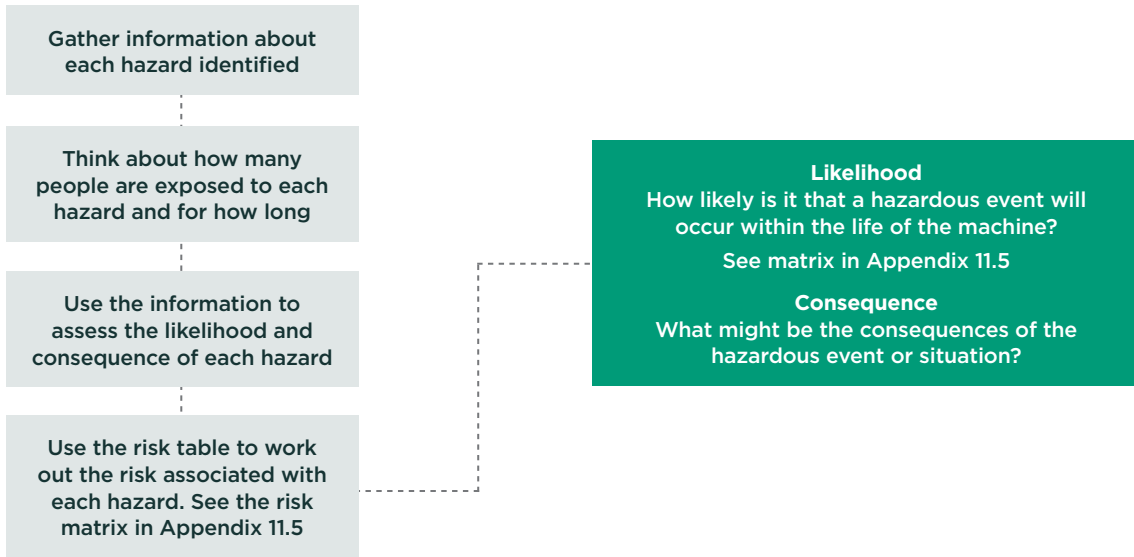


Figure 17: Risk assessment explains one process for assessing risks and hazards

RISK RATING TABLE				
Likelihood of injury or harm to health	Consequences of injury or harm to health			
	Insignificant <i>no injuries</i>	Moderate <i>first aid and/or medical treatment</i>	Major <i>extensive injuries</i>	Catastrophic <i>fatalities</i>
Very likely	High	Extreme	Extreme	Extreme
Likely	Moderate	High	Extreme	Extreme
Moderate	Low	High	Extreme	Extreme
Unlikely	Low	Moderate	High	Extreme
Highly unlikely (rare)	Low	Moderate	High	High

Extreme = immediate action

Figure 18: A example risk rating table



# 05/

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## **CONTROLLING MACHINERY HAZARDS**

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### **IN THIS SECTION:**

- 5.1 Eliminate hazards**
- 5.2 Isolate hazards**
- 5.3 Minimise hazards**
- 5.4 Matrix of guarding controls**

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## Employers and principals are responsible for making sure the hazards associated with machinery are controlled in the workplace so they do not harm workers and operators.

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Sections 8-10 of the HSE Act outline a hierarchy of controls that must be used when a significant hazard has been identified. The hierarchy consists of three steps: eliminate, isolate or minimise the hazard. If employers cannot eliminate or isolate the hazard (because it is not practicable to do so) they must minimise it.

### 5.1 ELIMINATE HAZARDS

With elimination, the hazard or hazardous work practice is removed from the workplace. With machinery, this may involve employers changing processes and machinery so workers are not exposed to significant hazards. Hazards can be eliminated at the design stage too (see section 6 of this guideline).

### 5.2 ISOLATE HAZARDS

If elimination is not practicable, the significant hazard must be isolated. This involves isolating or separating the hazard or hazardous work practice from those who may be harmed by it. These usually protect everyone around the machine (which is known as a group control). They can be fixed guards, interlocked guards or safe by position.

### 5.3 MINIMISE HAZARDS

If it is not practicable to eliminate or isolate the hazard, then the likelihood of it causing harm must be minimised. Minimisation provides a framework of expected behaviours, such as rotation of staff to reduce exposure to a hazard, personal protective equipment or a documented safe system of work – such as ‘lock-out – tag-out’. These types of controls rely on extensive instruction, information, training and supervision.

Minimising a hazard can stop injuries, but it is the least effective option because it relies more on human behaviour, maintenance programmes and supervision. In the long term, minimisation can also be more expensive, because it needs time and ongoing oversight by managers and employers, and additional costs of personal protection, eg hearing protection.

When a hazard can only be minimised, section 10 of the HSE Act requires employers to monitor employees’ exposure to the hazard and monitor their health. Employers can only monitor employee’s health with their informed consent.

Because minimisation relies on human behaviour, hazard management needs to consider the actions of the people who:

- > install or dismantle machines
- > operate machines and equipment
- > maintain or repair machines
- > clean machines.

With changes in technology and cost of solutions over time, measures to eliminate and/or isolate a hazard may become practicable. Duty holders should continue to assess significant hazards that are being minimised in order to determine whether there are other methods to control them. For example, replace with a newer machine that eliminates or isolates the hazard.

### **5.3.1 AS 4024 SAFETY OF MACHINERY SERIES**

Duty holders should use the AS 4024 *Safety of Machinery series* as the standard that gives the current state of knowledge in relation to safeguarding machinery and plant. It should be referred to by duty holders as the primary standard against which to benchmark.

Employers, suppliers, manufacturers and designers can work to other standards, but they need to show that they can reach the same level, or better, of safety in the circumstances in which they are used.

The level of familiarity with AS 4024 will depend on the responsibilities of the duty holder. For instance, when buying new machinery or hiring machinery, the employer must make sure any machinery purchased or hired meets AS 4024, or equivalent or higher standards.

The employer must make sure that any competent person they hire to give advice or services on machine guarding or safe use of machinery is experienced in using AS 4024, or equivalent or higher standards.

However, an engineer maintaining and repairing machinery and/or installing guarding should be very familiar and experienced with AS 4024 and be able to readily access a copy.


See Section 11.4 for a summary of the AS 4024 *Safety of Machinery series*.

## **5.4 MATRIX OF GUARDING CONTROLS**

Table 1 covers options for eliminating hazards, the types of guards and methods that isolate workers from hazards, and examples of how hazards can be minimised. The controls are split into two categories, individual and group controls. Group controls protect more than one person, whereas individual controls can only protect one person at a time.

If hazards can't be eliminated, there are a number of options to isolate operators from machinery. When deciding which guarding methods to use, consider practicality and how the operator will use the machine.

Many factors determine the choice of guard. Depending on the situation, a combination of two or more guards may be needed to keep workers safe.



HIERARCHY OF CONTROLS	GROUP CONTROLS	INDIVIDUAL CONTROLS
<b>ELIMINATE</b>	<ul style="list-style-type: none"> <li>&gt; Design or modify machine to eliminate the hazard</li> <li>&gt; Eliminate by substitution</li> <li>&gt; Eliminate human interaction (eg automate handling)</li> <li>&gt; Eliminate pinch points</li> <li>&gt; Increase clearances or remove forces</li> </ul>	
<b>ISOLATE</b>	<ul style="list-style-type: none"> <li>&gt; Fixed guard</li> <li>&gt; Interlock guard</li> <li>&gt; Interlock distance bars</li> <li>&gt; Failsafe interlocking</li> </ul>	<ul style="list-style-type: none"> <li>&gt; Safe by position</li> </ul>
<b>MINIMISE</b>	<ul style="list-style-type: none"> <li>&gt; Presence sensing devices</li> <li>&gt; Light curtains</li> <li>&gt; Computer warnings</li> <li>&gt; Light beacons and strobe lights</li> <li>&gt; Lock-out systems</li> </ul>	<ul style="list-style-type: none"> <li>&gt; Two-hand controls</li> <li>&gt; Emergency stop</li> </ul>
<b>MINIMISE</b>	<ul style="list-style-type: none"> <li>&gt; Safe system of work</li> <li>&gt; Signage</li> <li>&gt; Training</li> <li>&gt; Supervision</li> <li>&gt; Safe operating procedures and instructions</li> <li>&gt; Administrative controls (eg safety inspections)</li> </ul>	<ul style="list-style-type: none"> <li>&gt; Personal protective equipment</li> </ul>

Table 1: Matrix of guarding controls



# 06/

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## **ELIMINATE HAZARDS AT THE DESIGN PROCESS**

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### **IN THIS SECTION:**

- 6.1 Eliminate hazards through design**
- 6.2 Reliability of safety functions**
- 6.3 Designing for safety throughout the life cycle**
- 6.4 Concept stage - health and safety in the business case**
- 6.5 Construction of machinery**
- 6.6 Validation and verification**



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The best time to eliminate hazards is at the machinery design stage. This section covers some of the common hazards that can be eliminated through design. The section also outlines the principles of including health and safety in the design process.

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The design process usually begins with:

- > the buyer or employer wanting a piece of machinery to meet business needs and/or modifications
- > a manufacturer seeing an opportunity to meet an industry need
- > a supplier seeing a gap in the market
- > a supplier looking for other products to promote.

At this point, the designer should get advice from safety experts, people who might use it and engineers to help design a safe machine. Machinery must be designed that does not hurt anyone at any point in the process of its manufacture, installation, use, maintenance or repair.

Designers must consider how the machinery can injure people working with it. Injuries include:

- > amputation and crush injuries
- > workplace stress and fatigue
- > manual handling injuries
- > occupational illness from fumes, dust, noise, radiation.

## 6.1 ELIMINATE HAZARDS THROUGH DESIGN

Common hazards that can be eliminated through design include:

- > **mechanical hazards** – hazards made by the shape, relative location, mass and stability, movement and strength of machine parts
- > **electrical hazards** – contact with or distance from live parts, suitability of insulation, static electricity, heat radiation and results of overloads or short circuits
- > **heat hazards** – contact with high-temperature objects or materials
- > **noise and vibration hazards**
- > **radiation hazards** – both ionising, for example x-rays and gamma rays, and non-ionising, for example electric and magnetic fields, radio waves, microwaves, infrared, and ultraviolet radiation
- > **materials and substances hazards** – hazards made, used or released by machinery or from the construction materials
- > **ergonomic hazards** – poor machine set-up leading to injuries and operational errors
- > **maintenance hazards** – when guarding is removed or switched off for cleaning, maintenance or access to the area around a machine
- > **slips, trips and falls hazards** – flooring surface and access
- > **work environment hazards** – environmental conditions, such as temperature, weather or lighting.

### **6.1.1 INHERENTLY SAFE DESIGN MEASURES**

Experience shows that protective measures built into the design are more likely to stay effective even when well-designed safeguarding fails, an error is made or safety procedures are not followed.

Hazard identification is the first step in the design process. Examples of safe design that eliminates particular hazards rather than relying on safeguards to prevent harm include:

- > putting oil filters and grease nipples on the opposite side of a machine to its hot parts
- > placing lubrication points away from moving parts

Avoid creating hazards by considering:

- > visibility of working areas from the control position
- > shape of and spacing between components
- > reducing sharp edges
- > enabling effective working positions and ease of access to controls
- > limiting forces or emissions.

Find more information on inherently safe design in *AS 4024.1202 Safety of machinery: Part 1202: General Principles – Technical Principles*.

### **6.1.2 STABILITY ASPECTS**

When designing the machine's stability, consider:

- > the shape of the base
- > weight distribution
- > dynamic forces
- > vibration
- > oscillations
- > the surface the machine sits on
- > external forces
- > earthquakes
- > wind loadings.

### **6.1.3 TECHNICAL INFORMATION**

The designer must develop technical information for the supplier and buyer from standards, codes and calculations. The information should cover:

- > forces which may be applied to material used in construction
- > management of emissions including noise fumes and dust
- > tests and procedures to ensure continued safe operation of the machine.

## **6.2 RELIABILITY OF SAFETY FUNCTIONS**

The designer must consider:

- > the reliability of all machinery parts
- > use of safety failure modes of components
- > duplication or redundancy of safety features
- > automatic monitoring of faults.

The designs of safety-related parts of control systems need to be validated by a competent person. Validation confirms that all steps of the safety life cycle were implemented and verified.

Designers can find information on reducing safety system failure through good design and typical failure modes in *AS 4024.1502 Safety of Machinery: Part 1502: Design of Safety Related Parts of Control Systems – Validation*.

## **6.3 DESIGNING FOR SAFETY THROUGHOUT THE LIFE CYCLE**

Different hazards exist at different stages of a machine's life cycle; many of these can be reduced or removed through thoughtful design.

### 6.3.1 MANUFACTURE

The making of machinery is the first phase of the life cycle. Examples of removing or controlling hazards include:

- > replacing spoked gears with gears with a solid disc, to get rid of a shear hazard
- > building housing around obvious hazards rather than having to fit guards after manufacture.

HSE Regulation 66 describes the duties of designers of plant.

### 6.3.2 TRANSPORT

Moving the machine to where it will be installed is the next important step.

*An example of removing a transport hazard is a metal lathe is to be delivered fully assembled and is much heavier at one end. The designer notes the chance for the lathe to slip out of its lifting slings, so they incorporate lifting eyes for the slings in positions that mean the lathe can be lifted in a horizontal position.*

### 6.3.3 INSTALLATION

Once a machine is safely delivered, it needs to be installed.

*For example, to reduce hazards during installation, design a large machine to be delivered in modules that are put in place by a crane. Then installers do not need to work at height or handle heavy items by hand.*

### 6.3.4 COMMISSIONING

The designer can build in test points for instruments and alarms so a machine or parts of machinery cannot be energised by mistake.

### 6.3.5 OPERATION

Designers must design machinery and plant that is safe to use. Some examples of designing machinery for safe operation:

- > consider the type of seating an operator may use and the ease of using the controls from the seat.
- > if an operator needs to move around a large machine, provide a portable emergency stop button.
- > give easy and safe access to areas that need regular maintenance. Access will be needed for cleaning, lubrication and adjustment. Maintenance considerations include:
  - > routine adjustments – people should be able to do these with the machine stopped but without needing to remove safeguards or take apart any of the machine
  - > when frequent access is needed – use interlocked guards
  - > when access is difficult – consider self-lubrication or central lubrication for parts
  - > positive lock-off devices to stop the machine restarting accidentally, particularly if a machine was shut down in error.

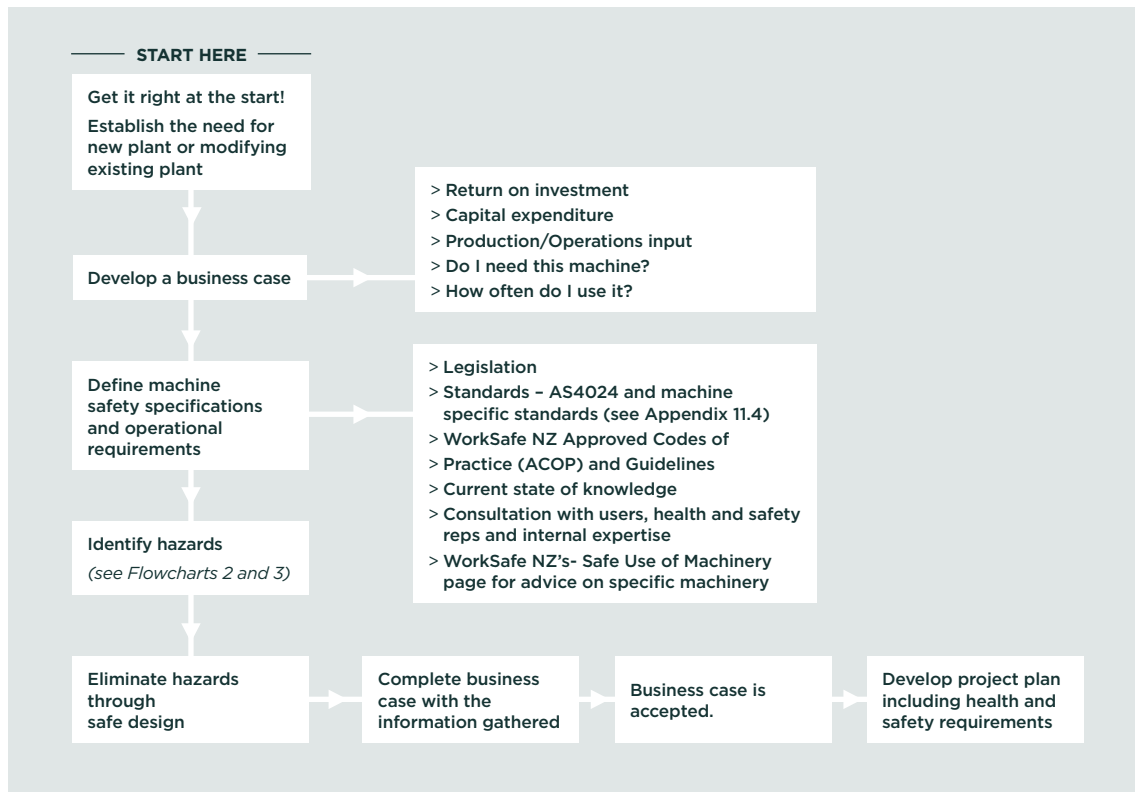
### 6.3.6 STORAGE

Manufacturers and designers should make sure machinery can be stored without creating hazards or when started after inactivity. They can include information on how to break down the machine for safe storage.

### 6.3.7 DISPOSAL

People breaking down machines for scrap can face significant hazards. These include:

- > energy stored in springs and pressure devices
- > hazardous substances that are part of the machine.



Flowchart 5: Concept stage - Health and safety in the business case

## 6.4 CONCEPT STAGE - HEALTH AND SAFETY IN THE BUSINESS CASE

The concept stage of a project is the best time to get things right. With thorough research, planning and consultation, many hazards can be eliminated before a machine is designed, purchased, installed or modified.

### 6.4.1 HEALTH AND SAFETY IN THE BUSINESS CASE

Once the need for new machinery or a change to existing machinery is identified, adding health and safety into the business case will help to assess hazards and risks. This can also help avoid budget blow outs, unpleasant surprises and costly retrofitting.

A thorough business plan includes at least the following elements outlined in sections 6.4.2 to 6.4.7 of this guideline.

### 6.4.2 RETURN ON INVESTMENT (ROI)

A return on investment (ROI) assessment should incorporate health and safety implications. For example, two different machines can get the same results. One machine costs \$10,000 more but is insulated and does not make enough noise to damage hearing. If the cheaper machine was purchased, the company would have to spend \$15,000 on hearing protection and hearing monitoring for operators.

The machine that is \$10,000 more expensive will actually save the company \$5000 in safety equipment and health checks.

### 6.4.3 CAPITAL EXPENDITURE (CAPEX)

Some businesses incorporate health and safety costs in the CAPEX sign-off process. A senior manager responsible for health and safety ensures an assessment is done and any risks addressed before the machine is purchased.

#### 6.4.4 LEGAL REQUIREMENTS

Anyone buying or modifying machinery to be used in a place of work has legal duties. The person putting together the business case should check what laws apply to their business. All businesses must comply with the HSE Act and the HSE Regulations.

#### 6.4.5 SAFETY AND OPERATIONAL STANDARDS

The business case should address health and safety and consider the following:

- > the WorkSafe NZ *Position Paper on the Safe Use of Machinery*
- > the AS 4024 *Safety of Machinery series*
- > any standards relating to the equipment (eg if there is a conveyor, refer to AS 1755 *Conveyors – Safety Requirements*)
- > any relevant WorkSafe NZ approved codes of practice, guidelines, guides and factsheets
- > the current state of knowledge from industry associations, manufacturers and other sources
- > involvement of health and safety representatives, union representatives (if applicable), operators, cleaners, maintenance staff and engineers.

#### 6.4.6 IDENTIFY, ASSESS AND CONTROL HAZARDS

By doing a detailed hazard identification process before starting, hazards can be eliminated at the design stage. Use Flowcharts 2 and 3 to identify the most common machinery hazards.

While removing hazards is the best option, not all hazards can be eliminated. If hazards cannot be eliminated, consider how they can be isolated. Flowchart 7 can help choose the right guarding solution.

If guarding is not possible, hazards must be minimised. Flowchart 8 covers the minimum requirements for a safe system of work.

#### 6.4.7 PROJECT PLAN

Once the business case is accepted, a project plan is usually developed. Health and safety implications and information about hazard management should be included in the project plan.

### 6.5 CONSTRUCTION OF MACHINERY

All machinery should be soundly built. Machinery should also be built so it is free from dangerous vibrations when in use. This includes any cutter fitted to a machine running at full speed or at idle.

### 6.6 VALIDATION AND VERIFICATION

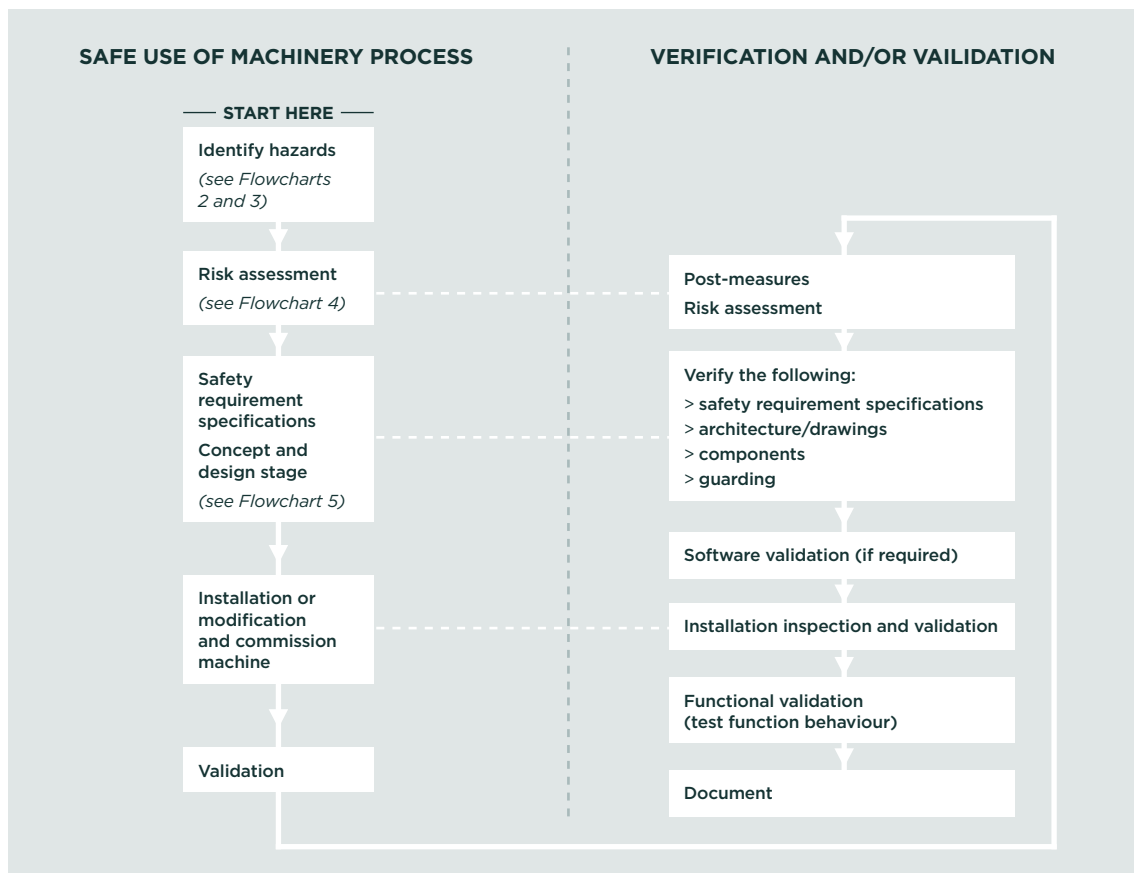
In the flowchart 6, the left hand column specifies steps in the process of ensuring the safety of a machine. The right column lists procedures carried out to test and ensure the safety of a machine.

- > **Verification** – did we build it right?
- > **Validation** – did we build the right thing?

#### 6.6.1 VALIDATION – IS IT CORRECT, SAFE AND FIT FOR PURPOSE?

Safety validation is a documented examination of the machine and its processes. The examination must be done to national or international guidelines or standards. The examination compares the actual status of the machine or work with what it should be.

Anyone doing a validation needs extensive knowledge of the equipment and how it should work. The person must be competent to compare the machine's safety features and performance to the planned results established by the safety requirement specifications and risk assessment.



Flowchart 6: Validation and verification

Validation verifies that the safety design was put in place correctly and checks that the machine works safely and meets the safety requirement specifications. Depending on the machine, validation can include:

- > reviewing machine risks
- > examining mechanical guarding
- > examining safety-related control circuits (eg electrical, pneumatic, hydraulic)
- > examining safety-related software
- > functional validation
- > examining essential health and safety requirements (eg noise, ergonomics).

### 6.6.2 VALIDATION STEPS

The following are some recommended steps to take to complete the validation process.

### 6.6.3 RISK ASSESSMENT AFTER MODIFICATIONS AND CHANGES

This is done by the person in charge of the validation once the risk reduction methods have been put in place on the machine. It should include descriptions of how the machine was made safe to operate and any minor hazards remaining should be noted. If new hazards have appeared as a result of any modifications, these must be noted and controlled.

### 6.6.4 SAFETY DESIGN CONTROL AND SOFTWARE VALIDATION

Validation must also check the design of controls and how the software functions.

#### **6.6.5 INSTALLATION VALIDATION**

This can include:

- > physical inspection of machine
- > review of guarding design
- > check that reach distances meet the ergonomics of machine guarding requirements
- > electrical inspection
- > hydraulic inspection
- > pneumatic inspection
- > ensure components are fit for purpose
- > system architecture meets the needs of risk assessment and safety requirement specifications
- > inspection of components for things like damage and correct mounting
- > check that wiring and piping match drawings and are labelled correctly.

#### **6.6.6 FUNCTIONAL SAFETY VALIDATION**

Each safety feature is individually tested and validated; for example, each emergency stop is pressed and what happens is compared to what the safety requirement specifications say is supposed to happen.

#### **6.6.7 ESSENTIAL HEALTH AND SAFETY REQUIREMENTS VERIFICATION**

Assess the machinery for other hazards. Flowcharts 2 and 3 can help in this assessment.





# 07/

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## **GUARDING TYPES - ISOLATE**

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### **IN THIS SECTION:**

- 7.1** Types of guards that isolate the hazard
- 7.2** Machine guarding and ergonomics

This section covers the types of machine guarding available and the situations where it is generally used. Depending on the situation, a combination of two or more safeguards may be needed to keep workers safe.

## 7.1 TYPES OF GUARDS THAT ISOLATE THE HAZARD

### 7.1.1 FIXED GUARDS

Fixed guards are physical barriers that keep people out of dangerous areas during normal use, maintenance or cleaning. The need to adjust drive belts and transmission chains, other machinery parts, can affect guard design.

Fixed guards can be:

- > **permanent** - welded into or part of the body of the machine
- > **removable** - but they can only be removed when the machine is stopped with a special tool that is not easily available to operators. Do not use wing nuts, wedge inserts or anything that can be undone with the fingers.

Barriers or fences held securely in place with fasteners or other suitable devices can stop access to dangerous areas.

Machine guards should be made of substantial materials (such as sheet steel, wire mesh) that cannot be easily damaged.

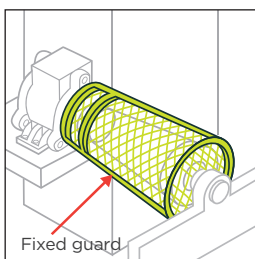


Figure 19: Example of a fixed guard

### 7.1.2 INTERLOCKED GUARDS

Interlocked guards work by cutting power to the machine when the guard is opened. They are a good guard to use when a machine needs to be accessed often.

If parts keep moving when the machine is not working, you must use a type of guard that cannot be opened until all parts have stopped moving, or fit devices that stop the machinery. Any brakes fitted to machinery must be well maintained.

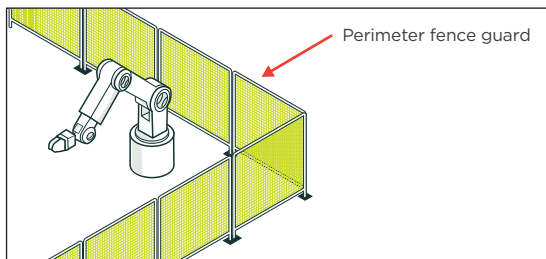
Use a suitable anti-freefall device with interlocked rise and fall guards on machine tools that can injure if they freefall under gravity.

Power-operated guards should work with a minimum of force so they do not create a trapping hazard. Where it is not possible to reduce the closing force of a guard, fit a safety trip device to the leading edge of the guard that will stop and reverse the guard if it contacts an object, like a hand.

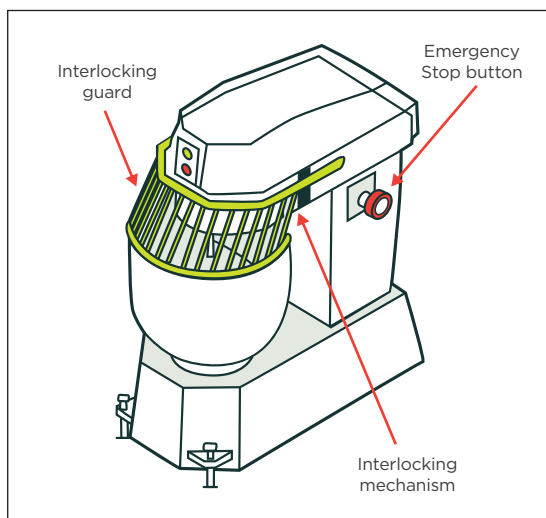
With barriers like fences, there is a danger that machines can start when someone is close to them, such as when an interlocked door accidentally closes and the machine re-starts. To avoid this hazard, fit devices to stop an interlock door or gate closing accidentally (such as a spring or gravity latch, which need a deliberate action from someone to close the door).

Interlocked guards must be designed so that any failure or loss of power does not expose people to danger. The design also needs to consider the possibility of someone being inside the area enclosed by the guard when someone tries to start the machine.

Only after doing a risk assessment can you know what type of safety device to install with the guard, and the level of integrity of the related control circuitry. If needed, more information is available in *AS 4024.1501 Safety of Machinery: Part 1501: Design of Safety Related Parts of Control Systems – General Principles for Design*.



**Figure 20:** Perimeter fence guard with fixed panels and interlocking access door



**Figure 21:** Food mixer with an interlocking guard

### 7.1.3 SAFE BY POSITION

This method of hazard management relies on putting dangerous machinery parts out of reach of people. The problem with this method is that people can often use ladders, furniture or machine parts to reach the hazard. This method needs policies and practices in place to make sure that the protection is not compromised.

When deciding how far away to put dangerous machinery, also consider how maintenance people will get access, such as by ladder, scaffold or mobile elevating work platform.

### 7.1.4 TRIP GUARDS

When other guarding methods are not practical, you can use trip guards. A trip guard is designed to cut the power if someone reaches into a dangerous part of a machine.

However, if this system fails, there is no physical barrier to stop people touching dangerous parts. All safety trip guards should be hardwired to the machine control and power brake systems.

## 7.2 MACHINE GUARDING AND ERGONOMICS

Ergonomic principles cover how a worker uses and works with a machine. Making sure workers cannot reach past the guarding into the machine is a key part of machine guarding and isolating the people from hazards.

Typical ergonomic principles include:

- > the nature of operator postures and movements
- > the ease of physical operation
- > the effects of noise and temperature
- > the lighting environment
- > the clarity and location of manual controls
- > the design of dials, markings and displays.

PART OF BODY	GAP (MAXIMUM SIZE OF ANY APERTURE OR OPENINGS IN THE MACHINERY)	MINIMUM SEPARATION DISTANCE FROM DANGER ZONE
Fingertip	4mm	2mm
Finger	6mm	20mm
Arm	20mm	850mm
Arm (reaching above head)		2,700mm

Table 2: Separation distances and gaps

Reach is limited by the length of arms, fingers and hands, legs and feet. The distance a person can reach sets the minimum height for some guards or the minimum distance of barriers from the hazard.

The average size and reach of humans is used to set design criteria. There will be some people – the very tall or very slender – whose size means they are not fully protected by the standard measurements given. Protect these people using the more restricted measurements in the following publications:

- > *AS 4024.1801 Safety Distances to Prevent Danger Zones Being Reached by the Upper Limbs*
- > *AS 4024.1802 Safety Distances and Safety Gaps – Safety Distances to Prevent Danger Zones Being Reached by the Lower Limbs.*

### 7.2.1 DANGER ZONE SEPARATION DISTANCES

Use Table 2 above to assess the risk in equipment and the design and positioning of guards. The minimum separation distances are based on people with long arms, hands and fingers. The gaps are based on people (over 14 years old) with small fingers and hands.

The separation values are more conservative than values calculated from the *Ergonomics of Machine Guarding Guide*. Where needed, more information is in *AS 4024.1801 Safety of Machinery: Part 1801: Safety Distances to Prevent Danger Zones Being Reached by the Upper Limbs*.

The anthropometric data used in this standard was based on information available when the standard was developed. Better sources may become available. If your workforce is significantly different from the general population, you may need to take your own measurements.

If someone can fit an arm through a gap, the hazard assessment should also consider any smaller openings inside the machinery.

If the arm can be bent at:

- > the elbow – the minimum separation distance from the elbow to any danger zone should be 550mm
- > the wrist – the minimum separation distance from the wrist to any danger zone should be 230mm.

### 7.2.2 LOCATION OF DISTANCE GUARDS

Distance guards should be at least 1600mm tall and at least 900mm away from the danger zone; further or higher if there is a projectile hazard.

If the guard is between 1000mm and 1600mm tall, it must be at least 1500mm away from the danger zone. No guards should be less than 1000mm high.



# 08/

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## **GUARDING TYPES - MINIMISE**

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### **IN THIS SECTION:**

- 8.1 Power controls**
- 8.2 Other guarding requirements**
- 8.3 Other control measures**
- 8.4 Providing information on machinery**
- 8.5 Safe systems of work**
- 8.6 Monitoring and reviewing effectiveness of control measures**
- 8.7 Keeping documents and records**

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**This section details the type of guarding and control options that will only minimise the likelihood of harm occurring. These controls should only be used if the hazard cannot be eliminated or isolated.**

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These guarding options generally protect more than one person and are called group controls. Pictures in this section show guards in yellow and emergency stop buttons in red.

### **8.1 POWER CONTROLS**

The power control is the device on a machine that controls the flow of energy to the prime mover. This energy may be:

- > electricity
- > hydraulic oil under pressure
- > compressed gas.

The power control should be able to stop the flow from all energy sources. Interlocks and labels should clearly indicate where there is more than one energy source and stop all sources of energy to the prime movers.

**HSE Regulation 66 requires that plant and power control placement are designed with ergonomic principles.**

The power controls should be:

- > able to open all energy sources (such as all phases of a three-phase electrical supply)
- > built and shrouded so the machine cannot be started accidentally
- > clearly identified, with labels giving information on when and how to start the machine
- > convenient to use and placed using sound ergonomic principles away from dangerous parts
- > fail-safe, in case the energy supply is cut

- > lockable in the off position when a person at the controls might not be able to see staff working on the machine (refer also to section 8.1.11 of this guideline)
- > showing the direction of the movement of the controls, which match up to the motion of the moving parts
- > unable to be locked out in the on position
- > unable to indicate off position if it is in fact in the on position.

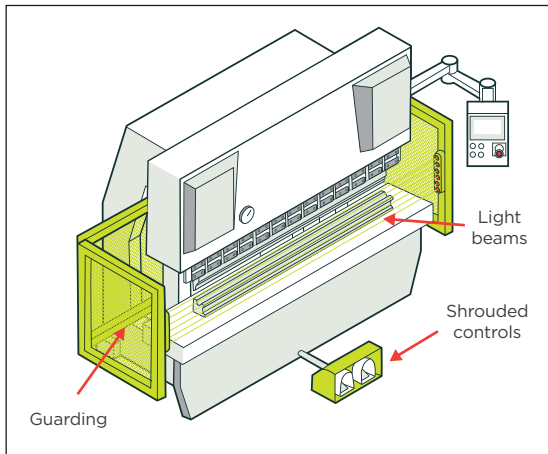
Hydraulic controls should be either dead-man or hold-to-run type with anti-tie down, so that if the control is released the machine stops moving.

When a machine's power falls to a low level or stops completely, exposing parts of the machine, this can create a significant hazard when the power is restored. The machine should need the deliberate operation of the power control to start the dangerous parts.

If the machine operator cannot see the whole machine, a warning device must alert people either visually, by sound or both before the machine restarts.

#### **8.1.1 PHOTOELECTRIC SAFETY DEVICES**

Photoelectric safety devices use light beams that stop machines working when the light beam is broken. This method is often used when fixed or interlocked mechanical guards are not practical. However, if the system fails, there is no physical barrier to stop people being exposed to the hazard. Photoelectric devices can be set to control how much anyone can enter a restricted space, such as a hand but not the arm, or an arm but not the body.



**Figure 22:** Example of a photoelectric light curtain used as a trip guard

Single light beams are not normally suitable because people can reach around the light beam and access the hazard. You can use a number of light beams so there are no gaps that people can reach through, around, under or over. When any of the beams are broken, the power is cut.

Consider carefully what distance a light beam curtain is placed from the hazard. If it is too close, someone can reach through the light curtain to danger faster than the control system can stop the machine. If the beam is too far away, someone can stay inside the protected area without interrupting the light beam.

You can use extra protection (such as extra light beams/curtains, safety mats or laser scanners) to monitor the area inside the light curtain. You can use photoelectric safety devices with other types of guard to make a safe zone where an operator has to access the machine frequently.

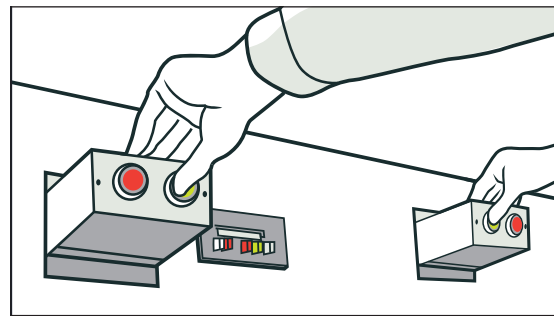
As photoelectric systems can fail without visible warning, any failure must not put a user at risk.

Photoelectric safety devices should meet and be installed to high performance standards, such as the International Electrotechnical Commission standard *IEC 61496 Safety of Machinery – Electro-Sensitive Protective Equipment*.

### 8.1.2 AUTOMATIC PUSH-AWAY GUARDS

With this type of guarding, a barrier moves towards the user when they approach the hazard making them step back, out of reach of the hazard. If push-away guards are not carefully designed and maintained then they too can become a hazard. Users need thorough training to safely use machinery guarded like this.

### 8.1.3 TWO-HAND CONTROLS



**Figure 23:** Example of a two-hand control

Only use this method to isolate people from machinery hazards as a last resort. Even when used properly, two-hand controls only protect the machine operator, not other people who may be near.

Two-hand controls should:

- > need to be turned on together (so people cannot tape one control down)
- > need to be held to run, so the machine stops immediately when the control is released
- > be spaced well apart and shrouded so one arm cannot run both controls.

The rear and sides of the machine should be guarded by fixed guards to prevent stop access by other people.

### 8.1.4 PRESSURE-SENSITIVE MATS

Pressure-sensitive mats are designed to cut the machine's power if someone steps on them to access a dangerous part. Only use pressure-sensitive mats when you cannot use physical barriers or other methods of isolating people from hazards.



Pressure-sensitive mats use a number of well-spaced electrical or fluid switches or valves in a mat. The mat covers any entries to a restricted space. Pressure on the mat stops the automatic operation of the machine. You should design the guard so no one can step over or around it into a restricted area.

Operate and maintain pressure-sensing safeguard systems to the manufacturers' instructions. Keep records of any maintenance, inspection, commissioning and alteration to a presence-sensing system, as well as any test results. Make sure workers and health and safety representatives can access the records.

Because pressure-sensitive mats do not usually show any visible sign of failure, use a control system that shuts down the machine if a mat fails.

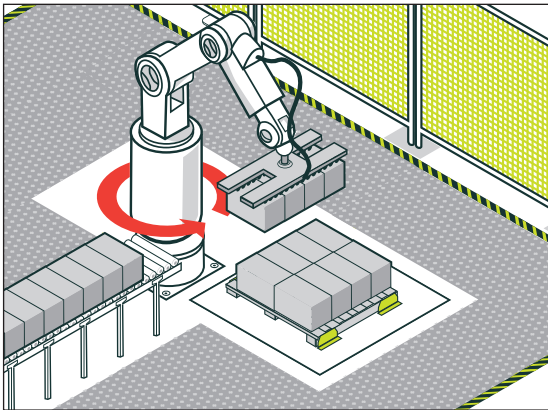


Figure 24: Pressure mat enclosing a robot

### 8.1.5 LOCKED GUARDS AND GATES

Locking guards and gates need a responsible person (usually a manager) to hold the key at all times. This person must also make sure the gate is not opened until the machine is switched off, isolated and has stopped.

Only use locked guards and gates if after diligent trials, there are no practical alternatives. Senior management in association with staff should also write, approve and monitor any safe operating procedures and monitor the effectiveness of the safety process as a temporary means to minimise the hazards.

Isolation, hold cards and lock-out devices (see section 8.1.11 of this guideline) can also be used so a machine is not accidentally restarted.

### 8.1.6 ADJUSTABLE GUARDS

Adjustable guards are made up of a fixed guard with adjustable elements that are moved to suit each task. They can be:

- > **self-adjusting** - guards that are forced open by the entry of work
- > **distance guards** - barriers that can be moved to a safe distance from the danger zone.

Guards that move out of the way for each operation (automatic guards) need special care. Hazards can be created between the guard and:

- > machine
- > person
- > work piece.

Staff need full training on using and adjusting these guards. These guards are only effective when the people use them correctly.



Figure 25: The self-adjusting guard over the cutting wheel swings back as the cutting wheel cuts through steel

### 8.1.7 EMERGENCY STOP DEVICES

Emergency stop devices should not be the only method used to control hazards. They are only a backup for other control measures. They should be red with a yellow background. Do not use emergency stops to lock-out the machine because the actuators can separate from the contacts. If this happens, the control will show the machine is off but it is actually on.

Do a hazard assessment when choosing an emergency stop device and consider:

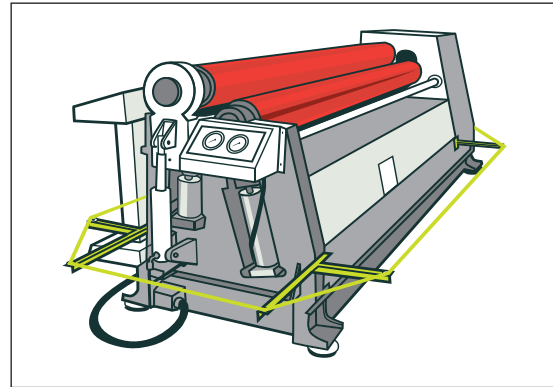
- > whether part of the machine still needs to work in an emergency situation
- > what other safety features still need to work (such as pressure release valves)
- > whether the stop introduces any new hazards
- > what level of integrity any associated circuitry needs.

Make sure emergency stop devices:

- > are prominent, and clearly and durably marked
- > are immediately accessible to each user of the machine
- > have red handles, bars or push buttons (labelling can also be used)
- > are not affected by electrical or electronic circuit failure.

Other considerations include:

- > whether stop devices should be easily seen in contrast to their surroundings
- > the best access for workers - ideally they are near where someone can be trapped in the machine
- > the environment the machine is used in (eg whether the device is exposed to dust, chemicals, temperature extremes or vibration)
- > the number of emergency stop devices needed (if the machine is large, several devices or pull wires may be needed)
- > a manual way to reset an emergency stop device
- > a regular testing routine to check the device still works.



**Figure 26:** The green line shows the emergency stop cord on the rollers that act as a trip guard

Badly placed emergency stop devices may slow shutdown in an emergency and encourage dangerous practices, such as:

- > reaching across moving parts
- > failing to shut down machinery when there is a problem
- > allowing one worker to start the machine while another is in a dangerous location (like cleaning a machine).

When there is more than one device, use a safe procedure so machinery cannot restart during maintenance or other temporary situations (such as a blockage of product). A lock-out and tag-out system is essential to isolate the machine from a power source to stop accidental start-up.

When servicing emergency stop devices, actuators can separate from contacts, meaning the machine appears to be off, but because of the fault it is still on. This why emergency stops are unsafe to use as a means of lock-out.

### **8.1.8 COLOUR CODING**

It is good practice to paint safety guard posts or frames yellow and any mesh black so it can be seen through more easily and staff do not need to open the guards for observation as much.

So workers can easily see when a guard is out of place, it is good practice to:

- > use high visibility yellow paint for the guard that is different from the machine's colour
- > paint surfaces behind the guard a bright or contrasting colour (like blue or red).

### **8.1.9 LOCK-OUT SYSTEMS AND ISOLATION PROCEDURES**

Lock-out systems are used to safely isolate machinery from its power source. They are used when someone needs to inspect, repair, maintain, alter or clean the machine, or when it is to be withdrawn for assessment or repair. The method used to isolate depends on the type of machinery. Employers should develop these safe operating procedures with employees. Once a procedure has been put in place it should be strictly obeyed.

Employers must make sure there is a safe system to isolate all machinery from power sources.

They must:

- > have procedures to prepare a machine for the application of isolation devices, locks and tags
- > train and instruct workers in the system so they are competent to isolate or lock-out and tag-out machinery
- > give supervision to make sure that isolation procedures, are followed.

Workers trained in the safe system of isolation for machinery must make sure the system is followed at all times.

If the machine is powered by electricity, the employer or principal should have a qualified electrician remove and keep the fuses. Where other sources of power are used, the parts that are removed to achieve isolation should also be kept in a place where they can not be accessed by other workers.

If access to machinery is required and it is not practical to stop it, employer, principal or duty holders must ensure that:

- > the machine is fitted with operating controls that allow controlled movement
- > there are written procedures to be followed for inspections, repairs, maintenance, alteration and cleaning
- > people working on the machine carry out the work in accordance with the written procedures.

### **8.1.10 COMPETENT PERSON FOR PLANNED ISOLATION**

The competent person must be the key person to:

- > stop and isolate the machine
- > minimise any risks associated with identified hazards (including telling any workers who may be affected by isolating the machine).

The competent person must make sure:

- > all energy sources are de-energised and isolated using an isolation device, and locked out using a lock-out device
- > all energy-isolating devices are activated and all switches and valves are in the off or safe position, to stop any attempts to activate the machine
- > stored energy is released or restrained, including, for example, completing the cycle of a flywheel, releasing steam and bleeding valves
- > an out-of-service tag is fixed to the machine and danger tags are fixed to the energy sources and operating controls
- > tests are in place to de-energise and isolate the energy sources, to make sure the machine cannot be re-energised
- > the machinery is isolated before any inspection, repair, maintenance, alterations, cleaning or withdrawal happens.

The competent person who isolated the machinery must be the one to remove the lock-out equipment and make the machine operational again. A procedure should be in place where this is not possible (such as where work is done over a number of shifts or the worker has gone home sick).

If the competent person cannot complete all steps in a planned isolation, they must make sure a competent person develops written procedures and that these are followed by the person doing the work.

**8.1.11 ISOLATION, HOLD CARDS AND LOCK-OUT DEVICES**

Chains, clasps and locks are examples of devices that can be used to isolate machinery. Isolation devices must be reliable and clear. Each lock should:

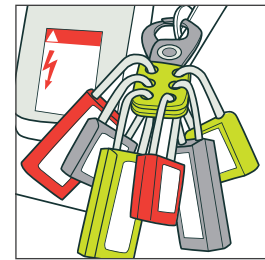
- > be strong enough to take physical abuse, either intentional or unintentional
- > be made of material suitable for the environment
- > have only one key and one owner who is responsible for it.

Master or spare keys should be kept in a designated place, away from the workplace and under the control of a competent person. There must be strict procedures about when to use spare keys. They must only be used in an emergency after thorough safety checks are done.

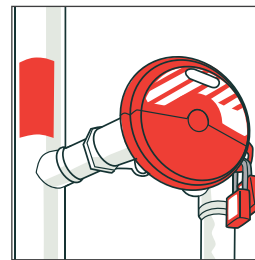
Lock-out and tag-out cards should be used together and be attached to the power controls of isolated machinery. This reduces the chance of someone starting the machinery inadvertently. The cards must clearly state that under no circumstances should the machinery be connected to the power source or be started until the hold card is removed by the person named on the tag-out card. Include advice on the tag-out card of the actual or potential danger, where appropriate.



*Tag and lock*



*Multiple locks*



*Valve lock and tag*

**Figure 27:** Shows various types of tag-out and lock out devices that can be used

Lock-out devices make sure people are out of the danger area before a machine can be started. They are mechanical-locking mechanisms used to physically lock machinery controls so they cannot be used.

Use lock-out devices when people have to work on or inside machinery and are out of sight of other people in the workplace. Anyone who has to work in a hazardous area should have a lock-out device that identifies who is protected by the device. The lock used with these devices should be durable and must only have one key, held by the operator.

Tag-out cards are sometimes referred to as danger tags, restricted-use tags and warning tags. Use a tag out card with lock-out devices and isolation to improve staff safety.

**8.2 OTHER GUARDING REQUIREMENTS**

The duty holder must ensure that fences or guards are:

- > constantly maintained
- > of substantial construction for their intended purpose
- > kept in position while the machinery is used.

Even when there are mechanical methods to control hazards, other ways to minimise risk might still be needed, such as safe work systems or protective clothing and equipment (see section 8.3). Do not use only non-mechanical control measures to control hazards. They rely on human behaviour and need commitment management and enforcement to work effectively.

### **8.3 OTHER CONTROL MEASURES**

There are control measures that minimise the risk of harm that can be used with machine guarding. Some of these control measures are systems and others are activity-based, such as maintenance.

#### **8.3.1 DEVELOPING WORK PROCEDURES**

Work procedures are needed to make sure that hazard control measures are effective.

All work procedures must:

- > define responsibilities for management, supervisors and workers
- > have systems to make sure appropriate guarding is bought and correctly installed
- > explain how workers will be trained and supervised to make sure the machinery is only used with the guarding in place
- > require workers to follow the work procedures
- > have arrangements to maintain the machine and guards
- > have a system for workers to report malfunctions or problems with machinery
- > have emergency procedures and training for staff on what to do.

#### **8.3.2 CONSULTATION AND COMMUNICATION**

Involving workers and health and safety representatives in hazard management is essential. They are most likely to know about the hazards of their work. They can help develop measures to eliminate, isolate or minimise hazards before an injury or incident occurs when:

- > new machinery is introduced
- > changes are made to existing machinery
- > changes are made to how they work.

#### **8.3.3 TRAINING INFORMATION**

Employers must train workers, supervisors and others so they can use hazard control measures and work safely.

#### **8.3.4 SUPERVISION**

Operators and workers must be supervised by a competent person to make sure hazard control measures are used correctly.

#### **8.3.5 MAINTENANCE**

Work procedures should identify any maintenance needed to keep control measures effective. Looking at maintenance of control measures is an important part of the implementation process.

So maintenance can be done safely, consider:

- > the ease of accessing parts
- > ensuring machinery parts are safe to maintain
- > ease of handling
- > designing machinery to reduce the range of tools and equipment needed for maintenance.

#### **8.3.6 PERSONAL PROTECTIVE EQUIPMENT**

Employees may need personal protective equipment when working with machinery that makes heat, fumes, noise or other hazards. Personal protective equipment must be provided by the employer and maintained and replaced when required. Standards New Zealand have a range of guidance relating to personal protective equipment.

### **8.3.7 FIRST AID**

Every workplace should have first aiders and first aid supplies. Employers should put first aid provisions in place based on the types of accidents, injuries and illnesses that could occur in the workplace. For more information, see WorkSafe NZ's *First Aid for Workplaces: A Good Practice Guide*.

## **8.4 PROVIDING INFORMATION ON MACHINERY**

Employers must give staff this information in a way workers can easily understand it – be aware of language and literacy issues.

Employers may also need to give information to others who enter the workplace, including cleaners, visitors and contract staff.

This could be a machinery instruction handbook or other written instructions that include:

- > a publication date and revision details (if the information has been redrafted or updated)
- > any transport, handling or storage requirements, including the machine's dimensions, weight and lifting points
- > information about installation and connecting to a power source, including any assembly information and power supply requirements.

Specific information about an individual machine should include:

- > a detailed description of the machine (including any fittings, guards or protective safety devices)
- > reference to any machinery safety standards used in its design, including any mandatory requirements (eg conformance declaration, verification of design)
- > details of any emissions (eg noise, fumes, dust) the machine makes when running.

### **8.4.1 SPECIFIC USER INFORMATION**

Written information for the user should include:

- > the machine's intended use
- > a description of the machine's controls (especially emergency stops)
- > operating instructions, including start-up preparations, process change-over and shutting down
- > common faults and any reset instructions the user may need
- > any guards or protective safety devices for particular hazards
- > safety sign descriptions and details
- > any prohibited uses or likely misuse
- > any hazards the manufacturer could not eliminate
- > any personal protective equipment that needs to be used
- > any training that is needed.

### **8.4.2 MACHINERY INFORMATION**

A wide range of information sources can be used to help identify hazards, including:

- > employee and health and safety representative participation and involving those working with the machinery
- > Australian, Australia/New Zealand, New Zealand or European standards
- > manufacturer's instructions and advice
- > maintenance logs of machinery
- > documentation of safe work practices and their effectiveness
- > injury or incident information and hazard alerts
- > relevant reports from occupational health and safety agencies, unions, employer and professional bodies
- > articles from health and safety journals
- > safety information from safety authorities on the Internet.

### 8.5 SAFE SYSTEMS OF WORK

A safe system of work is a formal work procedure developed after a systematic examination of a task to identify all the hazards. It defines safe ways to work so hazards and risks are minimised. When hazards cannot be completely eliminated or isolated, you may need to use a safe system of work.

An competent person must agree that a safe system of work is the only way to control a hazard. In this case, a competent person is someone with current knowledge and understanding of:

- > AS 4024 and other relevant standards
- > the guards and other safety devices
- > how to use guards and other devices on that type of machine.

A safe system of work should never be used as the main hazard control without first assessing whether the hazards can be eliminated, or isolated with guarding, either provided by the manufacturer or retro-fitted to existing machinery.

Workers need extra training, more supervision and other protective measures when using a safe system of work. These also need to be documented.

### 8.6 MONITORING AND REVIEWING EFFECTIVENESS OF CONTROL MEASURES

Once control measures are in place, they must be regularly monitored and reviewed. To do this, it is useful to ask the following questions.

- > Have control measures been implemented as planned?
- > If control measures have not been implemented, why not, and what is happening in the meantime?
- > Are the control measures being used correctly?

- > Are the control measures working?
- > Have the control measures isolated or minimised the risk from the hazard as intended?
- > Have the control measures made any new hazards?
- > Have the control measures made any existing hazards worse?

In order to answer these questions, you may need to:

- > talk with workers, supervisors and any health and safety representatives
- > measure levels of exposure (eg take noise measurements where a noise source was identified)
- > refer to manufacturers' instructions
- > monitor incident reports
- > contact industry associations, unions, government bodies or health and safety consultants.

When deciding when to monitor and review control measures, consider:

- > the level of risk – high risk hazards need more frequent assessments
- > the type of work practices or machinery involved
- > whether new methods, tasks, equipment, hazards, operations, procedures, rosters or schedules have been introduced
- > whether the environment has changed
- > any indication that risks are not being controlled.

### 8.7 KEEPING DOCUMENTS AND RECORDS

Documenting your chosen control measures helps show you have met your legal obligations. Keep records to track what has been done and what is planned; effective record-keeping can save time and money.

The level of documentation should be appropriate for the level of risk and control measures.





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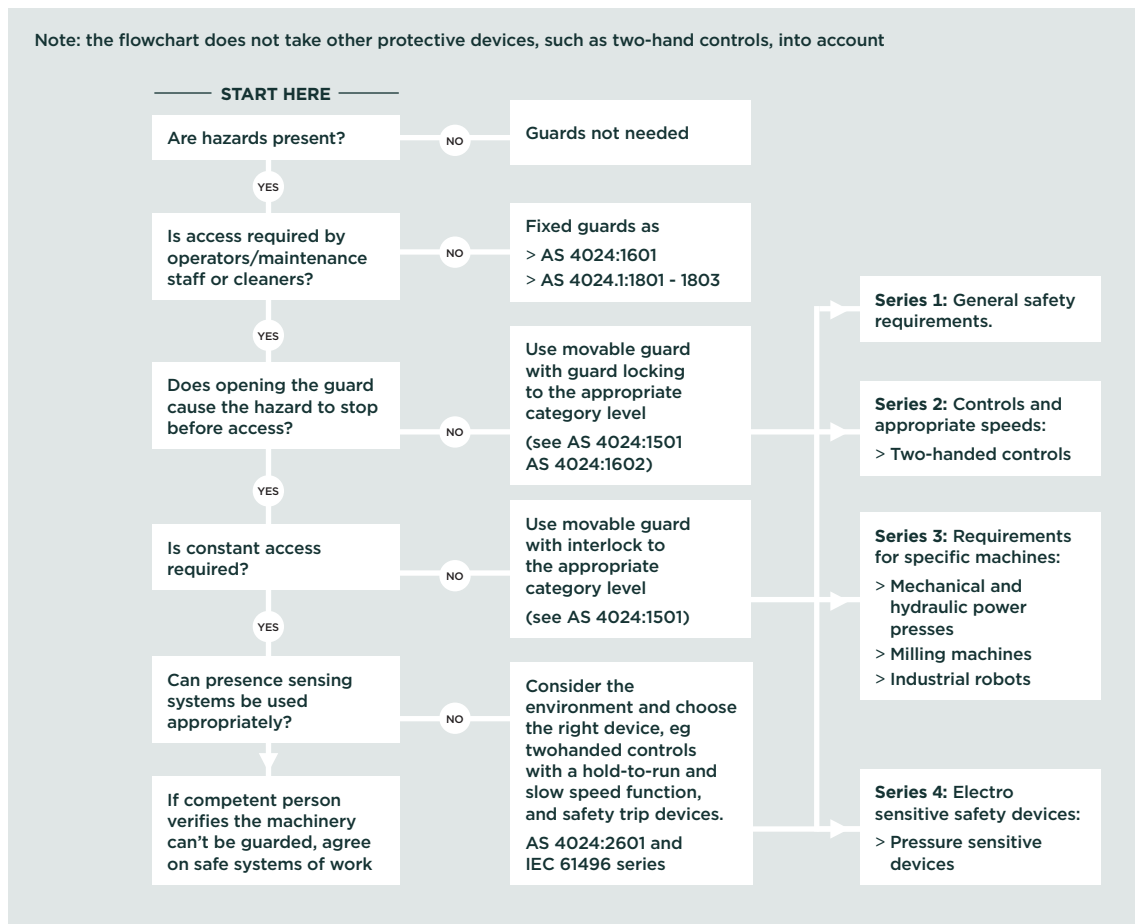
## **CHOOSING THE RIGHT GUARD**

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### **IN THIS SECTION:**

- 9.1 Choosing a guard**
- 9.2 Basic rules for guard design**
- 9.3 Guarding of operational and non-operational parts**
- 9.4 Choosing the material for guards**
- 9.5 Servicing and maintenance considerations**
- 9.6 Guards for exposed rotating cutting machinery**
- 9.7 Pulleys and drives**
- 9.8 Rotating shafts and rollers**
- 9.9 Conveyors (bulk handling)**
- 9.10 Press brakes**
- 9.11 Robotics**

Choosing the right guard for the machine will create a physical barrier between a worker and the dangerous parts of the machinery. When choosing guards, careful attention to design and layout, and the use of the machine, can remove many health and safety hazards and can prevent health issues and injuries occurring.



Flowchart 7: Choosing a guard

Flowchart 7 details how to make decisions around the most appropriate guard taking into account whether the machine parts require access.

Sections 7-11 of the HSE Act describe a way to identify hazards, manage health and safety issues, and follow up on health and safety matters.

## 9.1 CHOOSING A GUARD

Machine guarding options in order of preference:

- > if access is not needed during normal operation, maintenance or cleaning, use a permanently attached physical barrier
- > if access is needed during normal operation, maintenance or cleaning, use an interlocked physical barrier

- > if opening the guard stops the hazard before access, use a moveable guard with guard locking interlock, and safety switches of an appropriate category level. Category levels are outlined in AS 4024 and a summary can be found in Flowchart 7 of this guideline.

If constant access is needed:

- > use a safety interlock system that meets the appropriate rating in its failsafe control category (a hazard and risk assessment determines what failsafe category is needed)
- > add extra protections to minimise hazards, such as safety trip devices, accessible emergency stops, slow speed and/or two-hand hold-to-run control devices.

If there is no practicable way to guard a hazard, a safe system of work must be put in place (see section 10 of this guideline).

## 9.2 BASIC RULES FOR GUARD DESIGN

The basic rules for guard design are:

- > use materials of suitable strength and good quality
- > use the right guard. Custom-designed is best – poorly designed or inappropriate guards can cause injuries
- > the environment and the needs of operators and maintenance workers affect how well a guard works.

If a guard is used from another machine, check carefully that it:

- > is not faulty
- > fits the target machine
- > is strong enough for the new use
- > controls the risk.

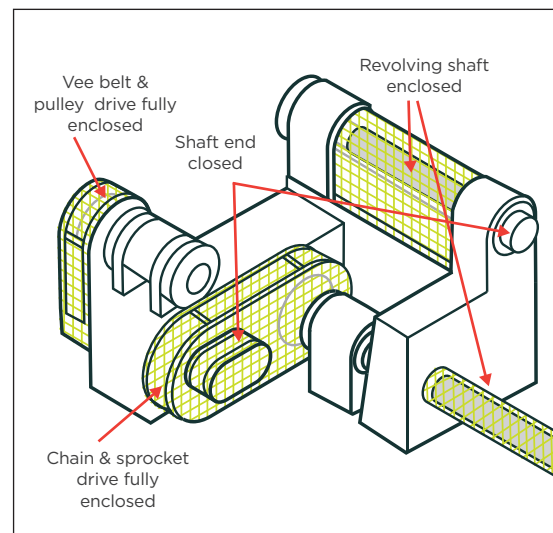
## 9.3 GUARDING OF OPERATIONAL AND NON-OPERATIONAL PARTS

When deciding what needs to be guarded, look at operational and non-operational parts of the machine. Start with obvious operational parts such as:

- > rollers – mills
- > saws – circular and band saws
- > drills and drill chucks
- > cutters in metal working machines, including the blades of guillotines and the tools of power presses
- > beaters.

Then consider non-operational parts such as:

- > chains and sprockets
- > belts and pulleys
- > gears (including rack and pinion sets)
- > shafts (plain or threaded)
- > flywheels.



**Figure 28:** Examples of machine guards isolating various hazards

## 9.4 CHOOSING THE MATERIAL FOR GUARDS

There are four main considerations when choosing material to make a guard:

- > **strength and durability** – use of non-metallic materials in corrosive environments
- > **effects on machine reliability** – a solid guard may cause the machine to overheat

- > **visibility** – there may be operational and safety reasons for needing a clear view of the danger area
- > **control of other hazards** – eg the use of a material that will not eject molten metal.

### 9.5 SERVICING AND MAINTENANCE CONSIDERATIONS

When designing guards, consider what safe procedures are needed for their removal for repair, clearing jams and breakdowns.

Servicing matters to consider include:

- > following documented safe work procedures, including manufacturers' instructions
- > proximity to hot or sharp parts
- > cool-down or warm-up periods
- > run down periods
- > lock-out provisions or permission for guard removal
- > enough room to do tasks without risk of injury or strain
- > stored energy in the machine or materials being processed
- > any additional hazards from maintenance procedures – such as testing while the machine is unguarded (a 'dry run' or 'trial run'), working at heights, use of solvents
- > maintaining or updating service records.

Maintenance considerations include:

- > where servicing is needed
- > how much servicing is needed
- > what kind of servicing is needed
- > how often servicing needs to be done.

### 9.6 GUARDS FOR EXPOSED ROTATING CUTTING MACHINERY

Exposed rotating cutting machinery includes:

- > cut-off saws
- > milling machines

- > friction cutting equipment
- > boring equipment.

Hazards arise from the exposed blades and risks include cutting people or entanglement.

Guards (or visors) that move must stay close to the work piece. The cutter's teeth can be exposed if the visor is:

- > not attached to the fixed guard
- > in a poor position
- > jams in the open position.

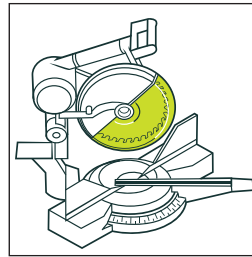


Figure 29: Self-adjusting guard for a drop saw

### 9.7 PULLEYS AND DRIVES

Pulleys and drives are used in many machines. Nip-points are the main hazard. They must be guarded so no one can get entangled.

Interlocked guards are preferable for pulleys and drives. In some cases, a hinged section may be appropriate to access the machine when setting it. Design and install the guard so a tool is needed to remove and replace it.

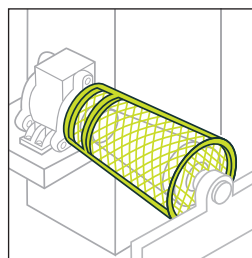


Figure 30: Fixed guard for a pulley and drive preventing access to transmission machinery

## 9.8 ROTATING SHAFTS AND ROLLERS

Interlocked guards are preferable for rotating shafts and rollers, such as:

- > couplings
- > spindles
- > fan-shafts
- > ironing rollers.

Guards should stop loose clothing and long hair getting caught in rotating shafts. In addition to a guard, it may be appropriate to tell operators not to wear loose clothing (such as long-sleeved shirts or jackets) and tie long hair back or wear a head covering.

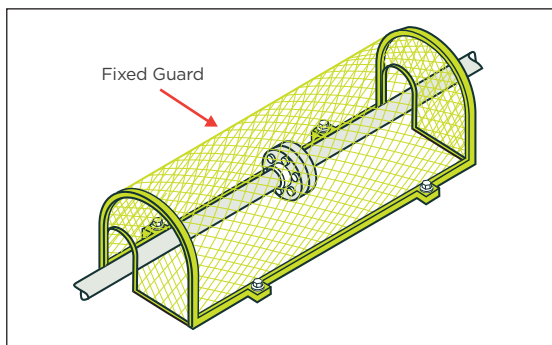


Figure 31: Fixed guard on rotating shaft or coupling

## 9.9 CONVEYORS (BULK HANDLING)

Conveyors move materials from one place to another. Types include belt, screw and bucket conveyors.

### 9.9.1 HAZARDS

The main hazards of a conveyor are the many in-running nip-points, which can entangle, crush and abrade people. The drive system can also pose risks of entanglement or abrasion.

### 9.9.2 CONTROL MEASURES

Fixed guards that enclose in-running nip-points and the drive mechanism are usually the best way to guard conveyors.

Large conveyors, such as stockpilers, generally need both carry idlers and return idlers guarded where they are under high tension and accessible. This should be done to an appropriate standard, such as *AS 1755 Conveyors – Safety Requirements*, *AS 4024.3610 Conveyors – General Safety Requirements* or equivalent.

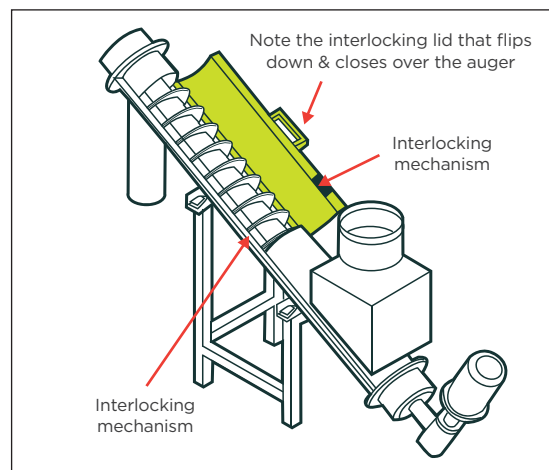


Figure 32: Typical guard for head and tail section of a conveyor

### 9.9.3 ELECTRICAL ISOLATION (LOCK-OUT AND TAG-OUT)

Electrical isolation safeguards (which prevent access during most phases of machinery life) may not be effective when hazardous areas need to be accessed, such as during maintenance and set-up.

Because of this, conveyors should have appropriate drive power isolation, whether its power source is electrical, hydraulic, pneumatic or mechanical. A lock-out and tag-out system should secure isolation.

### 9.9.4 START AND STOP CONTROLS

Each conveyor start location needs a clearly labelled 'stop' control. If any part of the conveyor operation cannot be seen from the start control, there must be a visible or audible signal to warn people nearby.

### 9.9.5 EMERGENCY STOP CONTROLS

A lanyard-type pull-wire emergency stop is the best emergency stop for exposed belt conveyors where workers must access the belt area while the conveyor is in use (such as when placing and removing parcels at a transport depot).

The lanyard type means wherever someone is working on the conveyor, they can reach the emergency stop. Emergency stop controls should be manually reset before the conveyor can be restarted from its normal start control.

### 9.9.6 ACCESS PROVISIONS

The machine design should let people do routine adjustment and lubricate and maintain the machine without removing guards or much taking apart. Wherever practical, people should be able to lubricate and maintain the machine from outside the danger area. If people need access to the danger area (such as for machine setting), use safe isolation procedures.

### 9.9.7 TRAINING

Make sure people working around conveyors are trained on how to use the machinery and are aware of the potential hazards.

### 9.9.8 MORE INFORMATION

*AS 1755 Conveyors – Safety Requirements and AS 4024.3610* (or equivalent) give more information on minimum safety requirements for the design, installation and guarding of conveyors and conveyor systems and training.

## 9.10 PRESS BRAKES

A press brake is a variable stroke machine generally limited to straight bending and forming of material, such as sheet metal and heavy gauge material.

### 9.10.1 HAZARDS

For press brakes, the main hazards are:

- > the die sets mounted to the main moving beam and table coming together to form the product
- > the work piece and the press frame coming together in the fold-forming process.

The impact from both can have a pinching, crushing, cutting or shearing motion, which creates a risk to the operator of being crushed or cut.

Drive belts on press brakes have in-running nip points, which present a risk of entanglement and abrasion. Hydraulic hoses may leak or burst, causing slip hazards and workers getting sprayed with hydraulic fluids under pressure.

### 9.10.2 CONTROL MEASURES

The front dies of a press brake and its sides and rear require guarding. Three forms of guarding for the front of the dies on a press brake are:

- > a fixed guard
- > interlocked guard
- > a light or presence-sensing system.

Where workers have to hold or stabilise the material, or need frequent access to closing dies, presence-sensing devices may be required to ensure safe operation. Presence-sensing devices may be light curtains or light beams. Automatic stops should also be guarded and back-gauging equipment is recommended.

Presence-sensing devices (cameras, light curtains or light beams) may not protect the operator in all circumstances.

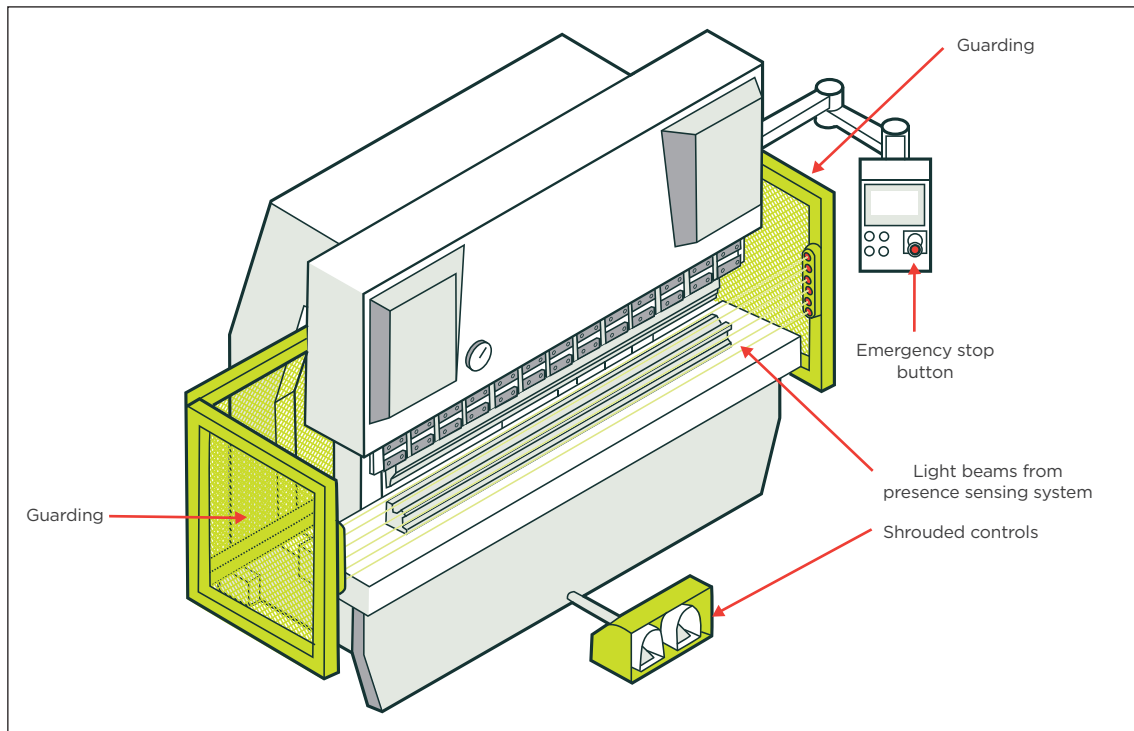


Figure 33: Press brake with fixed guards and a presence-sensing light curtain

### 9.10.3 SAFE SYSTEM OF WORK FOR PRESS BRAKES

On occasions it may not be possible to perform work with the guarding system in place. Removal of or turning off a guard should only occur if the guard makes it impracticable to perform close work or jobbing and a hazard and risk assessment is carried out by a competent person. A safe system of work must be developed in conjunction with the employer and operators and approved by a competent person with appropriate knowledge and experience of machine safety.

In cases where guarding of any moving parts of the plant does not eliminate risks of entanglement, or where it is not practicable to guard the parts, people must not operate or pass close to the moving part unless a safe system of work is in place to reduce the risks.

Additional training, experience and higher levels of supervision, and other protective measures may be required and will need to be documented. For more information on safe systems of work see section 10 in this guideline.

### 9.10.4 CLOSED TOOL METHOD

The closed tool method of reducing the press brake's opening to 6mm limits the risk of introducing a part of the body into this hazardous zone. The distance between the point of the upper tool and the top of the bottom die is where the 6mm is measured from.

Where possible, the closed tool method should be used with a safety light curtain, a laser beam device or a two-hand control device.

## 9.11 ROBOTICS

Using robots can remove the more traditional hazards of working with machinery. They can do high-risk work, such as in the biotechnology field.

It is wrong to think that robotic operations are safe just because there is little or no worker interaction. Hazards when using robotics can come from:

- > errors during use
- > ejection of materials
- > trapping points
- > failures and malfunctions.

Hazards can also come up during installation, repair and maintenance. There may also be biological, chemical or environmental hazards.

A hazard assessment should be done to ensure workers' safety during all phases of the machinery's life and use. Follow a hazard management process (with reference to the manufacturer's instructions) during installation or commissioning, testing, start-up, repair and maintenance.

### 9.11.1 HAZARDS AND RISKS

Robots have inherent dangers. Some of the hazards of industrial robot use include:

- > **Impact.** Robots can move at high speed in an unexpected direction either in a straight line or circular directions. The robot can also eject work pieces, off-cuts or molten metal. Workers are at risk from being hit by the robot or parts of the work.
- > **Trapping points.** These can be made by the robot's movement or other equipment – such as work carriages, pallets or transfer mechanisms. With the robot itself, trapping points are found on the arm of the robot, between the arm and the column, and between the arm and fixed objects. Workers can be crushed by or entangled with the robot, including being crushed between a rapidly rotating robot arm and barriers close by.

- > **Control errors.** These come from faults in the control system of the robot (such as software, electrical interference, programme corruption and sub-controls associated with the electrics, hydraulics and pneumatics).
- > **Human error.** These can happen during programming, teaching, maintenance and repair, working close to the robot or at loading or unloading stations.
- > **Failure or malfunction.** Electrics, hydraulics and pneumatics can all create hazards when they fail.
- > **Biological or chemical hazards.** These can happen when robots are used to reduce the risks from hazardous or infectious processes. Workers may risk inhaling or absorbing hazardous substances. In this case, the work process needs close attention, along with any breakdown or emergency procedures that may be needed – such as for spillage, contamination or breach of the system.
- > **Environmental hazards.** These include dust vapours, fumes, lasers, noise, radiation and flammable and explosive atmospheres that can cause serious harm, such as burns and inhaling or absorbing hazardous substances and hearing loss.

### 9.11.2 CONTROL MEASURES

Industrial robots can be made safe using one or more guarding and presence-sensing devices. Control measures include:

- > enclosing the robot
- > restricting access
- > turning the robot off when people are near.

**Designers, manufacturers and suppliers of robotic systems have the same obligations as designers, manufacturers and suppliers of other machinery (HSE Regulations 66 and 67, and section 18A of the HSE Act).**



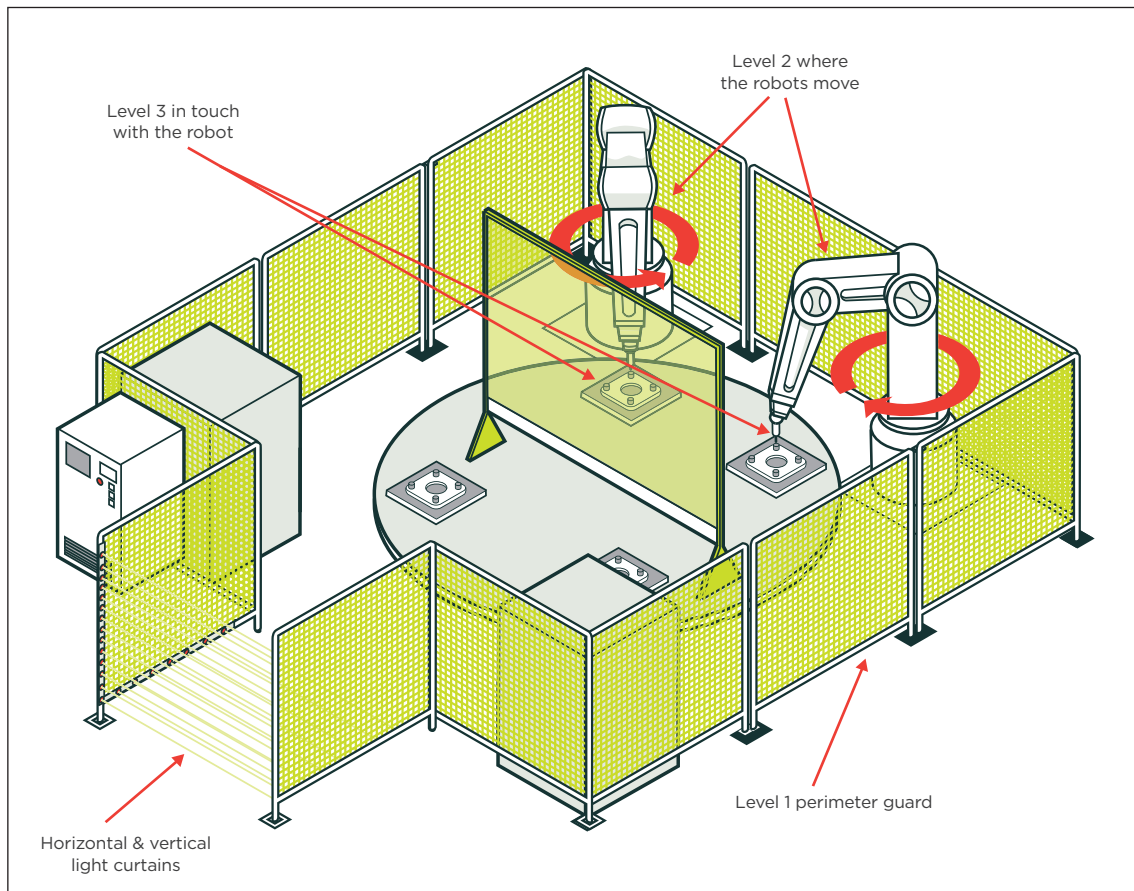


Figure 34: Robot cell showing Levels 1, 2 and 3

Robot safety has different hazards and precautions in each of the three levels around a robot workstation.

1. Level 1 is the workstation perimeter, usually a physical barrier guarded with an interlock gate and possibly with presence-sensing devices.
2. Level 2 is within the workstation (where the robot moves). Here safety systems should detect if someone is present, usually with presence-sensing devices.
3. Level 3 is contact with the robot. A safety system should detect a person touching the robot and stop it moving immediately using safety trip devices or sensors.

Fixed or distance guards at (Level 1) are practical as long as the guard does not interfere with the mechanism of the robot. Someone should have to use tools to remove the guards to enter the restricted danger area. Guards or fences should be placed so people cannot reach into a restricted area. Any openings for feeding material in should be designed to keep every part of a person away from any hazard.

To stop trapping, any fixed barriers should be at least 500mm from the robot work envelope (extreme reach of the robot arm and tooling).

Design and place presence-sensing devices (such as photoelectric curtains) to detect if anyone enters a restricted space or danger area (Level 2). The device must stop the automatic operation of the robot when entry is detected. Operation must also stop if this device fails.

You can use laser scanners or pressure-sensitive mats as a back-up safety protection for high-risk machinery in areas inside the primary light curtain. This way the system cannot restart while someone is inside the area protected by a light curtain.

### 9.11.3 ADDITIONAL CONTROL MEASURES

Because robots are highly technical and programmable, consider extra safeguards beyond just guarding moving parts. These include making sure:

- > only competent people can access and start the robot system
- > no one can access the robot through or by removing associated equipment, such as conveyors, transfer systems, loading stations or trolleys.

If people have to enter the robot cell (Level 2) while the robot is working, the control system should make sure the robot runs with reduced force. The robot also needs a sensor to stop it immediately if it hits someone.

Safe operating procedures also minimise some of the risks of working with robotics. A safe work system needs procedures for entry, including who can access the robot to do identified tasks, maintenance and repair. Inspecting and maintaining a robot can present different hazards from working with the robot. Assess all hazards for risks.

Staff must be trained to control the hazards of working with industrial robot machines. Inadequate training can increase risks at most stages of robot operation.

### 9.11.4 CONTROL SYSTEMS

Robots usually have programmable electronic start and control systems. These should be protected from unauthorised access, such as by putting them in a lockable cabinet or room. Make and place controls so people cannot accidentally start the robot. This can be done a number of ways, including shrouding, guarding, gating or appropriate positioning.

If people can access the robot, it must be isolated from its power source.

For more information see AS 62061 *Safety of machinery – Functional Safety of Safety-Related Electrical, Electronic and Programmable Electronic Control Systems*. AS 4024.3301 *Safety of machinery – Robots for industrial environments – Safety requirements*

### 9.11.5 MASTER SWITCHES

Robots should have master switches to cut power to any moving part of the robot. This can be the same device as an emergency stop. You should be able to lock the master switch in the isolating position so it needs to be manually reset.



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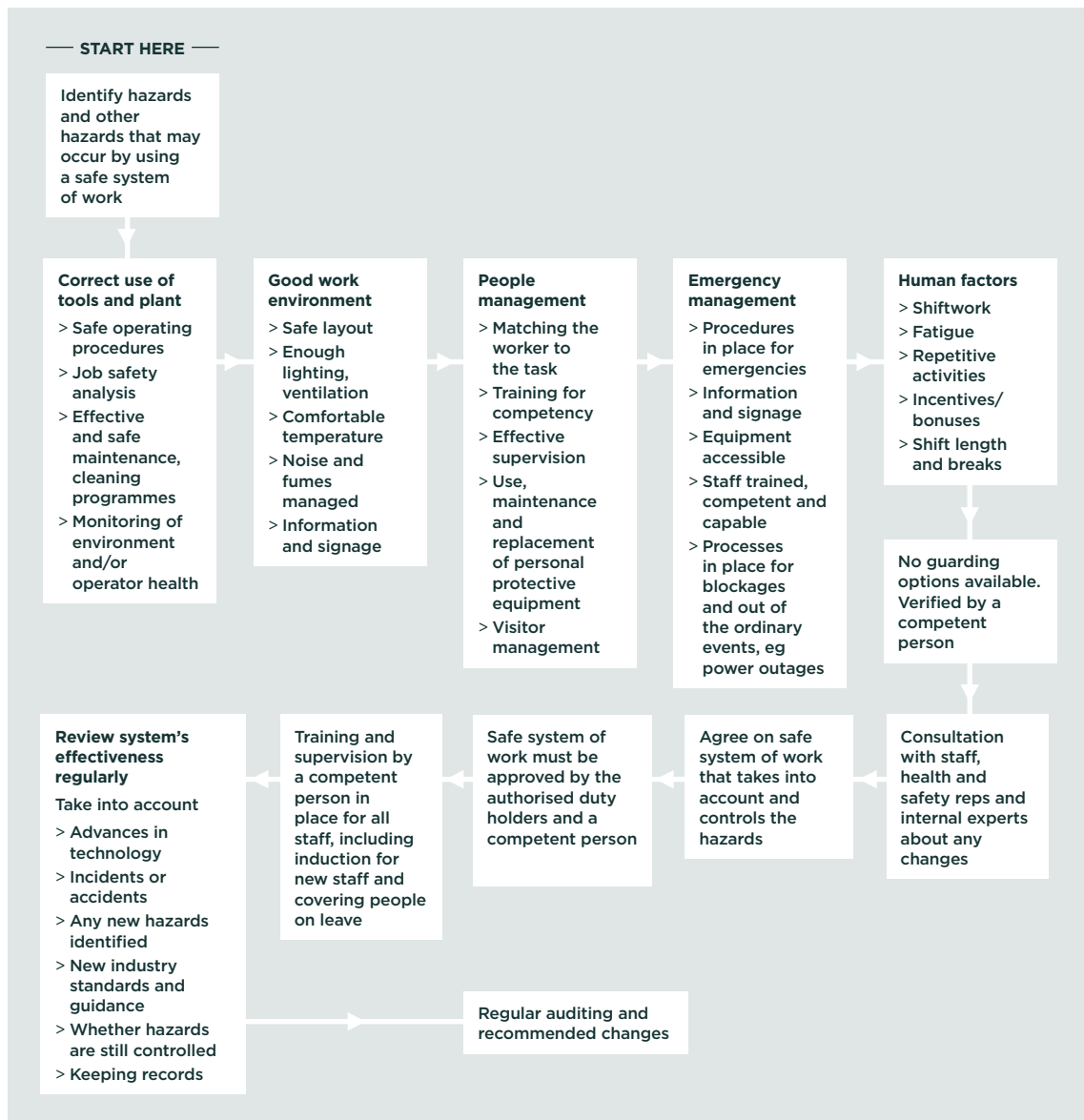
## **SAFE SYSTEMS OF WORK**

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### **IN THIS SECTION:**

- 10.1 Participation and consultation**
- 10.2 Hazard management**
- 10.3 Competency of operators and supervisors**
- 10.4 Emergency procedures**
- 10.5 When guarding is not an option**
- 10.6 Agreement and sign-off**
- 10.7 Competent person**
- 10.8 Reviewing**

In this guideline, a safe system of work means the steps which if followed, will minimise the hazard arising from doing a specific task or set of tasks, as far as practicable.



Flowchart 8: Developing and maintaining a safe system of work for specific tasks

Flowchart 8 gives details of the key factors that should be considered when developing a safe system of work.

Apart from assessing guarding options for machinery, all workplaces must have safe systems of work in place for tasks and processes that take into account:

- > hazards and controls
- > human factors
- > emergency management
- > people management
- > the work environment
- > correct use of tools and plant.

### **10.1 PARTICIPATION AND CONSULTATION**

For the safe system of work to be robust, anyone who could come in contact with the machine should be consulted. This includes:

- > operators
- > supervisors
- > health and safety representatives
- > maintenance staff
- > in-house engineers
- > any health and safety experts.

### **10.2 HAZARD MANAGEMENT**

Before a safe system of work can be put in place, employers must identify and assess all hazards, such as:

- > the work environment (eg layout, lighting, ventilation)
- > human factors (eg people's capabilities, shift work, fatigue)
- > the use and maintenance of personal protective equipment.

Then they must develop a way to control each hazard, such as:

- > safe operating procedures
- > job or task safety analysis
- > effective and safe maintenance
- > cleaning and blockages procedures
- > procedures for unexpected events, like power outages.

### **10.3 COMPETENCY OF OPERATORS AND SUPERVISORS**

Any operator using a safe system of work must be competent to do the job and be supervised by a competent person. Employers must have a training programme in place that works for:

- > new employees
- > existing employees
- > employees on leave when the safe system of work was introduced.

### **10.4 EMERGENCY PROCEDURES**

Emergency procedures must be in place and staff trained to use them. This includes information, signage and emergency equipment.

### **10.5 WHEN GUARDING IS NOT AN OPTION**

A workplace cannot opt for a safe system of work that does not include guarding to control a hazard, without first considering all possible guarding controls.

### **10.6 AGREEMENT AND SIGN-OFF**

Once agreement is reached on what a safe system of work is for a machine, the duty holders (employer or principal) must approve it, along with a competent person and document it.

### 10.7 COMPETENT PERSON

Before designing a safe system of work, a competent person must establish that all possible guarding options were considered, they must explain why none could be used, and give advice on the residual risks that remain. The competent person must also be consulted and approve the safe system of work.

Any proposed changes should involve anyone previously consulted on the safe system of work. The system and any changes need testing before they are included in the safe working system and approved by the duty holder.

### 10.8 REVIEWING

Every safe system of work needs regular reviewing to take into account:

- > advances in technology
- > incidents or accidents
- > any new hazards identified
- > new industry standards and guidance
- > whether the hazards are still controlled
- > monitoring of the environment and/or health of operators.





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## APPENDICES

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### IN THIS SECTION:

- 11.1 Definitions
- 11.2 Example of hazard checklist
- 11.3 Sample job safety analysis (JSA)
- 11.4 Summary of the AS 4024 Safety of machinery series
- 11.5 Example risk assessment process
- 11.6 Flowcharts
- 11.7 More information

## 11.1 DEFINITIONS

Please note some these definitions are based on the Health and Safety in Employment Act 1992 (HSE Act) but should not replace legal advice.

**All practicable steps** is defined in the HSE Act.

Briefly, it means doing what is reasonably able to be done in the circumstances, taking into account:

- > the severity of any injury or harm to health that may occur
- > the degree of risk or probability of that injury or harm occurring
- > how much is known about the hazard and the ways of eliminating, reducing or controlling it
- > the availability, effectiveness and cost of the possible safeguards.

**Current state of knowledge** is what is known about the hazard or risk, including actual or potential harm, and ways of eliminating, isolating or minimising the risk.

**Dynamic forces** are forces resulting from movement of an object, in this case movement of a machine.

**Functional validation** of a machine is the process of testing that a safety-related device performs as the designer intended.

**Group control** is a control that protects more than one person in the vicinity of the machine in addition to the operator.

### Harm

- a. means illness, injury, or both; and
- b. includes physical or mental harm caused by work-related stress.

### Hazard

- a. means an activity, arrangement, circumstance, event, occurrence, phenomenon, process, situation, or substance (whether arising or caused within or outside a place of work) that is an actual or potential cause or source of harm; and

b. includes

- i. a situation where a person's behaviour may be an actual or potential cause or source of harm to the person or another person; and
- ii. without limitation, a situation described in subparagraph (i) resulting from physical or mental fatigue, drugs, alcohol, traumatic shock, or another temporary condition that affects a person's behaviour.

**Inching** means limited motion of machinery where dangerous parts of machinery are exposed during cleaning, setting, adjustment or feeding material and, depending on the machine and industry, may include the terms jog, crawl and pulse.

**Ionising radiation** is radiation with enough energy so that during an interaction with an atom, it can remove tightly bound electrons from the orbit of an atom, causing the atom to become charged or ionised. Examples are x-rays and gamma rays.

**Machine life cycle** is the process beginning with design, continuing through manufacture, sale, transport, installation, test, use and maintenance, ending in disassembly and disposal.

**Machinery** is a collective term for machines and their parts. A machine is considered to be any apparatus that has interrelated parts and is used to perform work; machines may include an engine, motor, or other appliance that provides mechanical energy derived from compressed air, the combustion of fuel, electricity, gas, gaseous products, steam, water, wind, or any other source; and includes:

- a. any plant by or to which the motion of any machinery is transmitted; and
- b. a lifting machine, a lifting vehicle, a machine whose motive power is wholly or partly generated by the human body, and a tractor.

**Non-ionising radiation** is in the electromagnetic spectrum where there is insufficient energy to cause ionisation. It includes electric and magnetic fields, radio waves, microwaves, infrared, ultraviolet, and visible radiation.

**Plant** includes:

- a. appliance, equipment, fitting, furniture, implement, machine, machinery, tool, and vehicle; and
- b. part of any plant, the controls of any plant, and anything connected to any plant.

It is a general name for machinery, equipment, appliance, implement or tool and any component or fitting or accessory of these. It can include things as diverse as presses in a foundry, excavators and trucks in mining, and photocopiers in an office. It can range from electric drills, lifts, escalators, tractors, hand trolleys, cranes, and other lifting gear to arc welding gear.

**Prime mover** means an engine, motor, or other appliance that provides mechanical energy derived from steam water, wind, electricity, gas, gaseous products, or any other source. It includes any device which converts stored or potential energy into movement or mechanical energy.

**Risk** means a combination of probability and the degree of possible injury or damage to health in a hazardous situation.

**Safe by position** means so positioned that any person cannot reach or gain access to the dangerous parts.

**Safety requirement specifications** is the means by which the hazards of a machine or process are controlled to reduce risks of harm to those working at or near the machine or process.

**Safe operating procedures** are written instructions that detail the steps that will be performed during a given procedure; including information about hazards and how these hazards will be controlled.

**Safe system of work** means a formal procedure which results from systematic examination of a task in order to identify all the hazards. It defines safe methods to ensure that hazards are eliminated or risks minimised.

**Safety life cycle** refers to the safety of the machine, its assembly, its functioning and decommissioning at the end of its life.

**Securely fenced** means so guarded that the arrangements provided ensure that the dangerous part is no longer dangerous. There is no longer a reasonably foreseeable risk of injury to any person employed or working in the place of work, even a person who is careless or inattentive while in the vicinity of a machine or using a machine.

**Shall** and **must** are used in this guideline in places where there is a legal requirement to achieve the desired result.

**Should** is used in this guideline as a way of indicating a preference. It does not indicate a mandatory requirement as other alternatives may achieve an equivalent result.

**Supplier** is anyone who sells or hires out machinery. They have a number of legal responsibilities.

**Swarf** is metal removed from a workpiece during machining. It may be in the form of small 'chips', tightly curled strips, or long 'ribbons'.

**Transmission machinery** is a mechanism that transfers movement from the prime mover to the machine. It can be a shaft, wheel, drum, pulley, system of fast and loose pulleys, gearing, coupling, clutch, driving belt, chain, rope, band or other device.

**Validation** is the process of confirming that all required steps of the safety life cycle are tested, implemented, working and verified.

## 11.2 EXAMPLE OF HAZARD CHECKLIST

SAFE USE OF MACHINERY CHECKLIST		
Check	Present status	Recommendations
<b>Guarding requirements</b>		
Do guards stop workers touching dangerous moving parts?	Yes/No	
Are guards firmly secured and not easily removable?	Yes/No	
Do guards stop objects falling into the moving parts or from exploding out of the machine?	Yes/No	
Do guards allow safe, comfortable and easy use of the machine?	Yes/No	
Can the machine be maintained without removing the guard?	Yes/No	
Can the existing guards be improved?	Yes/No	
Are there safe procedures in place and a way to shut down the machine if something out of the ordinary happens, like a blockage?	Yes/No	
<b>Mechanical hazards: point of operation</b>		
Is a guard on the machine at every point of operation where there is a hazard?	Yes/No	
Does the guard keep the operator's hands, fingers and body out of the danger area?	Yes/No	
Have the guards been tampered with or removed?	Yes/No	
Is there a more practical or better guard?	Yes/No	
How can point of operation hazards be removed?	Yes/No	
Are the tools used for placing and removing material the right length, type and size to keep an operator's hands out of the machine?	Yes/No	
<b>Operator controls</b>		
Are start and stop controls in easy reach of the operator?	Yes/No	
If there is more than one operator station, are separate controls placed where operators can see the entire operation?	Yes/No	
Are controls, including foot controls, guarded against being turned on accidentally?	Yes/No	
Are controls labelled clearly with their function?	Yes/No	

**BEST PRACTICE GUIDELINES // SAFE USE OF MACHINERY**

Are controls similar in type and arrangement to other similar machines in the plant?	Yes/No	
Are emergency stop controls easily reached and clearly identified?	Yes/No	
Is the machine wired so it must be manually re-started if power is cut and then put on again?	Yes/No	
<b>Mechanical hazards: Power transmission</b>		
Are gears, sprockets, pulleys or flywheels guarded?	Yes/No	
Are there any exposed belts or chain drives?	Yes/No	
Are there any exposed sets, key ways, collars, etc?	Yes/No	
Are all hazardous moving parts guarded, including auxiliary parts?	Yes/No	
Are start and stop controls in easy reach of the operator?	Yes/No	
If there is more than one operator, are there separate controls?	Yes/No	
<b>Other hazards</b>		
Are other hazards like noise, fumes and vibrations identified and managed?	Yes/No	
Have special guards, enclosures, or personal protective equipment been provided to protect workers from exposure to hazardous substances?	Yes/No	
Have hazards associated with layout, repetitive movements and workload been identified and managed?	Yes/No	
<b>Electrical hazards</b>		
Is the machine regularly tagged and tested? If so, how often?	Yes/No	
Are there loose conduit fittings?	Yes/No	
Is the power supply correctly fused and protected?	Yes/No	
Do workers occasionally get minor shocks while using any of the machines?	Yes/No	

<b>Training and supervision</b>		
Are operators and skilled workers trained and competent to use the guards?	Yes/No	
Are production workers trained in: > where the guards are > how they give protection > what hazards they protect against?	Yes/No	
Are operators supervised by competent staff?	Yes/No	
Have workers been trained in what to do if they notice guards that are damaged, missing or inadequate?	Yes/No	
<b>Protective equipment and clothing</b>		
Is protective equipment and clothing needed?	Yes/No	
Is it right for the job, in good condition, kept clean and stored when not in use?	Yes/No	
Is the operator dressed safely for the job (no loose-fitting clothing or jewellery)?	Yes/No	
<b>Machinery maintenance, repair and cleaning</b>		
Do technicians, engineers or operators have up-to-date instructions on the machines they service or clean?	Yes/No	
Do staff or contractors lock-out machines from all energy sources before starting repairs or cleaning?	Yes/No	
Is the maintenance equipment properly guarded?	Yes/No	
Where several maintenance staff are working on the same machine, are multiple lock-out devices used?	Yes/No	
Is the machinery properly maintained and kept clean?	Yes/No	
<b>Machinery set-up</b>		
Is all machinery securely placed and anchored to prevent tipping or other movement?	Yes/No	
Is the machine laid out so it does not create hazards to operators or others in the workplace?	Yes/No	
Is there enough clearance around and between machines to allow safe operation, set-up, servicing, material handling and waste removal?	Yes/No	

**11.3 SAMPLE JOB SAFETY ANALYSIS (JSA)**

JSA number	Date	JSA team names
Clearance issuer		
Task description	Removal of guarding from No. 1 and No. 2 conveyors for routine cleaning	

Step number	Step/task description	Potential hazard	Potential consequence ranking	Likelihood ranking	Overall risk rating	Control measures	Revised risk rating
1	> Job preparation	> Lock-out not put in place > Nips and cuts > Residual gypsum	Major	Likely	Extreme	> Permit/JSA/induction current > Induction of contractors and employees are current. > Correct personal protective equipment to be worn as site procedure/clearance certificate.	High
2	> Isolate equipment as per isolation procedure. > No. 1 conveyor lock and tag off. > No. 2 conveyor lock and tag off.	> Lack of communication > Nips and cuts > Slips, trips	Major	Moderate	Extreme	> Inform affected parties before commencing isolations. > Be aware of pinch points. > Be aware of slip, trip hazards. > Follow isolation procedures.	High
3	> Using cold tools, remove end guarding as required.	> Equipment not correctly isolated > Use of tools > Nips, cuts > Manual handling > Residual gypsum	Major	Likely	Extreme	> Ensure equipment correctly isolated as before commencing. > Use correct tools for task.	High
4	> Clean end chutes on conveyors as required.	> As per standard operating procedures					
5	> Using cold tools replace end guarding as required.	> As per step 3					
6	> De-isolate the equipment as per the isolation procedure.	> As per step 2					

I have read, understand and agree to the procedure and controls documented.

<b>Person(s) performing the work:</b>	<b>Date:</b>
1.	
2.	
3.	

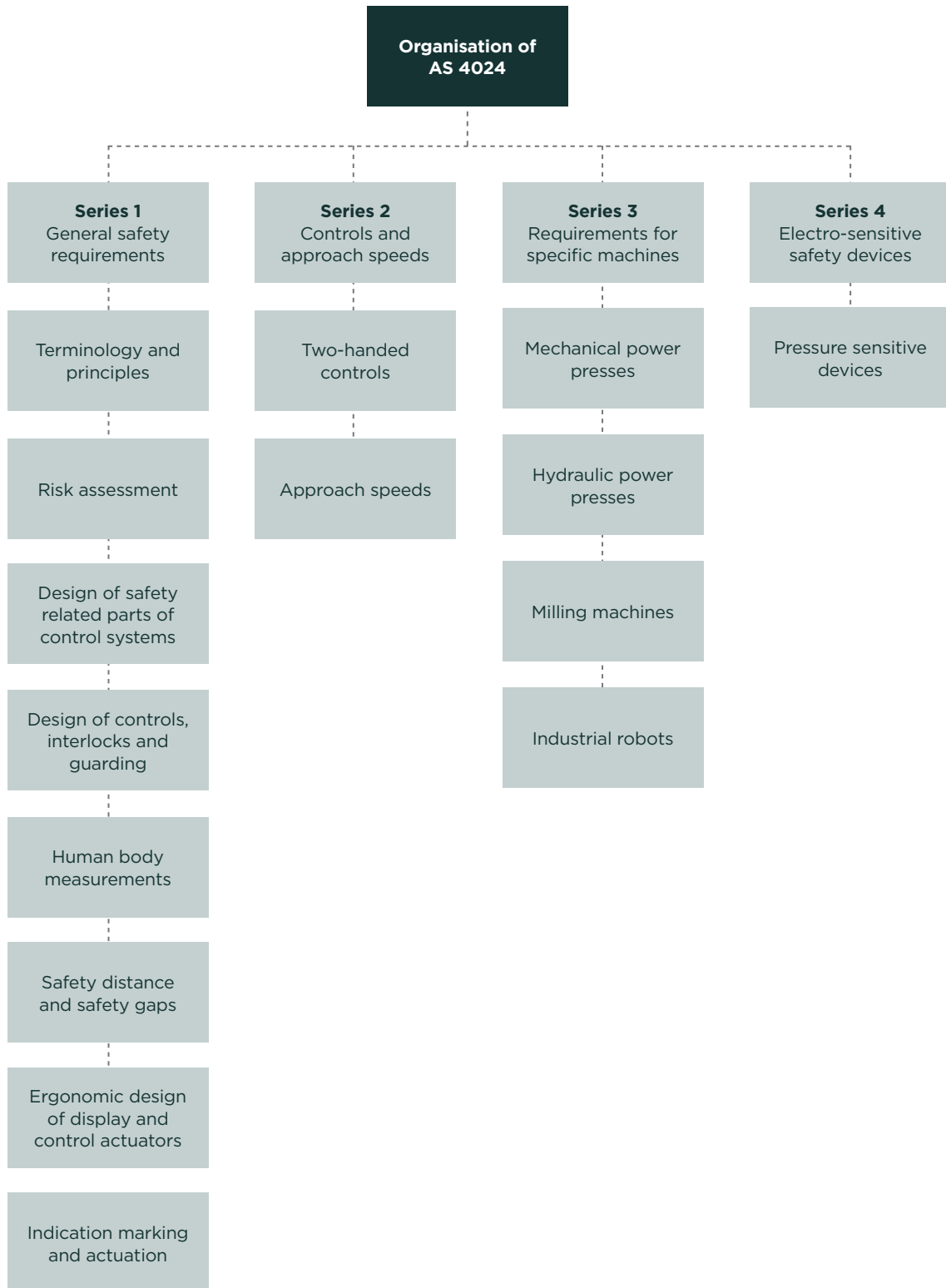
RISK RATING TABLE				
Likelihood of injury or harm to health	Consequences of injury or harm to health			
	Insignificant <i>no injuries</i>	Moderate <i>first aid and/ or medical treatment</i>	Major <i>extensive injuries</i>	Catastrophic <i>fatalities</i>
Very likely	High	Extreme	Extreme	Extreme
Likely	Moderate	High	Extreme	Extreme
Moderate	Low	High	Extreme	Extreme
Unlikely	Low	Moderate	High	Extreme
Highly unlikely (rare)	Low	Moderate	High	High

Extreme = immediate action



**11.4** SUMMARY OF THE AS 4024 SAFETY OF MACHINERY SERIES

AS 4024 is the Australian Standard for managing machinery hazards. The standard is available in four series. Their organisation is shown in the chart below.



Series 1, or to use its full title - *AS 4024.1, Safety of Machinery series*, has 26 Parts under the eight headings in the diagram above. The 26 Parts are European (EN) and Internationally based (ISO) safety and design standards with some modifications to meet Australia's safety practices and regulations.

The series gives designers, manufacturers, suppliers, employers and users of machinery guidelines to help reduce the risks of working with, or near machinery.

Designers, manufacturers, suppliers, employers and users of common manufacturing machinery not listed above can find specific guidance in:

- > *AS 1755 Conveyors - Safety Requirements*
- > *AS 1788 (series) Abrasive Wheels*
- > *AS 1473 (series) Wood Processing Machinery.*

People looking for more information about electro-sensitive safety devices (beyond what is in AS 4024 Series 4) should find it in IEC 61496 (series) Electro-sensitive Protective Equipment.

## **AS 4024.1-2006 SAFETY OF MACHINERY INCLUDES:**

### **SAFETY PRINCIPLES**

#### **Terminology and principles**

*AS 4024.1101 Terms and definitions*

Gives users a set of terms and definitions that are used in other machinery safety standards, as well as in discussions of machinery safety.

*AS 4024.1201 Basic terminology and methodology*

Specifies the basic terminology and methodology to be used by designers to achieve safety of machinery.

*AS 4024.1202 Technical principles*

Defines the technical principles needed to design safe machinery. Does not deal with injury to domestic animals, property or the environment.

#### **Risk assessment**

*AS 4024.1301 Principles of risk assessment*

Specifies principles for doing a risk assessment so the knowledge and experience of the harm related to machinery is gathered together to help assess risks during all phases in the life of machinery. Gives guidance on the information needed to carry out risk assessments and a brief outline of some of the techniques available.

*AS 4024.1302 Reduction of risks to health and safety from hazardous substances emitted by machinery - Principles and specification for machinery manufacturers*

Gives principles for controlling risks to health from the emission of hazardous substances from machinery.

### **Ergonomic principles**

*AS 4024.1401 Design principles – Terminology and general principles*

Specifies the ergonomic design principles and terminology to be used by designers.

### **DESIGN PARAMETERS**

#### **Design of safety-related parts of control systems**

*AS 4024.1501 General principles*

Gives safety requirements and guidance on the principles to be used in the design of the safety features of machinery control systems. Categories are specified and the characteristics of the safety functions are described.

*AS 4024.1502 Validation*

Specifies the conditions and procedures to be followed for the validation by both analysis and testing of safety functions provided and safety category achieved by the safety-related parts of control systems using the design rationale, including risk analysis, provided by the designer. When validating programmable electronic systems, this standard does not give complete requirements and needs the use of other standards such as the AS 61508 series.

#### **Design of controls, interlocks and guarding**

*AS 4024.1601 Guards – General requirements for the design and construction of fixed and moveable guards.*

Specifies requirements for the design and construction of fixed and movable guards that protect people from mechanical hazards in machinery.

*AS 4024.1602 Principles for design and selection.*

Specifies principles for the design and selection of interlocking devices used with guards. The principles are independent of the energy sources used on the machine.

*AS 4024.1603 Prevention of unexpected start-up.*

Gives ways to stop unexpected machine start-up to use at the design stage, including energy isolation and dissipation. Applies to all forms of energy, including those external to the machine, such as wind, gravity and electro-magnetic.

*AS 4024.1604 Emergency stop – Principles for design.*

Explains what an emergency stop needs to do and gives the design principles, regardless of the energy source used to control the functions. It does not apply to hand-guided machines, hand-held portable machines or to machines where having an emergency stop would not reduce the risk to anyone.

**ERGONOMICS****Human body measurements***AS 4024.1701 Basic human body measurements for technological design*

Gives information and descriptions of anthropometric (human body) measurements that ergonomists and designers of workplaces can use to compare population groups.

Use this standard to help design work stations where people stand, sit or reach controls or other items. There are pictures to help.

*AS 4024.1702 Principles for determining the dimensions required for openings for whole body access to machinery*

Gives the smallest size an opening can be when someone has to go through it to access machinery. There may be extra requirements for mobile machinery.

Use this standard to help design openings, such as for people to walk upright through or climb via a vertical ladder. Sizes are also given for users wearing personal protective equipment or carrying an injured person.

*AS 4024.1703 Principles for determining the dimensions required for access openings*

Gives minimum sizes for access openings in machinery. Additional space needs are also given. There may be extra requirements for mobile machinery.

Use this standard to help design access openings for putting body parts into a machine. It allows for different postures, such as standing or crouching.

*AS 4024.1704 Anthropometric data*

Gives the human body measurements needed to calculate the size of access openings in machinery. The measurements come from European surveys. Use AS 4024.1701 for information on how to source human body measurements.

**Safety distances and safety gaps***AS 4024.1801 Safety distances to prevent danger zones being reached by the upper limbs*

Gives the minimum safety distances between a barrier and a danger zone of a machine to stop anyone over three years old reaching the danger zone with their arms. Only use this standard when distance alone can remove the hazard. This standard does not protect against radiation or substances coming out of the machine.

*AS 4024.1802 Safety distances to prevent danger zones being reached by the lower limbs*

Gives safety distances to keep people's legs out of danger zones of machinery. Only use these distances when distance alone can remove the hazard, and there is no chance that someone can reach the hazard with their arms.

*AS 4024.1803 Minimum gaps to prevent crushing of parts of the human body*

Gives minimum gaps in machinery to stop parts of the body being crushed.

## **DISPLAYS, CONTROLS, ACTUATORS AND SIGNALS**

### **Ergonomic requirements for the design of displays and control actuators**

*AS 4024.1901 General principles for human interaction with displays and control actuators*

Gives general principles to design displays and controls so operators can use the machine efficiently.

*AS 4024.1902 Displays*

Gives the ergonomic requirements for visual, audible and tactile displays on machines. It helps you choose, design and place any displays to avoid ergonomic hazards.

*AS 4024.1903 Control actuators*

Helps you design, choose and place manual control actuators to suit the needs of the task and the operators.

### **Indication, marking and actuation**

*AS 4024.1904 Requirements for visual, auditory and tactile signs*

Explains how to give safety information, using sight, sound and touch. It sets out a system of colours, signs, markings and other ways to show hazards and help in emergencies.

*AS 4024.1905 Requirements for marking*

Gives rules on markings on machines for:

- > identification
- > safe use
- > preventing hazards from incorrect connections.

*AS 4024.1906 Requirements for the location and operation of actuators*

Gives the safety requirements for actuators run by hand or other body part. It applies to both single actuators and groups of actuators.

*AS 4024.1907 System of auditory and visual danger and information signals*

Gives a series of danger and information signals (both sight and sound) that indicate urgency and can be differentiated from each other. This standard does not apply to signals covered by specific standards or conventions, such as fire alarms, public transport or navigation signals.

## **POSITION OF TWO-HAND CONTROLS & SAFETY SENSORS**

### **Two-hand control devices**

*AS 4024.2601 Design of controls, interlocks and guarding – Two-hand control devices – Functional aspects and design principles*

Gives the safety requirements for two-hand controls.

This standard helps you design and choose two-hand control devices, using a risk assessment. It helps stop work-arounds and faults. It also gives standards for two-hand control devices with a programmable electronic system.

**Safety distances and safety gaps**

*AS 4024.2801 Safety distances and safety gaps – Positioning of protective equipment with respect to the approach speed of parts of the human body*

Explains how to work out the minimum distances for sensing or actuating devices of protective equipment to a danger zone. The safety distances are based on hand or arm approach speeds and the response time of the machine.

These devices are:

- a. trip devices defined in AS 4024.1201 (specifically electro-sensitive protective equipment, pressure sensitive mats), including those used to start the machine
- b. two-hand control devices defined in AS 4024.1201.

**Mechanical power presses**

*AS 4024.3001 Materials forming and shearing – Mechanical power presses*

Gives the safety requirements and measures to design, build and supply mechanical presses that work cold metal or material partly of cold metal. You can use the principles in AS 4024.1 for work with hot metal and tongs, but you might not be able to apply them fully. Read this standard with AS 4024.1 (series).

This standard also covers presses intended for work with cold metal, but are used in a similar way to work other materials (like cardboard, plastic, rubber or leather) and metal powder.

The requirements in this standard take account of intended use. This standard presumes access to the press from all directions and gives the safety measures for both the operator and other people.

This standard also applies to accessories that are vital parts of the press.

**Hydraulic power presses**

*AS 4024.3002 Materials forming and shearing – Hydraulic power presses*

Gives the safety requirements and measures for hydraulic presses that work cold metal or material partly of cold metal. You can use the principles in AS 4024.1 for work with hot metal and tongs, but you may not be able of apply them fully. Read this standard with AS 4024.1 (series).

This standard also covers presses intended for use with cold metal, but are also used in a similar way to work other sheet materials (like cardboard, plastic, rubber or leather) and metal powder.

The requirements in this standard take account of the intended use. This standard presumes access to the press from all directions, deals with the hazards and gives safety measures for the operator and other people.

This standard also applies to accessories that are vital to the press.

**Milling machines (including boring machines)**

*AS 4024.3101 Safety of machinery – Materials cutting – Milling machines (including boring machines) – Safety requirements*

Gives the safety requirements and measures to design, build, supply, install, take apart, transport and maintain milling and boring machines.

**Robots for industrial environments**

*AS 4024.3301 Robots for industrial environments – Safety requirements*

Gives requirements and guidelines to design, build and use industrial robots and robot systems safely. It describes some hazards of working with robots and how to avoid them.

While this standard does not cover non-industrial robots, the safety principles can be used for them. Non-industrial robot applications include:

- > undersea
- > military and space robots
- > tele-operated manipulators
- > prosthetics and other aids for the physically impaired
- > micro-robots (smaller than 1mm)
- > surgery or healthcare
- > service or consumer products.

**AS 4024.4-1998 SAFEGUARDING OF MACHINERY INCLUDES:**

**Pressure-sensitive devices**

*AS 4024.4 Safeguarding of machinery – Installation and commissioning requirements for electro-sensitive systems – Pressure-sensitive devices*

Explains the requirements to install and commission pressure-sensitive fixed mats, floors, edges and bars that will be used with plant and machinery. You will need to adapt or extend this standard if safety devices are to be used in other situations, such as protecting children or in exposed places with wide temperature limits.

## **11.5** EXAMPLE RISK ASSESSMENT PROCESS

The process can be used to identify hazards, assess their risks and identify controls to implement in relation to safeguarding of machinery and plant. This risk management process is outlined below.

### **1. IDENTIFY POTENTIAL HAZARDS - THESE MAY INCLUDE:**

- > drawing-in or trapping hazards
- > entanglement hazards
- > shearing hazards
- > cutting hazards
- > impact hazards
- > crushing hazards
- > stabbing and puncturing hazards
- > friction and abrasion hazards
- > hot or cold hazards
- > ejection hazards
- > other contact hazards
- > noise hazards
- > release of hazardous substances
- > hazards related to location of the machine or plant
- > hazards related to systems of work associated with the machine or plant
- > concurrent hazards.

### **Questions to ask to identify hazards:**

- > Where fixed guards are provided, are they of substantial construction and secured into position while machinery is in operation?
- > Where interlocked guards are provided, do they prevent operation of the machinery when open, and are the guards prevented from opening while the machinery is in operation?
- > Where a presence-sensing system is used, does it operate as intended and stop the machinery when light beams or sensors are interrupted?
- > Do guards protect against hazards at the rear and sides of machinery?
- > Are pre-operational checks conducted to ensure safety features are in working order?
- > Are adequate isolation procedures provided for maintenance?
- > Are manufacturers' manuals available?
- > Are machine controls protected to prevent unintentional operation, clearly marked and within easy reach of the operator?
- > Are warning signs and decals clearly visible?
- > Where it is not practical to provide guarding and people are required to operate or pass close to dangerous moving parts, is a safe system of work in place to reduce risks?



- > Is it practical to provide a higher level of guarding than currently provided?
- > Are operators and maintenance workers adequately trained, familiar with the operation and set up of machinery and able to demonstrate safety features?

**2. ASSESS THE LEVEL OF RISK FOR IDENTIFIED HAZARDS**

- > Gather information about the hazard(s). Consult with relevant people, including workers.
- > Work out the likelihood of an injury or harm occurring. Consider how many people are likely to be exposed to the hazard and for how long. Take into account different situations or conditions that might exist at the workplace and could increase risk, such as changes to operations, inspection, cleaning, maintenance, servicing and repairs and new or inexperienced workers.
- > Use the information you have gathered to assess the potential consequences of any injury or harm occurring from the hazard(s); for example, whether people die or suffer major, minor or negligible injuries.
- > Rate the risk by using the risk rating table below to work out the level of risk associated with each hazard.

**3. CONTROL MEASURES**

Once the risk has been assessed, where required, choose control measures to eliminate the risk. See section 4 of this guideline for options to control hazards.

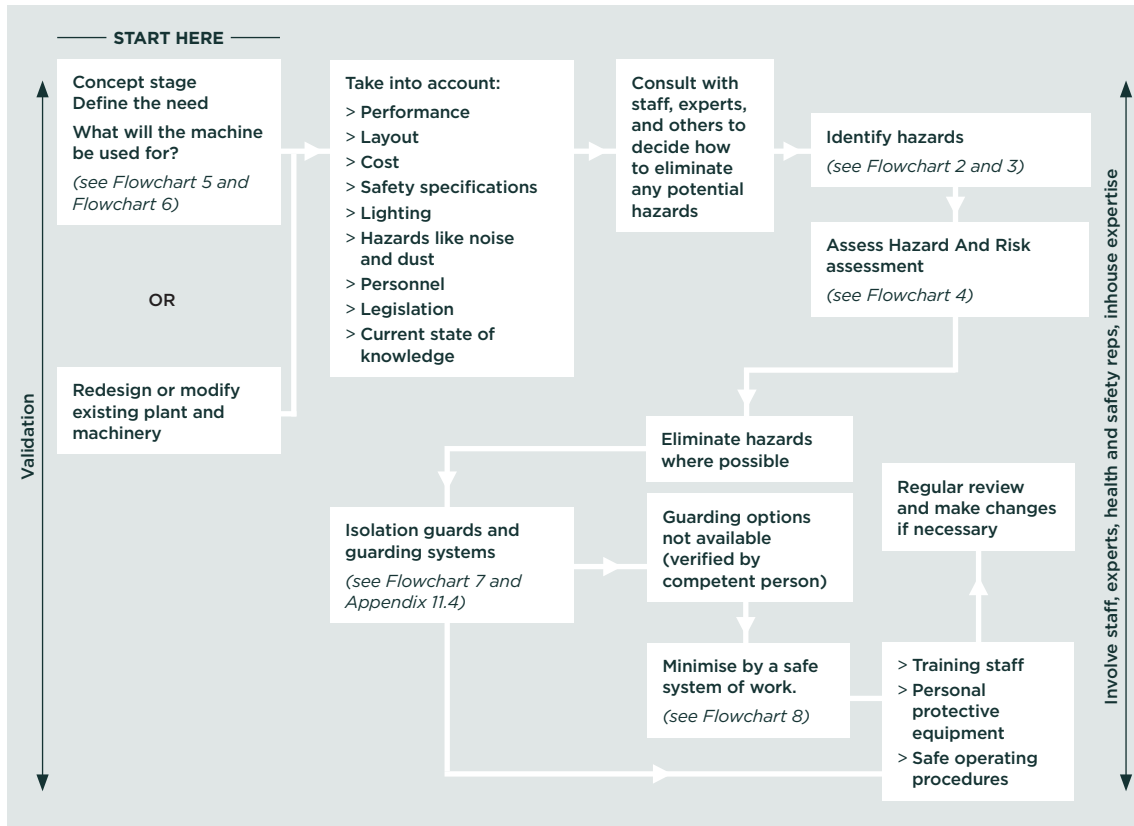
**4. RESIDUAL RISK**

The risk may then be assessed after taking into consideration how much the hazard controls will prevent harming workers.

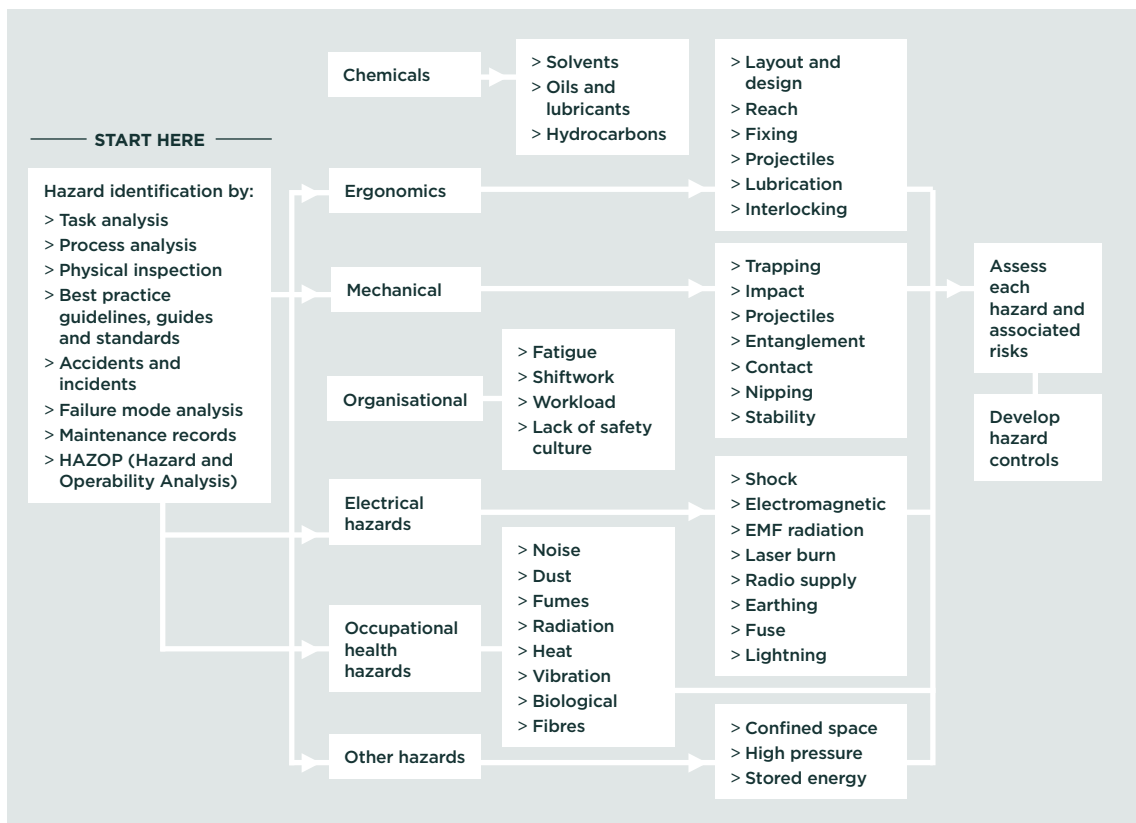
<b>RISK RATING TABLE</b>				
<b>Likelihood of injury or harm to health</b>	<b>Consequences of injury or harm to health</b>			
	<i>Insignificant no injuries</i>	<i>Moderate first aid and/ or medical treatment</i>	<i>Major extensive injuries</i>	<i>Catastrophic fatalities</i>
<b>Very likely</b>	High	Extreme	Extreme	Extreme
<b>Likely</b>	Moderate	High	Extreme	Extreme
<b>Moderate</b>	Low	High	Extreme	Extreme
<b>Unlikely</b>	Low	Moderate	High	Extreme
<b>Highly unlikely (rare)</b>	Low	Moderate	High	High

Extreme = immediate action

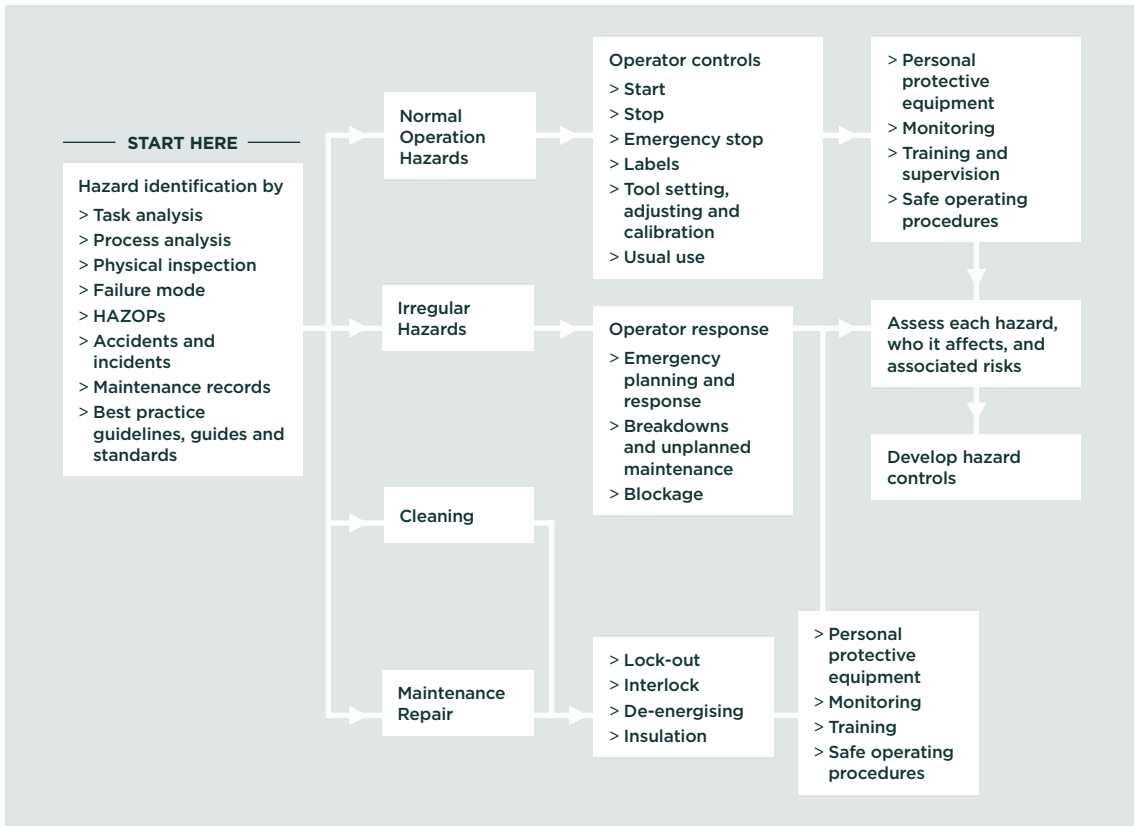
**11.6 FLOWCHARTS**



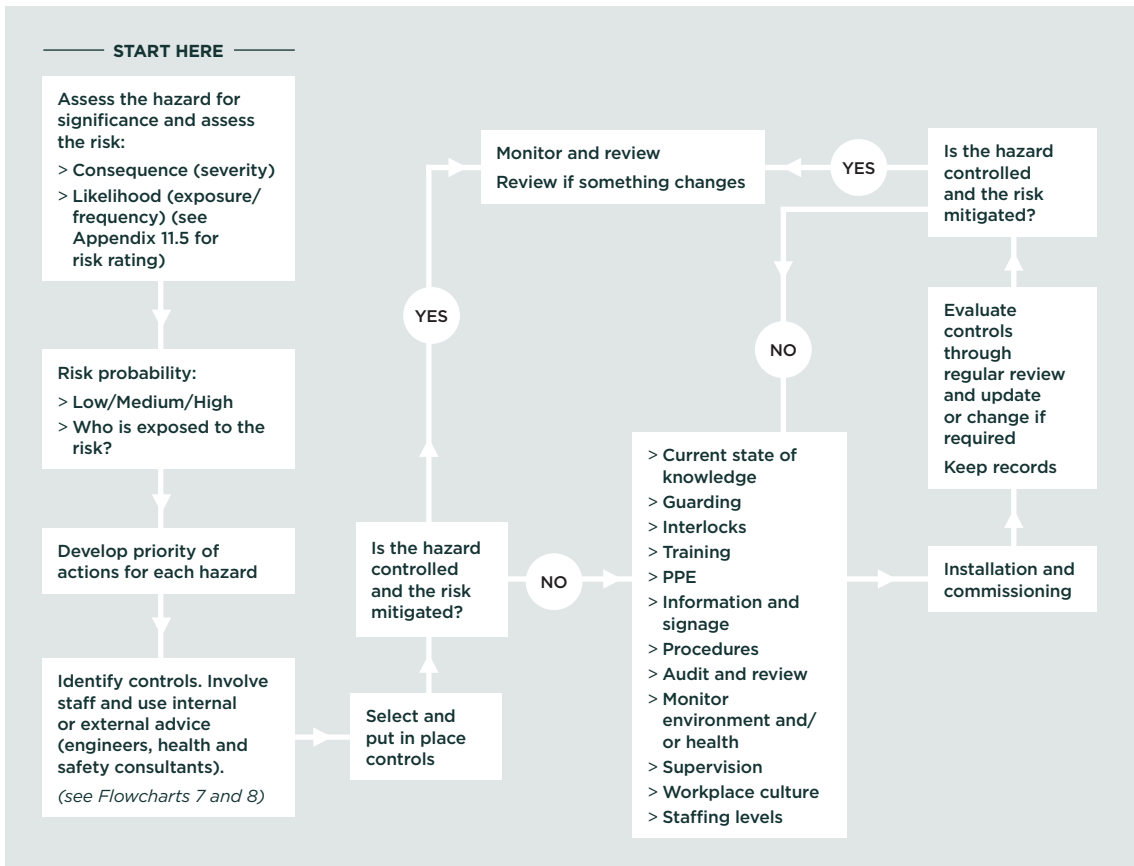
Flowchart 1: Get it right from the start – overview of safe use of machinery guideline



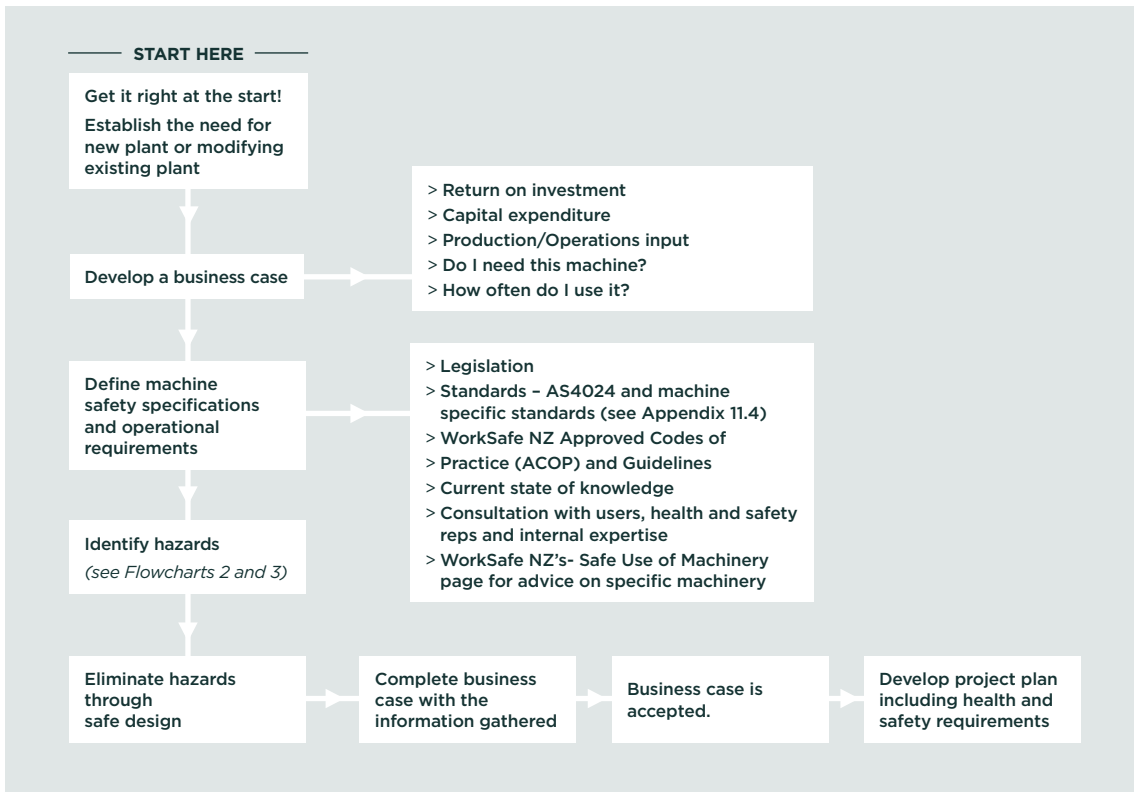
Flowchart 2: Common machinery hazards



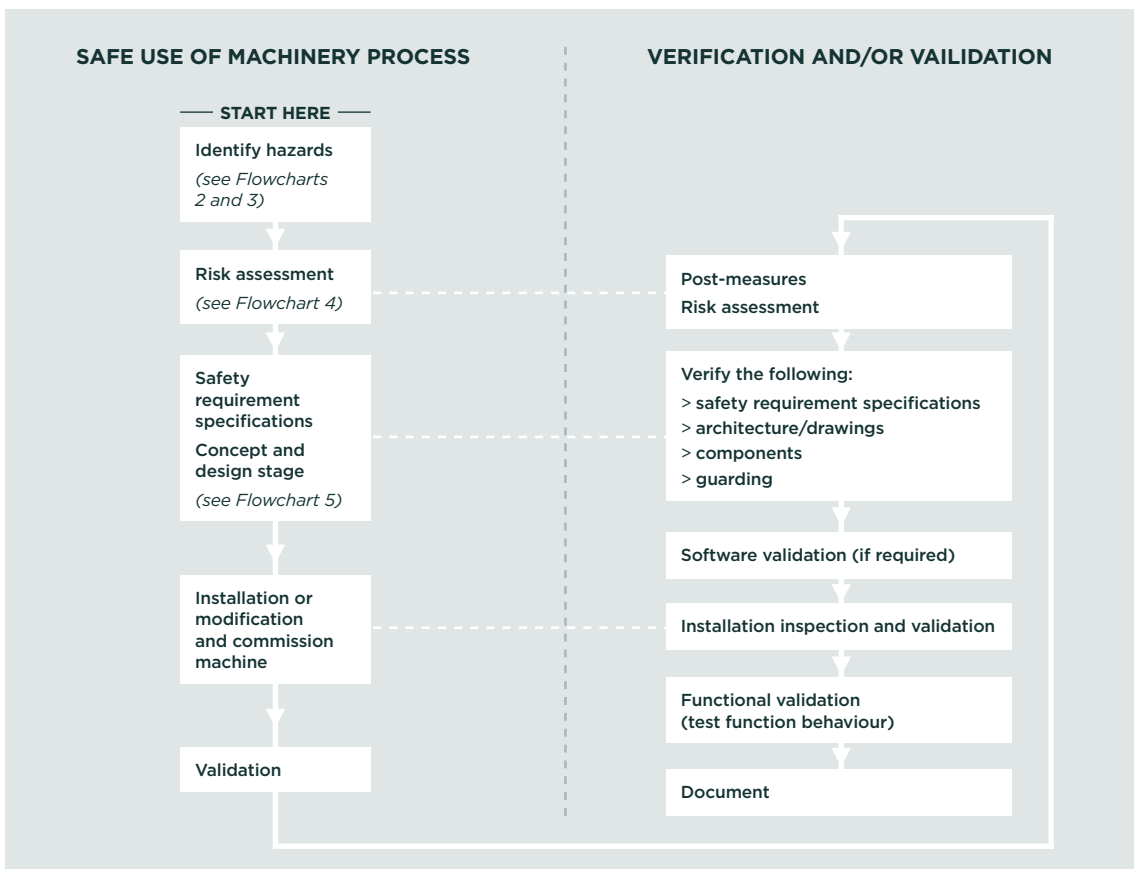
Flowchart 3: Identify operational hazards to use machinery safely



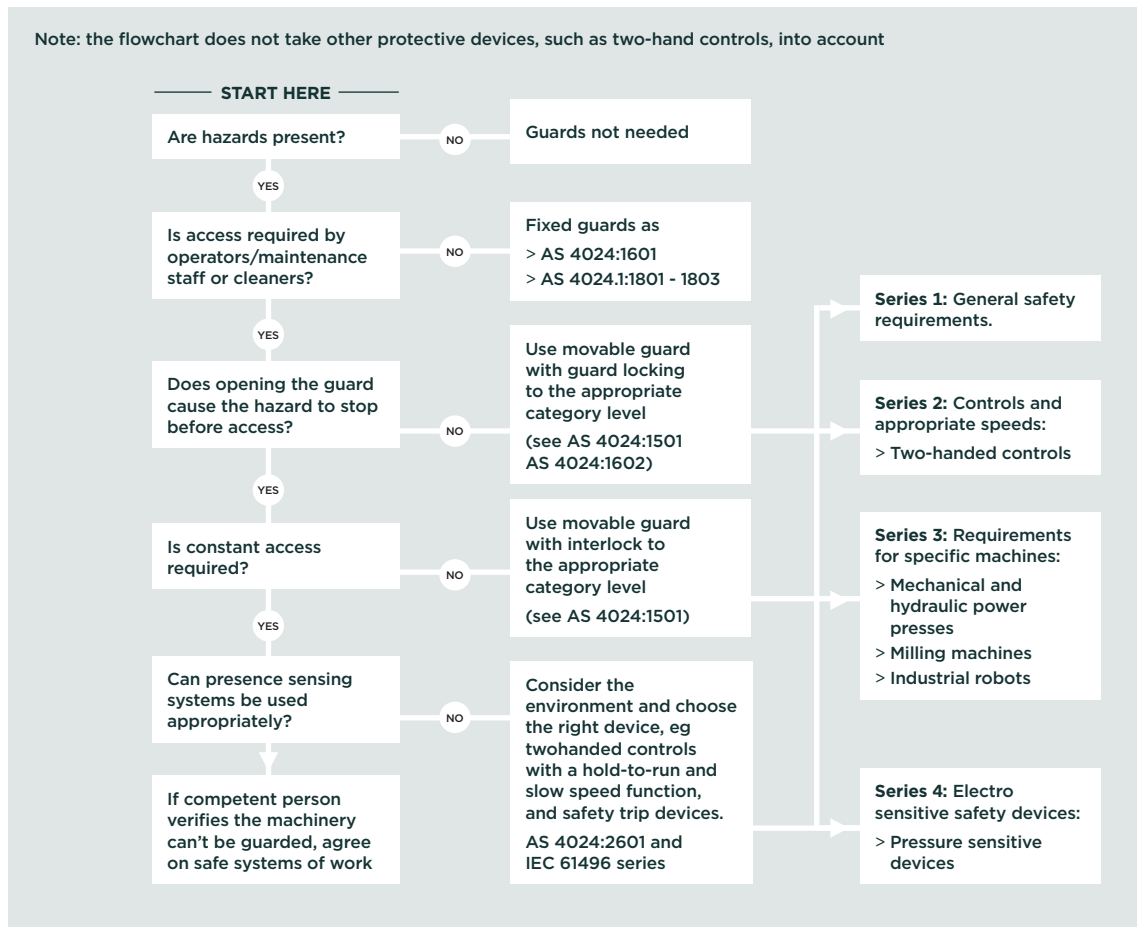
Flowchart 4: Assess hazard and risks - eliminate hazards where possible



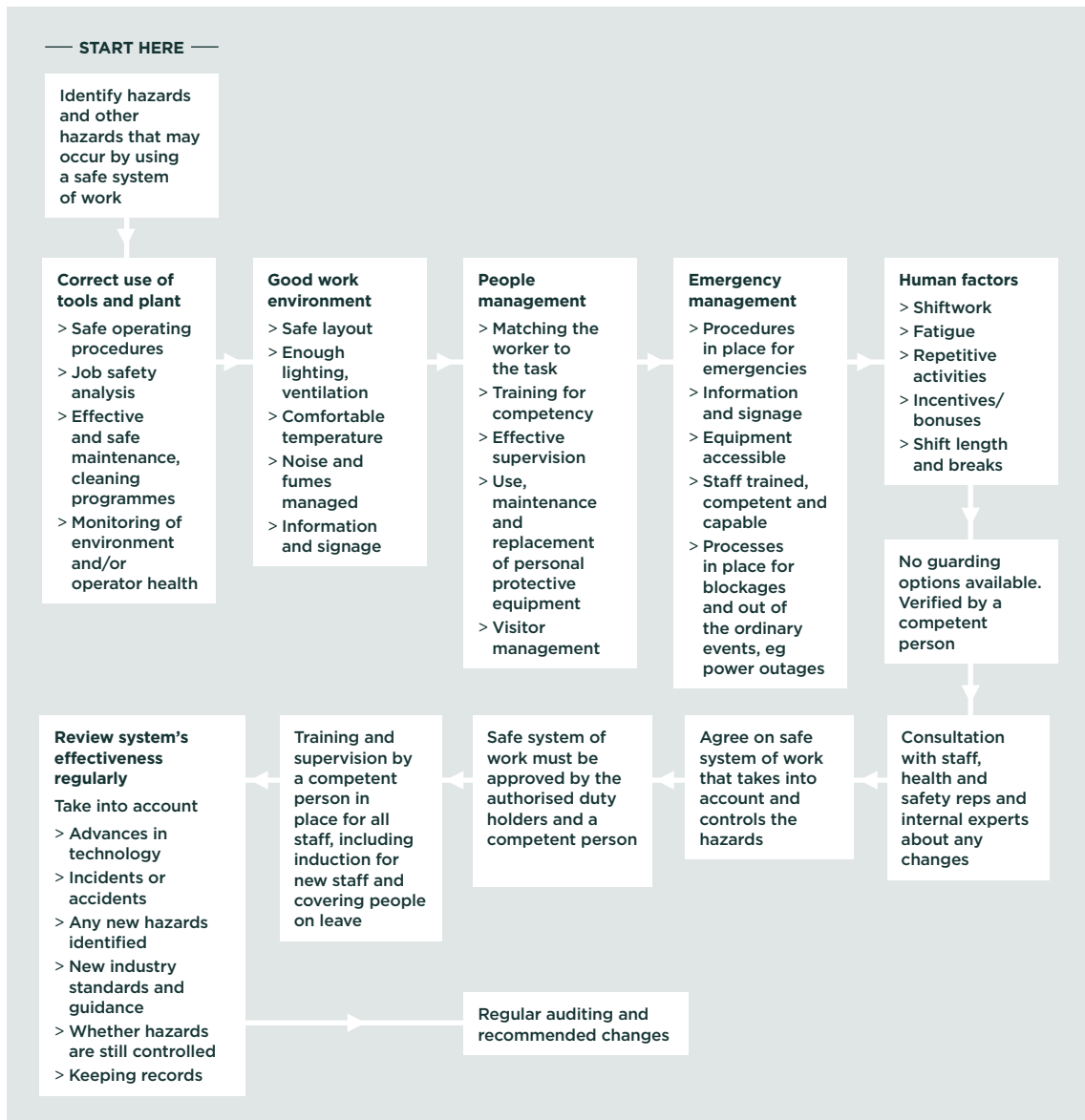
Flowchart 5: Concept stage – Health and safety in the business case



Flowchart 6: Validation and verification



Flowchart 7: Choosing a guard



Flowchart 8: Developing and maintaining a safe system of work for specific tasks

## 11.7 MORE INFORMATION

This list of standards is included for general guidance only, and is not inclusive of all standards. Readers should check the latest version of a standard at the time of use.

New Zealand has performance based legislation and there is a duty on designers, manufacturers, suppliers, importers, sellers and employers to take all practicable steps to eliminate, isolate and/or minimise hazards. Complying with the requirements of an appropriate best practice standard may be considered as taking all practicable steps to ensure safety of machinery and plant. Evidence of failure to comply with the requirements of the best practice standard may be used as evidence in proceedings for an offence under the HSE Act.

Some standards listed may be out of date and not available. The hierarchy for application of standards are that if there is no New Zealand Standard for a subject, the first appropriate standard to use is an Australian standard. If there is no Australian standard for the subject, the next most relevant standards are ISO, European or British standards. If there is no such standard available, then refer to the American, Canadian or other recognised relevant standards. The criteria will also be which standard or guideline can provide the latest current state of knowledge and good practices about the safety of a plant or process.

### Legislation

- > *Electricity Act 1992*
- > *Electricity (Safety) Regulations 2010 and Electrical Codes of Practice (ECP)*
- > *Health and Safety in Employment Act 1992*
- > *Health and Safety in Employment Regulations 1995*

### Standards

- > *AS 1121.4 Agricultural tractor power take-offs – Guards for power take-off (PTO) drive-shafts – Strength and wear tests and acceptance criteria*
- > *AS/NZS 1680.1 Interior and workplace lighting – General principles and recommendations*
- > *AS/NZS 1680.2.4 Interior lighting – Part 24: Industrial tasks and processes.*
- > *AS 1755 Conveyors – Safety requirements*
- > *AS/NZS 1680.1 Interior and workplace lighting – General principles and recommendations*
- > *AS 2865 Confined spaces*
- > *AS 4024.1 (Series) Safety of machinery*
- > *AS 4024.1101 Terminology – General*
- > *AS 4024.1201 General principles – Basic terminology and methodology*
- > *AS 4024.1202 General principles – Technical principles*
- > *AS 4024.1301 Risk assessment – Principles of risk assessment*
- > *AS 4024.1302 Risk assessment – Reduction of risks to health and safety from hazardous substances emitted by machinery – Principles and specifications for machinery manufacturers*
- > *AS 4024.1401 Safety of machinery: Part 1401: Ergonomic principles – Design principles – Terminology and general principles*

- > AS 4024.1501 *Design of safety related parts of control systems – General principles*
- > AS 4024.1502 *Design of safety related parts of control systems – Validation*
- > AS 4024.1601 *Design of controls, interlocks and guarding – Guards – General requirements for the design of fixed and movable guards*
- > AS 4024.1602 *Interlocking devices associated with guards – Principles for design and selection*
- > AS 4024.1603 *Design of controls, interlocks and guards – Prevention of unexpected start-up*
- > AS 4024.1701 *Human body measurements – Basic human body measurements for technological design*
- > AS 4024.1702 *Human body measurements – Principles for determining the dimensions required for openings for whole body access into machinery*
- > AS 4024.1703 *Principles for determining the dimensions required for access openings*
- > AS 4024.1704 *Human body measurements anthropometric data*
- > AS 4024.1801 *Safety distances to prevent danger zones being reached by the upper limbs*
- > AS 4024.1802 *Safety distances and safety gaps – Safety distances to prevent danger zones being reached by the lower limbs*
- > wAS 4024.1903 *Displays, controls, actuators and signals – Ergonomic requirements for the design of displays and control actuators – Control actuators*
- > AS 4024.1907 *Safety of machinery – Displays, controls, actuators and signals – System of auditory and visual danger and information signals*
- > AS 4024.2601 *Safety of machinery – Design of controls, interlocks and guarding – Two-hand control devices – Functional aspects and design principles*
- > AS 4024.2801 *Safety of machinery – Safety distances and safety gaps – Positioning of protective equipment with respect to the approach speed of parts of the human body*
- > AS 4024.3 *Safety of machinery: Part 3: Manufacturing and testing requirements for electro-sensitive systems – Optoelectronic devices*
- > AS 4024.4 *Safety of machinery: Part 4: Installation and commissioning requirements for electro-sensitive systems – Pressure-sensitive devices*
- > AS 4024.3001 *Safety of machinery – Materials forming and shearing – Mechanical power presses*
- > AS 4024.3002 *Safety of machinery – Materials forming and shearing – Hydraulic power presses*
- > AS 4024.3101 *Safety of machinery – Materials cutting – Milling machines (including boring machines) – Safety requirements*
- > AS 4024.3301 *Safety of machinery – Robots for industrial environments – Safety requirements*
- > AS 4024.3610 *Conveyors – Safety requirements*
- > AS 4024.4 *Safeguarding of machinery: Part 4: Installation and commissioning requirements for electro-sensitive systems – Pressure-sensitive devices*
- > AS 60204.1 *Safety of machinery – Electrical equipment of machines – General requirements*
- > AS 62061 *Safety of machinery – Functional safety of safety-related electrical, electronic and programmable electronic control systems*



**European Standards**

- > *IEC 61496-1 Safety of machinery – Electro-sensitive protective equipment – Part 1: General requirements and tests*
- > *IEC 61496-2 Safety of machinery – Electro-sensitive protective equipment – Part 2: Particular requirements for equipment using active opto-electronic protective devices (AOPDs)*
- > *IEC 61496-3 Safety of machinery – Electro-sensitive protective equipment – Part 3: Particular requirements for active opto-electronic protective devices responsive to diffuse reflection (AOPDDR)*
- > *BS EN 1756-1 Tail lifts. Platform lifts for mounting on wheeled vehicles. Safety requirements. Tail lifts for goods*
- > *BS EN 1756-2 Tail lifts. Platform lifts for mounting on wheeled vehicles. Safety requirements. Tail lifts for passengers*

**WORKSAFE NZ PUBLICATIONS**

**Approved Codes of Practice**

- > *Approved Code of Practice for cranes*
- > *Approved Code of Practice for operator protective structures on self-propelled mobile mechanical plant*
- > *Approved Code of Practice for power-operated elevating work platforms*
- > *Approved Code of Practice for the management of noise in the workplace*
- > *Approved Code of Practice for load-lifting rigging*
- > *Code of Practice for manual handling*

**Guidelines and guides**

- > *An introduction to the safe use of machinery*
- > *Small business guide to the Health and Safety in Employment Act 1992*
- > *Guidance notes for electrical interlocking for safety in industrial processes*
- > *Ergonomics of machine guarding guide*
- > *First aid for workplaces – A good practice guide*
- > *Keeping safe at work – A guide for employees*
- > *Managing health and safety – A guide for employers*
- > *A principal's guide to contracting to meet the Health and Safety in Employment Act 1992, and its summary, Health and safety in contracting situations*
- > *Management of Substances Hazardous to Health – A guide to completing an assessment in your workplace*
- > *Guidelines for the provision of facilities and general safety in commercial and industrial premises*
- > *Stress and fatigue: Reducing their impact – Advice for employers and employees*
- > *Best Practice Guidelines for the use of elevating work platforms in the horticultural industry*
- > *Best Practice Guidelines for working at height in New Zealand*

**Factsheets**

- > *Employers must involve staff in health and safety*
- > *Employees have to help ensure a safe and healthy worksite*
- > *Factsheet: Band saws*
- > *Factsheet: Beam saws*
- > *Factsheet: CNC Woodworking machines*
- > *Factsheet: CNC machining centre*
- > *Factsheet: CNC turret punch*
- > *Factsheet: Dough brakes*
- > *Factsheet: Dough dividers*
- > *Factsheet: Circular saw benches*
- > *Factsheet: General principles of machine guarding*
- > *Factsheet: Guarding of conveyors*
- > *Factsheet: Information, installation, operation and maintenance*
- > *Factsheet: Fixed hand held grinders*
- > *Factsheet: Four siders*
- > *Factsheet: Injection blow moulding*
- > *Factsheet: Jig saws*
- > *Factsheet: Metal cutting shears*
- > *Factsheet: Metal turning lathes*
- > *Factsheet: Metalworking guillotines*
- > *Factsheet: Mitre saws*
- > *Factsheet: Mortisers*
- > *Factsheet: Overhand planing*
- > *Factsheet: Paper cutting guillotines*
- > *Factsheet: Pendulum saws*
- > *Factsheet: Plastics extrusion*
- > *Factsheet: Plastics granulator*
- > *Factsheet: Platen press*
- > *Factsheet: Power presses*
- > *Factsheet: Press brake machine guarding*
- > *Factsheet: Punch & shear*
- > *Factsheet: Radial arm saws*
- > *Factsheet: Rise & fall saws*
- > *Factsheet: Rotary printing press*
- > *Factsheet: Screw conveyor*
- > *Factsheet: Tenoners*
- > *Factsheet: Thicknessers*
- > *Factsheet: Three roll bending machines*
- > *Factsheet: Vertical spindle moulder*
- > *Health and Safety Representatives*







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## MORE INFORMATION

Information, examples and answers to your questions about the topics covered here can be found on our website [www.worksafe.govt.nz](http://www.worksafe.govt.nz) on the Safe use of machinery project page, or by calling us free on 0800 030 040.

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