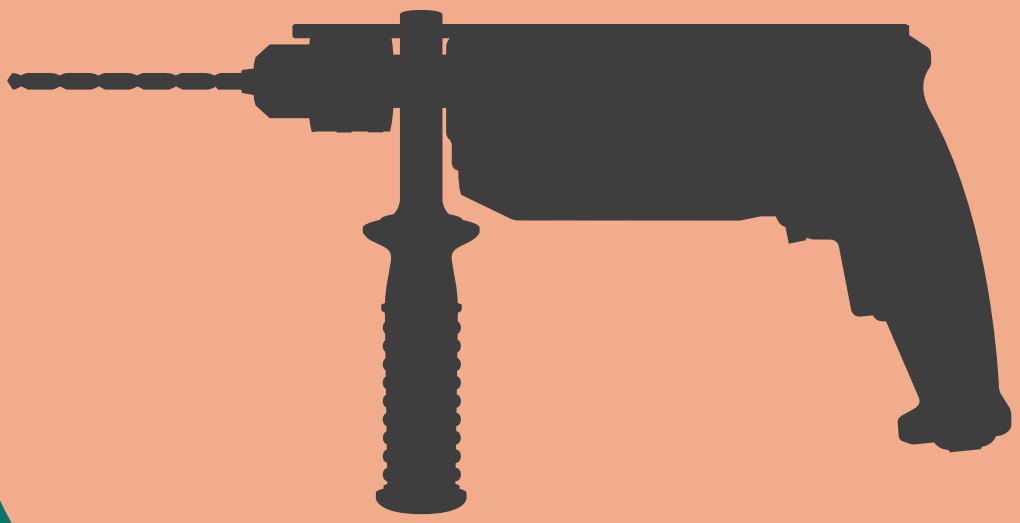
NEBOSH International General Certificate in Occupational Health and safety



# Element 9

Work equipment

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# 9.0 Learning outcomes

The learner should be able to:

- Do a general risk assessment in their own workplace – profiling and prioritising risks, inspecting the workplace, recognising a range of common hazards, evaluating risks (taking account of current controls), recommending further control measures, planning actions.

  **5-11** **Produce** a risk assessment of a workplace which considers a wide range of identified hazards (drawn from elements 5-11) and meets best practice standards (*'suitable and sufficient'*).

# 9.1 General requirements for work equipment

Effective arrangements for the management of the safety of work equipment and machinery are essential to ensure that the use of work equipment does not cause health and safety risks, regardless of age, condition or origin

The requirements can be broken down into two main areas:

- Management duties; and
- Physical aspects

Management duties include:

- selection of suitable equipment
- maintenance
- inspection
- specific risks
- information, instructions and training
- conformity with the requirements of EC Directives on product safety.

The physical aspects of machinery safety include::

- guarding of dangerous parts
- controls, including emergency stop controls
- stability
- warning markings and devices
- suitable and sufficient lighting.

Part 3 deals with certain risks from mobile work equipment (see **Element 3**).
Part 4 deals with power presses (not on course syllabus).

## Definition of work equipment

*'Work equipment'* means any machinery, appliance, apparatus, tool or installation for use at work (whether exclusively or not), *'use'* in relation to work equipment means any activity involving work equipment and includes starting, stopping, programming, setting, transporting, repairing, modifying, maintaining, servicing and cleaning.

The scope of *'work equipment'* is extremely wide. It covers almost any equipment used at work, *i.e.* hand tools, power tools and machinery. Examples include:

- *'tool box tools'* such as hammers, knives, handsaws etc.
- single machines such as drilling machines, circular saws, photocopiers etc.
- apparatus such as laboratory apparatus (Bunsen burners etc.)
- lifting equipment such as hoists, lift trucks, elevating work platforms, lifting slings etc.
- other equipment such as ladders, pressure water cleaners etc.
- an installation such as a series of machines connected together, for example a paper-making line or enclosure for providing sound insulation or scaffolding or similar access equipment.

## Management duties

### Suitability of work equipment

Work equipment must be suitable for the purpose for which it is used or provided, having regard to the working conditions and to the risks to the health and safety posed by its use.

The selection of suitable work equipment for particular tasks and processes makes it possible to reduce or eliminate many risks to the health and safety of people at the workplace.

Determining the suitability of work equipment requires consideration of:

**a.** its initial integrity
**b.** the place where it will be used
**c.** the purpose for which it will be used.

## Maintenance

Work equipment has to be maintained in an efficient state, in efficient working order and in good repair. It therefore must be maintained so that its performance does not deteriorate to the extent that people are put at risk.

*'Efficient'* relates to how the condition of the equipment might affect health and safety. It is not concerned with productivity.

Maintenance logs are a practical way of demonstrating that work equipment is subject to regular maintenance. They are not legally required, but if used they must be kept up to date.

The frequency at which maintenance activities are carried out should take into account the:

- type and age of the equipment
- manufacturers' recommendations
- intensity of use – frequency and maximum working limits
- reliability – based on breakdown history
- statutory and insurance requirements
- operating environment, (effects of temperature, humidity or dust)
- variety of operations – is the equipment performing the same task all the time or does this change?
- risk to health and safety from malfunction or failure
- the criticality of the equipment to the process.

Appropriate maintenance techniques should be selected through risk assessment and used independently or in combination to address the risks involved.

Practical precautions that should be taken prior to maintenance may include:

- permit-to-work system in high risk situations, *e.g.* whole body access to a machine
- isolation / locking off sources of energy
- dissipation of stored energy, *e.g.* pressure release, cooling of hot surfaces
- appropriate protection from moving parts *e.g.* temporary guards / covers, inching or hold-to-run controls
- segregation, *e.g.* barriers, warning signs
- provision of a safe means of access (including working at height)
- use of personal protective equipment
- use of competent personnel
- ensuring a safe working environment, *e.g.* ventilation, lighting.

Planned preventive maintenance involves maintenance interventions at pre-set intervals so

that risks do not occur as a result of the deterioration or failure of the equipment.

Condition-based maintenance involves monitoring the condition of safety-critical parts and carrying out maintenance activities when the monitoring data indicates an intervention is necessary.

Breakdown maintenance is totally reactive and involves carrying out maintenance only after faults or failures have occurred. It is only appropriate if the failure does not present an immediate risk.

## Safe maintenance operations

In addition to the requirement to maintain equipment in safe working order there is a duty to ensure that maintenance operations can be carried out without risk to health and safety.

The need for safe maintenance should have been addressed by the manufacturer at the design stage. Ideally access for maintenance activities should be achievable without exposure to risk, *e.g.* safe positioning of lubrication points.

Otherwise the installation should be designed so that the work can, so far as is reasonably practicable, be carried out with the equipment stopped or inactive.

If equipment has to run during a maintenance operation and this presents risks, appropriate controls should be introduced to reduce the risk, *e.g.*:

- provision of temporary guards
- limited movement controls
- crawl speed operated by hold-to-run controls.

Other measures that can be taken to protect against any residual risk include wearing personal protective equipment and provision of instruction and supervision.

## Inspection

Where the safety of work equipment depends on the installation conditions, it should be inspected, to ensure that it has been installed correctly and is safe to operate:

- after installation and before being put into service for the first time
- after assembly at a new site or in a new location.

Where work equipment may deteriorate because of operating conditions it should be inspected:

- at suitable intervals
- after any exceptional circumstance which could jeopardise the safety of the work equipment.

The purpose of an inspection is to identify whether the equipment can be operated, adjusted and maintained safely and that any deterioration (*e.g.* defect, damage or wear) can be detected and remedied before it results in unacceptable risks.

An inspection will vary from a simple visual external inspection to a detailed comprehensive inspection, which may include some dismantling and / or testing.

Records do not have to be kept in a particular form, but should normally include:

**a.** information on the type and model of equipment
**b.** any identification mark or number that it has
**c.** its normal location
**d.** the date that the inspection was carried out
**e.** who carried out the inspection
**f.** any faults
**g.** any action taken
**h.** to whom the faults have been reported
**i.** the date when repairs or other necessary action were carried out.

## Specific risks

Where the use of work equipment is likely to involve a specific risk to health or safety, its use should be restricted to those persons given the task of using it.

Maintenance activities (repairs, modifications, or servicing) should only be undertaken by specifically designated maintenance personnel.

### Information and instructions

Adequate health and safety information and, where appropriate, written instructions should be provided to all persons who use work equipment.

Supervisors and managers should also be provided with adequate health and safety information and, where appropriate, written instructions regarding the use of the work equipment.

Workers should have easy access to information and instructions and be able to understand them.

## Training

All persons who use work equipment should receive adequate health and safety training including training in:

- appropriate work methods
- risks which may arise during use
- precautions to be taken.

Supervisors and managers should also receive adequate training.

### Adequate training

Determining what constitutes adequate training will require:

- identification of existing levels of competence of employees, supervisors and managers
- establishing the necessary level of competence for the particular job or task
- designing and delivering a training programme to address any shortfall.

### Provision of training

The training need is likely to be greatest on recruitment. However, training will also be required:

a. if the risks to which people are exposed change due to a change in their working tasks
b. because new technology or equipment is introduced
c. if the system of work changes.

Refresher training should also be provided as necessary. Skills decline if they are not used regularly.

## Users responsibilities

Employees are generally required to take reasonable care of themselves and others and to cooperate with the employer.

Employees are particularly required to:

- use any machinery, equipment, transport equipment, means of production or safety device etc. in accordance with health and safety training and instruction; and
- to report any potentially dangerous situations or shortcomings in control measures.

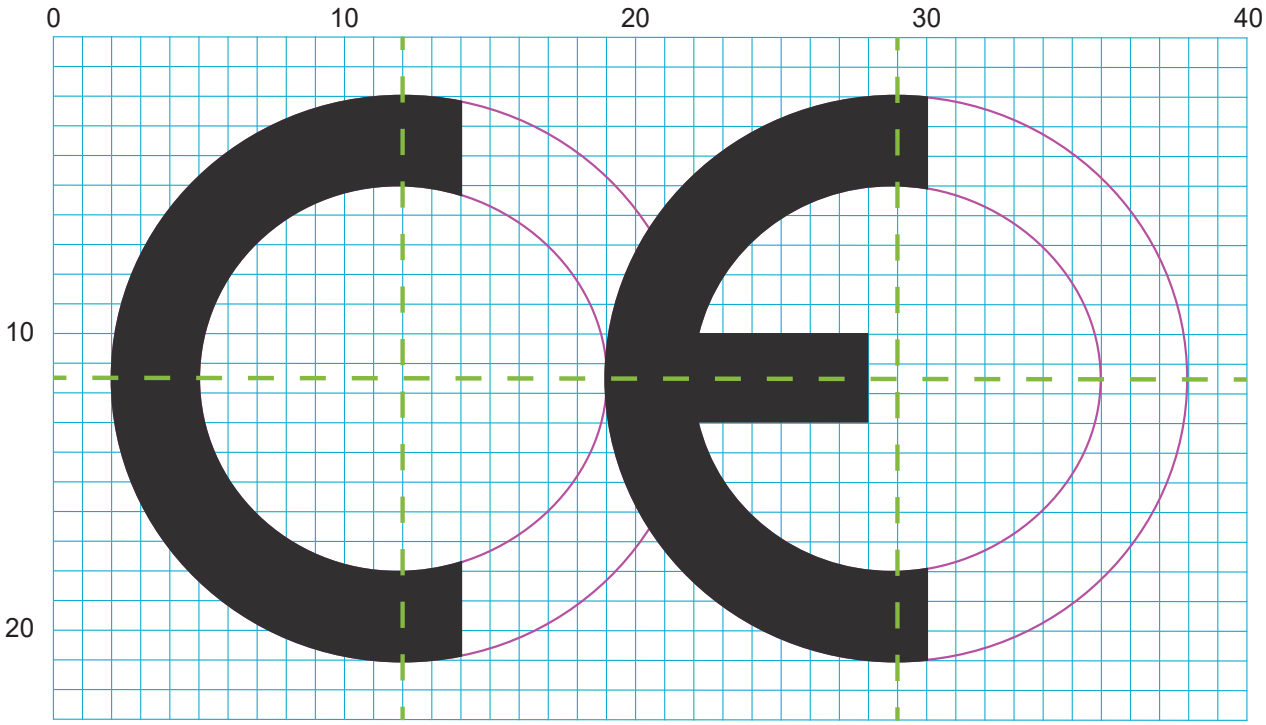


*Figure 9.1: CE Mark*

## Machinery guarding

*Note:*

In the UK 2017/18 13 workers were killed by accidents involving contact with moving machinery. Over 2 500 non-fatal injuries were also reported, including 567 specified injuries.

Effective measures must be taken to:

- prevent access to any dangerous part of machinery or to any rotating stock-bar
- stop the movement of any dangerous part of machinery or rotating stock-bar before any part of a person enters a danger zone.

*Definitions:*

*Danger zone* is the zone where a person is exposed to a risk to health or safety from contact with a dangerous part of machinery or a rotating stock-bar.

*Stock-bar* is a piece of stock metal which projects beyond the head-stock of a lathe while being turned.

The effective measures must be applied in accordance with the following hierarchy of control:

**a.** fixed guards enclosing every dangerous part or rotating stock-bar where it is *practicable* to do so, but where not, then

**b.** other guards or protection devices where it is practicable to do so, but where not, then

**c.** jigs, holders, push-sticks or similar protection appliances.

Appropriate information, instruction, training and supervision should also be provided to ensure the effective use of the control measures.

*Definitions:*

*Practicable* means feasible in light of current knowledge and invention, i.e. if it can be done it must be done.

*Guards* are physical barriers which prevent access to the danger zone.

*Protection devices* do not prevent access to the danger zone but stop the movement of the dangerous part before contact is made. They will normally be used in conjunction with a guard. (e.g. trip devices, light curtains, pressure-sensitive mats and two-hand controls).

*Protection appliances* are used to hold or manipulate a work piece at a machine while keeping the operators body clear of the danger zone. They are commonly used in conjunction with manually fed woodworking machines.

## Other physical requirements for machinery safety

### Protection against specified hazards

Appropriate safeguards are required to protect people using work equipment from the following specified hazards:

- material falling from equipment, *e.g.* a loose board falling from scaffolding or a straw bale falling from a tractor freeloader
- material being unexpectedly thrown out of equipment, *e.g.* swarf ejected from a machine tool
- parts of the equipment breaking off and being thrown out, *e.g.* an abrasive wheel bursting
- parts of the equipment coming apart, *e.g.* collapse of scaffolding
- overheating or fire due to:
  - friction (bearings running hot, conveyor belt on jammed roller)

    - electric motor burning out
    - thermostat failing
    - cooling system failure
- explosion of the equipment due to pressure build-up, *e.g.* failure of a pressure-relief valve
- explosion of substances in the equipment, *e.g.* exothermic chemical reaction or unplanned ignition of a flammable gas or vapour or dust.

**High or very low temperature**

Accessible surfaces of equipment or machinery, when hot or very cold, represent sources of risk of burn or other injury such as frostbite.

The risk from intentional and unintentional contact with hot surfaces should be reduced, where possible by engineering methods, *e.g.* reduction of surface temperature, insulation, shielding, barricading or guarding.

In many cases equipment surfaces have to be hot and accessible to operate, *e.g.* cooker hotplates or a flat iron. In such cases, no engineering protective measures can be taken.

Where engineering measures are not appropriate, alternative or complementary forms of protection should be considered, *e.g.*:

- PPE
- organisational measures such as warning signs (warning signals, visual and noise alarm signals)
- instructions, training and supervision.

**Controls and control systems**

The requirements for provision of controls only apply *'where appropriate'*, and should be determined by risk assessment.

Start, stop, and emergency stop controls are not generally appropriate where work equipment has no moving parts or where the risk of injury is negligible.

*Controls* should be located in a safe position and it should be easy to identify and understand what effect a particular control has, and which item of equipment it affects.

*Stop controls* should bring the equipment to a safe condition in a safe manner and should take priority over any operating or start control.


*Emergency stop controls* should be provided at control points and other appropriate locations to enable action to be taken quickly. They should be easily reached and actuated.

They should bring work equipment to a rapid but controlled halt so as not to create any additional hazards and should not be used as functional stops during normal operation.

Failure of any part of a *control system* or its power supply should lead to a *'fail-safe'* condition (minimised failure to danger). This should not impede the operation of the *'stop'* or *'emergency stop'* controls.

**Isolation from sources of energy**


Isolation means establishing a break in the energy supply in a secure manner ensuring that inadvertent reconnection is not possible.

For maintenance and cleaning activities the risks of reconnection should be identified during the task risk assessment, and the means for achieving a secure isolation should be achieved.

This may require the use of lock out tag out (LOTO) systems.

**Stability**

Work equipment or any part of work equipment should be stabilised where necessary for health or safety purposes.

Work equipment that might fall over, collapse or overturn should be fixed to the ground by bolting, tying, fastening or clamping and / or stabilised by ballasting or counterbalancing.

**Lighting**

Suitable and sufficient lighting, which takes account of the operations to be carried out, should be provided at any place where a person uses work equipment.

### Markings

Where markings are required for reasons of health and safety they should be appropriate, visible and clear.

### Warnings

Warnings or warning devices may be appropriate where risks to health or safety remain after other hardware measures have been taken.

A warning is normally in the form of a notice. A warning device is an active unit giving a visible and / or audible signal, *e.g.* reversing alarms on construction vehicles.

Warnings should be easily perceived and understood, and unambiguous.

## 9.2 Hand-held tools

There are many jobs that require the use of non-powered hand tools. Non powered hand tools include: screwdrivers, saws, knives, chisels hammers, planes, files, spanners, and wrenches.

The range of injuries associated with the use of hand tools is largely married to the function of the tool, *e.g.*:

- cuts from saws and knives
- punctures from screwdrivers and bradawls
- injuries from chipped materials when using chisels
- impact injuries from hammers
- upper limb disorders from screwdrivers and wrenches - repetitive work involving application of force.

The major causes of accidents involving hand tools are:

- using the wrong tool for the job
- using a defective tool.

The general management duties of PUWER regarding the selection and maintenance of work equipment etc. are intended to address these issues.

**Suitability of hand tools**

Hand tools must be suitable for the task and for the operating environment.

**Suitable for the task**

The right tool should be provided for the job. A screwdriver should not be used as a lever or a chisel. A wrench should not be used as a hammer.

**Suitable for the environment**

In flammable environments tools which do not generate sparks on impact are specified, *e.g.* a brass headed hammer.

## Maintenance of hand tools

Simple hand tools usually require minimal maintenance but there are some instances where regular maintenance is required *e.g.*:

- cutting tools will need regular sharpening
- adjustable tools such as wrenches will need regular lubricating
- tools that are hit, such as cold chisels will need mushroomed heads to be ground off regularly.

*Note:*

Many tradespeople keep their own tools which are taken from job to job.

Even if an employer has not provided tools he is responsible for ensuring that they are suitable for use and maintained in good condition.

## Inspection of hand tools

Hand tools should be subject to pre-use checks buy the user. For tools in routine use throughout the working day this may be a daily check.

Formal periodic inspections should be undertaken by supervisors or managers. The frequency should be determined by risk assessment, but depending on the nature of the work environment weekly or monthly checks may be appropriate.

If defective equipment is identified it should be removed from use until it can be repaired. If it cannot be repaired it should be disposed of and replaced.

## General rules for safe use of hand tools

- always use the correct tool for the job
- inspect the tool before use
- do not use tools with obvious signs of damage
- store tools properly in suitable racks and boxes
- where necessary clean and lubricate tools after use and before storage
- carry tools in a tool belt or tool box, not in pockets
- do not leave loose tools lying around

- pass tools carefully, by the handle
- use the right personal protective equipment (PPE) for the job
- ensure sound footing and secure grip before starting work.

## Hazards associated with portable power tools

Portable power tools will present the range of mechanical and non-mechanical hazards discussed in Section 9.3. If they are electrically powered they will also present the range of electrical hazards discussed in **Element 11**.

They are also subject to the same control framework discussed for hand tools but because of the mechanical hazards and power supply will require more regular inspection and testing and more sophisticated maintenance.

The course syllabus specifies the need to understand the hazards and control measures associated with the use of powered drills and sanders. Although there will be some variations based on specific design (*e.g.* belt, disc or random orbital sanders) the broad issues are covered in the following tables.

# Portable electric drill

### Mechanical hazards

- entanglement around rotating drill chuck and bit
- puncture from drill bit
- ejection of pieces of drilled material, broken drill or chuck key.

### Non-mechanical hazards

- electricity
- noise
- vibration – especially with hammer drill
- dust
- heat – drill bit and work piece
- trailing cable – trip hazard
- manual handling
- drilling into hidden services
- environmental hazards *e.g.* exposure to weather.

### Control measures

- double insulated equipment
- reduced voltage
- residual current device (RCD)
- correct bit for material
- pre use inspections
- regular inspection, testing and maintenance
- proper storage and handling
- checking for services before drilling
- personal protective equipment – eye protection, dust mask as necessary
- suitable work clothing
- competent operators.

# Portable electric sander

### Mechanical hazards

- contact with abrasive material – abrasion
- entanglement – disc sander
- drawing in – belt sander.

### Non-mechanical hazards

- dust – respiratory hazard and fire / explosion hazard
- noise
- vibration
- electricity
- trailing cable – trip hazard
- manual handling
- environmental hazards *e.g.* exposure to weather.

### Control measures

- double insulated equipment
- reduced voltage
- residual current device (RCD)
- regular inspection, testing and maintenance
- competent operators
- pre use inspections
- ensure abrasive material is properly fixed
- inspect work surface to be sanded for obstructions – *e.g.* nail heads
- regular emptying of dust bags
- suitable work clothing
- suitable PPE – eye protection, dust mask, hearing protection as necessary
- safe storage and handling.

## General rules for the use of power tools

- always use the right tool for the job
- inspect the tool before use to ensure it is in good order
- do not use damaged or unsuitable tools
- ensure tools are subject to routine maintenance
- do not carry tools by the power cord or yank on power cord to disconnect from power supply
- ensure the tool is disconnected from the power supply before cleaning or changing components etc.
- avoid accidental starting – do not carry with hand on trigger / start control
- position the cord safely to avoid damage
- use both hands to operate and support the tool (secure work piece with clamps etc.)
- use an RCD
- ensure the work area is clear before starting
- ensure sound footing and a good grip
- wear appropriate work clothes
- wear correct PPE for the job.

# 9.3 Machinery hazards

Hazards associated with the use of machinery are normally categorised as mechanical (to do with the moving parts) or non-mechanical (to do with all other aspects).

## Mechanical hazards

Mechanical hazards associated with a machine, machine parts or surfaces, tools, work-pieces, loads, or projected solid or fluid materials can result in:

- crushing
- shearing
- cutting or severing
- entanglement
- drawing-in or trapping
- impact
- stabbing or puncture
- friction or abrasion
- high pressure fluid injection (ejection hazard).

These can be summarised and remembered with the acronym **EnTICE**.

**En**tanglement

**T**raps – crushing, shearing, and drawing-in

**I**mpacts

**C**ontacts – cutting / severing, friction / abrasion, stabbing / puncture

**E**jection, including high pressure fluid injection.

A number of mechanical hazards are illustrated in Figure 9.3. A simple machine may well present several mechanical hazards as shown in Figure 9.2, the abrasive wheel.

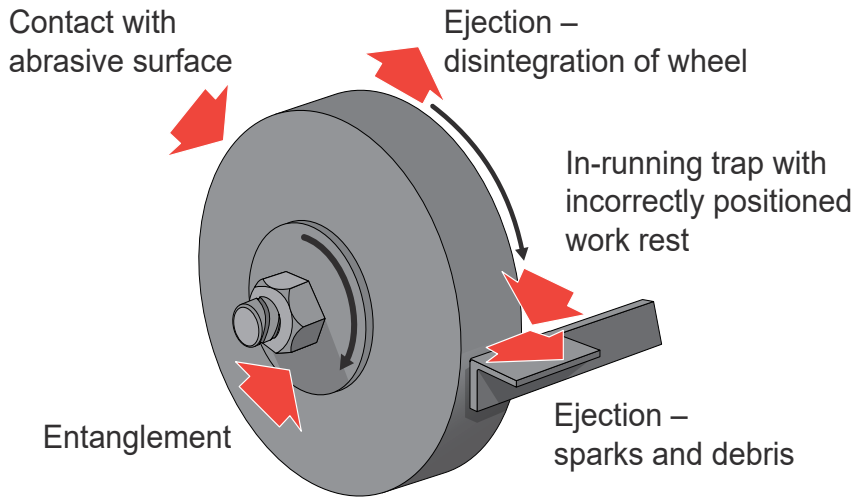


*Figure 9.2: Abrasive wheel – mechanical hazards*

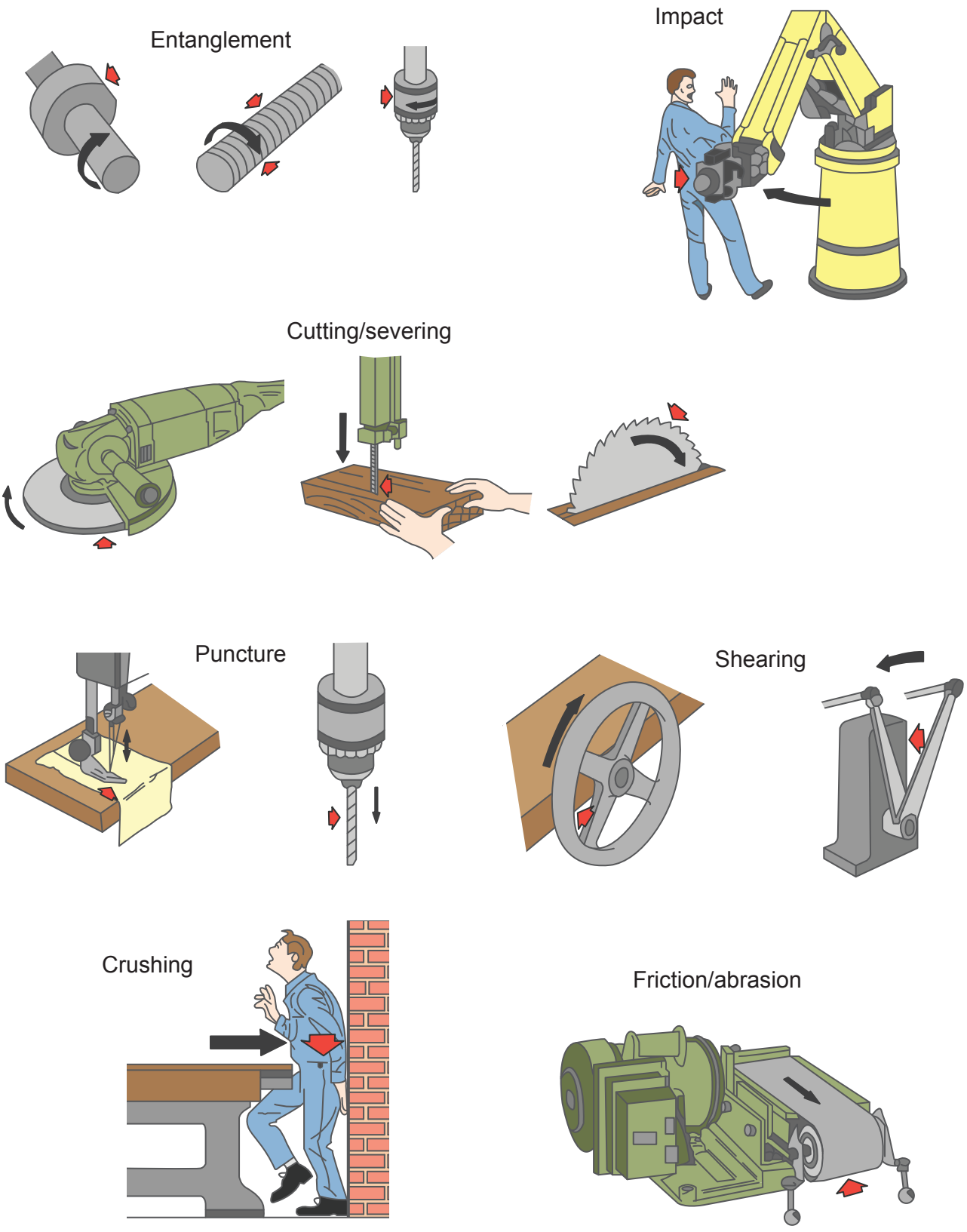


*Figure 9.3: Mechanical hazard illustrations*

## Non-mechanical hazards

Non-mechanical hazards arising from the use of machinery include:

- electrical
- thermal
- noise
- vibration
- radiation
- materials and substances
- ergonomic
- slip trip
- environmental hazards
- hazard combinations (minor individual hazards can combine to be equivalent to a significant hazard).

## 9.4 Control measures for machinery hazards

As discussed in section 4.1 the hierarchy for machinery guarding, which should be applied so far as is *'practicable'* is:

- fixed guards
- other guards or protection devices
- protection appliances.

Each of which should be supported by appropriate information, instruction, training and supervision.

A *guard* provides a physical barrier between a person and the dangerous parts of machinery, a *protection device* stops the movement of the dangerous part before a person can reach it. A *protection appliance* is a jig, push-stick or holder, intended to keep the operators hands away from the dangerous parts.

All guards and protection devices should be designed, fitted and used in accordance with the following principles:

- be suitable for the purpose for which they are provided
- be of good construction, sound material and adequate strength
- be maintained in an efficient state, in efficient working order and in good repair
- not give rise to any increased risk to health or safety
- not be easily bypassed or disabled
- be situated a sufficient distance from the danger zone
- not unduly restrict the view of the operating cycle of the machinery, where a view is necessary
- allow safe access for maintenance work, restricted to the area where the work is to be carried out and, if possible, without having to dismantle the guard or protection device.

## Fixed guards

A *fixed guard* may be:

- an *enclosing guard* which prevents access to the danger zone from all sides (Figure 9.4)
- a *distance guard* which does not completely enclose the danger zone but prevents access by virtue of its dimensions and distance from the danger zone, *e.g.*
  - a *perimeter fence* (Figure 9.5)
  - a *tunnel guard* (Figure 9.6).

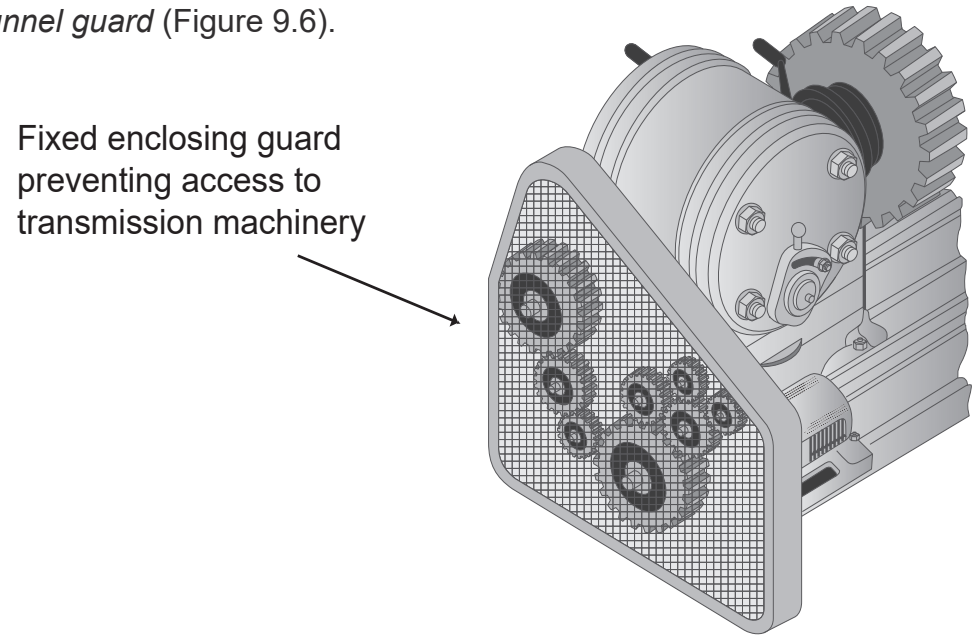


*Figure 9.4: Enclosing guard*

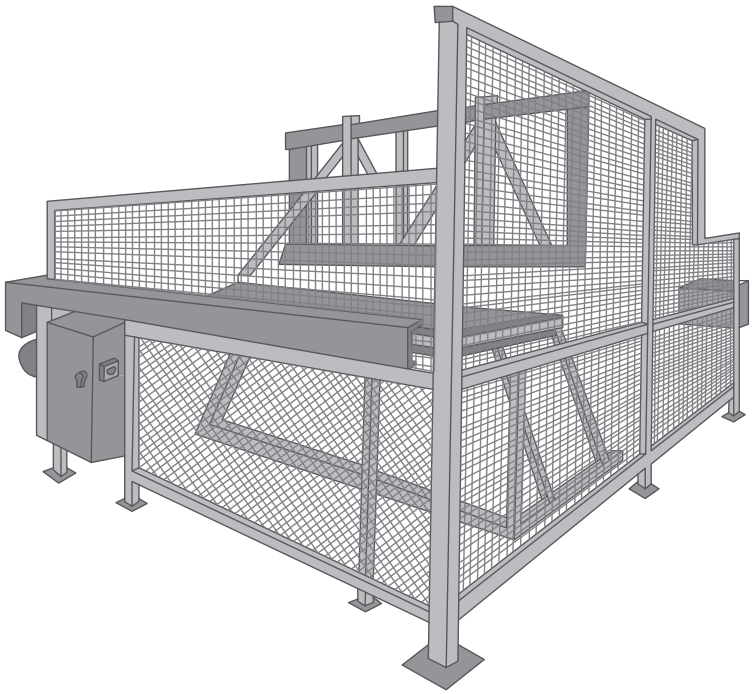

*Figure 9.5: Perimeter fencing*

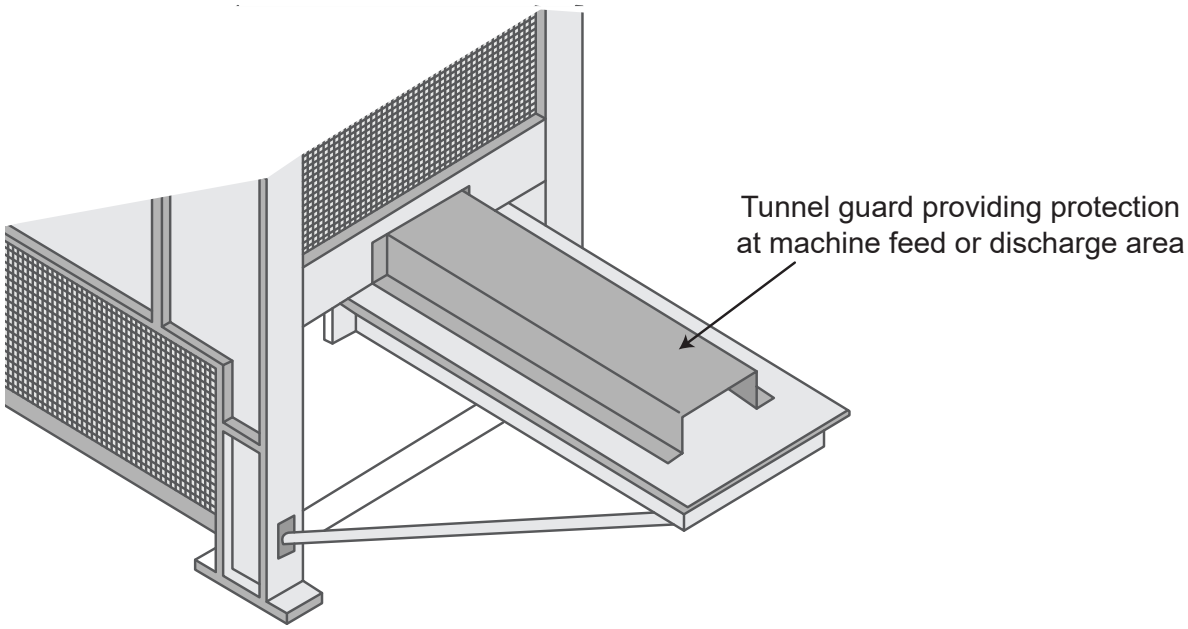


*Figure 9.6: Tunnel guard*

Fixed guards have no moving parts and are fastened in a constant position relative to the danger zone. They are kept in place either permanently (*e.g.* by welding) or by means of fasteners (*e.g.* screws or nuts) making opening or removal impossible without using tools.

Depending on its design, a fixed guard may include casing, shields, covers, screens, or doors.

The advantages and disadvantages of fixed guards are presented in Table 9.1.

| Advantages | Disadvantages |
|---|---|
| • Low cost<br>• Easy to monitor by visual inspection<br>• Can only be defeated by intentional act<br>• Minimal ongoing maintenance – no moving parts or complex systems<br>• May offer some protection from other hazards such as noise, dust or ejected parts and materials | • Removal of the guard does not stop the machine<br>• If the guard needs to be removed regularly for maintenance it is likely to be left off<br>• May impede operators view<br>• May impede ventilation |

*Table 9.1: Advantages and disadvantages of fixed guards*

## Interlocked guards

An interlocked guard comprises a guard (physical barrier) associated with an interlocking device and the control or power systems of a machine to ensure that:

- the machine cannot operate until the guard is in place
- opening the guard while the machine is in use causes it to stop (or the guard cannot be opened until the machine has safely stopped)
- the closing of the guard does not by itself restart the machine.

An interlocking guard relies on the movement of the guard to operate the interlocking device (a position switch - typically mechanical or magnetic which triggers an on / off electrical control signal) (Figure 9.7).

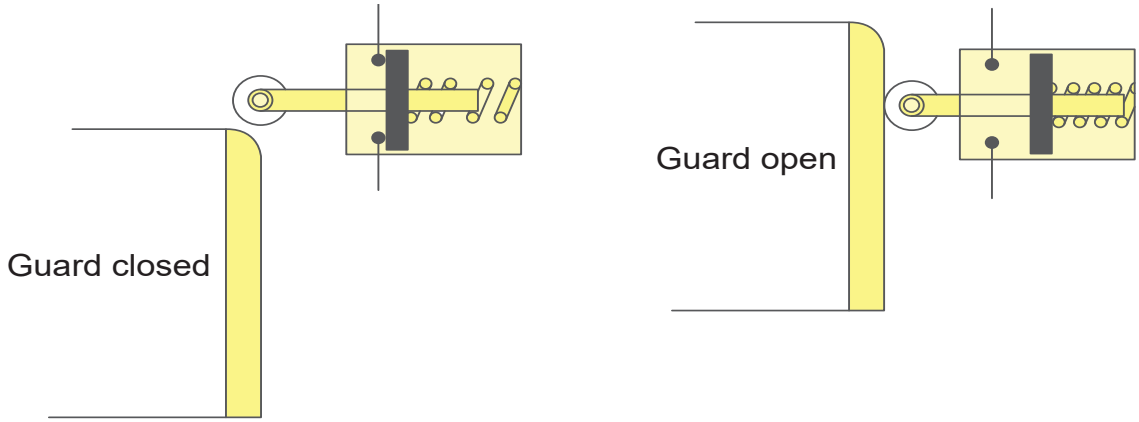


*Figure 9.7: Cam operated switch in positive mode*

*Note:*

Figure 9.7 is intended to illustrate a position switch rather than a well-designed interlocking guard system.

Interlocking systems must be carefully designed and constructed to minimise the risk of failure and to ensure that if the guard fails the machine is safe and not useable in a dangerous condition.

The reliability of the system can be improved by introducing a second switch so that if one switch fails the second keeps the guard operational, and by electronically monitoring the condition of the switches so that failures can be identified before a worker is placed at risk.

An interlocking guard with guard locking uses a mechanical key transfer system to lock the guard in place and start the machine (Figure 9.8).

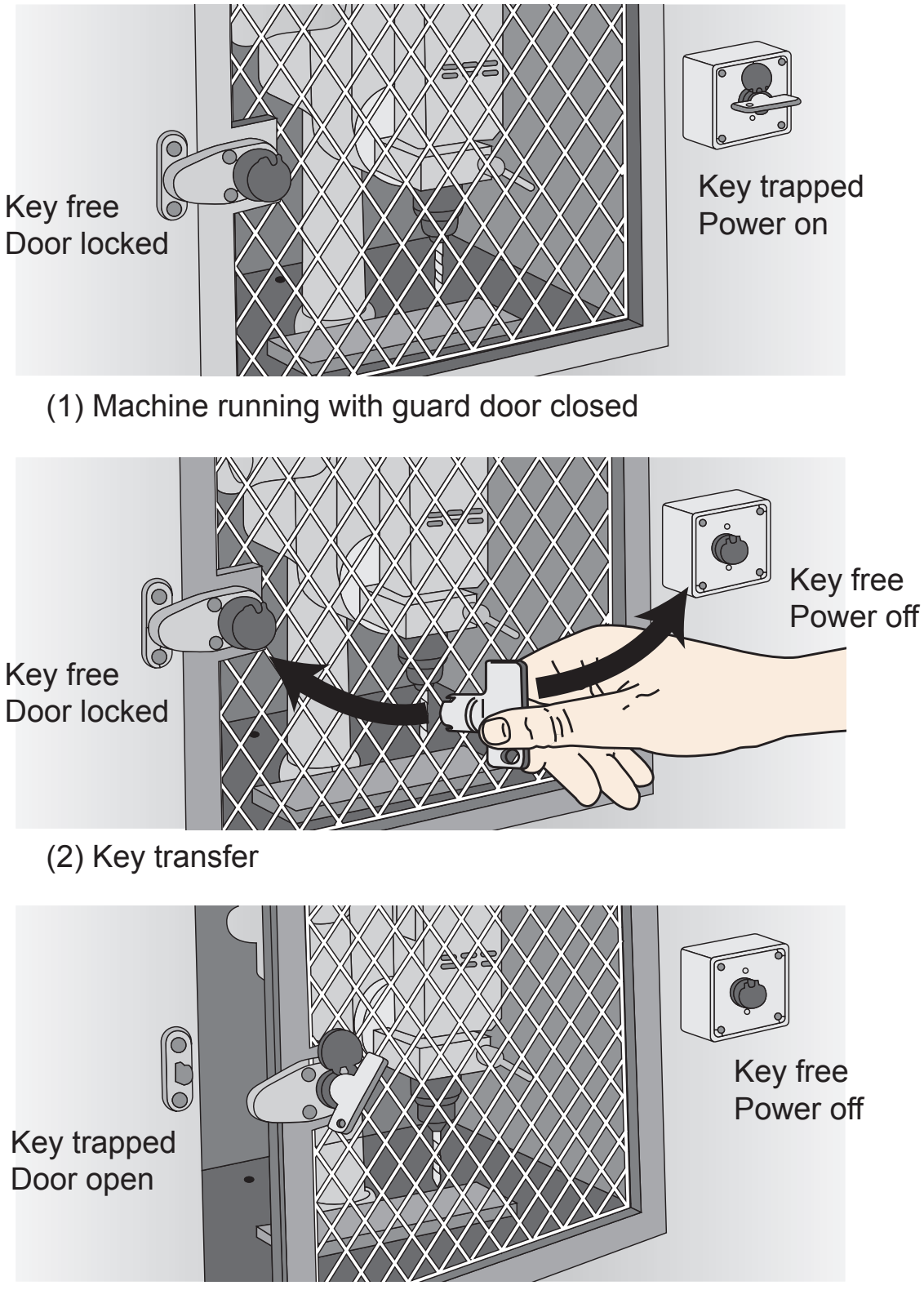


*Figure 9.8: Trapped key interlock – key transfer*

The advantages and disadvantages of interlocked guards are presented in Table 9.2.

| Advantages | Disadvantages |
|---|---|
| • Convenient where frequent access is required<br>• Allow safe access when opened – machine is powered down | • Complex systems requiring regular testing and maintenance<br>• Components may fail in use<br>• May be defeated (spare keys, stuck contacts etc.)<br>• Failure may not be apparent until after an incident |

*Table 9.2: Advantages and disadvantages of interlocked guards*

## Self-closing guards

Self-closing guards (also known as self-adjusting guards) automatically open and close as the work-piece is put in and pulled out. The moveable guard automatically returns (by means of gravity, a spring, etc.) to the closed position as soon as the work-piece has vacated the opening through which it has been allowed to pass. Figure 9.9 shows a self-closing guard on a hand held circular saw.

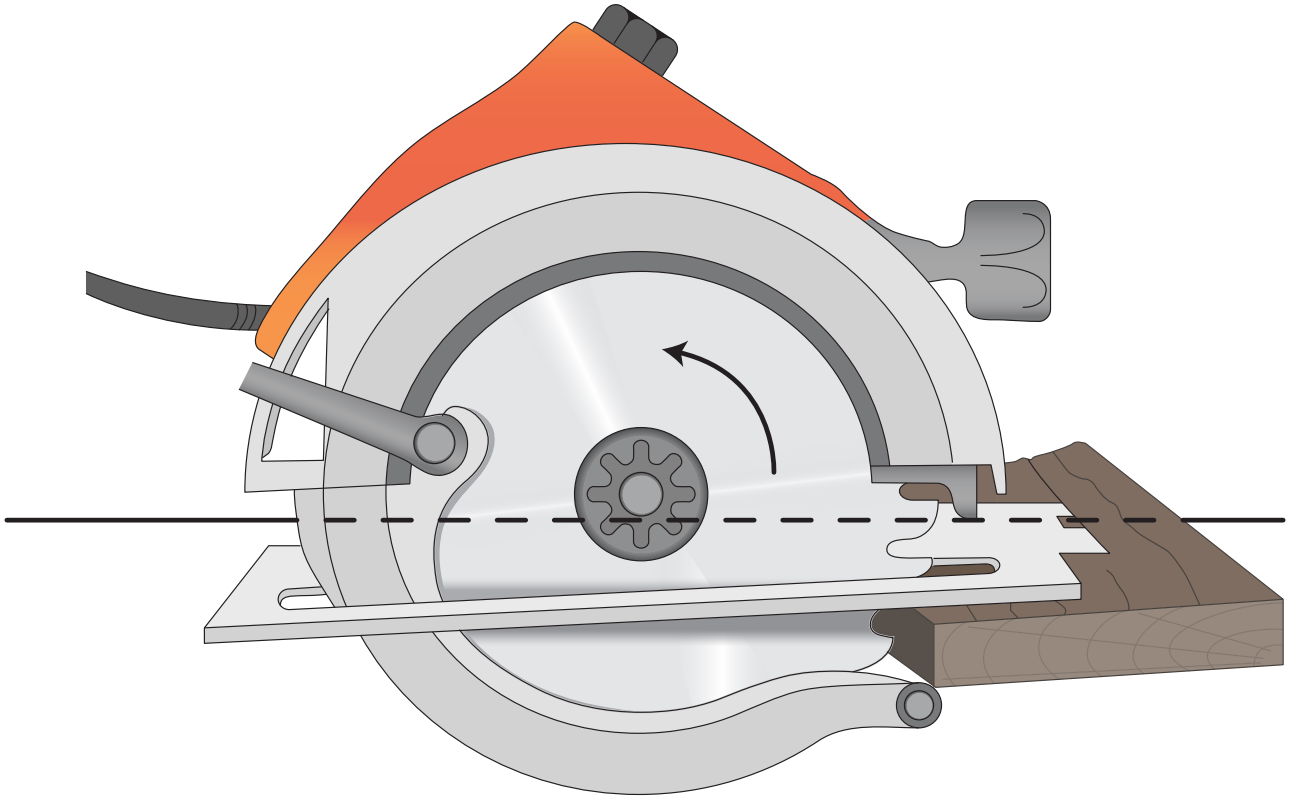

*Figure 9.9: Spring loaded self-closing guard on hand held circular saw*

The advantages and disadvantages of self-closing guards are presented in Table 9.3.

| Advantages | Disadvantages |
|---|---|
| • Automatically adjust to accommodate the work piece | • Only provide a partial guarding solution – still allows some access to the dangerous parts<br>• Require regular inspection and maintenance |

*Table 9.3: Advantages and disadvantages of self-closing guards*

## Adjustable guards

Adjustable guards are prevalent on traditional engineering workshop and woodworking machines such as band saws, circular saws, pillar drills and lathes. Adjustable guards rely on the operator to set the guard up properly for each operation to allow the work piece to be fed into the machine whilst minimising the likelihood of personal contact with the exposed dangerous parts.

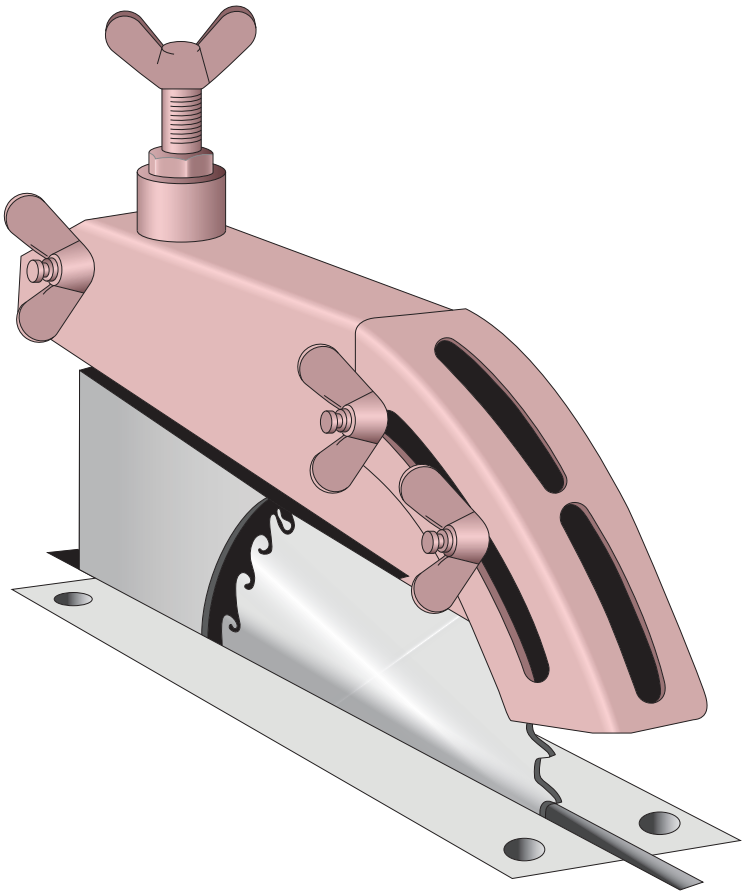

*Figure 9.10: Adjustable top guard on bench mounted circular saw*

The advantages and disadvantages of adjustable guards are presented in Table 9.4.

| Advantages | Disadvantages |
|---|---|
| • Probably the only practical solution where a work piece needs to be brought into contact with a cutting tool, especially if used in conjunction with a protection appliance. | • Have to leave part of the cutting tool accessible for it to do its job<br>• May be set up to accommodate largest job of a shift rather than adjusted to best setting for each job.<br>• Can be removed and machine is still useable |

*Table 9.4: Advantages and disadvantages of adjustable guards*

## Protection devices

### Two handed controls

A two hand control device can be used when guarding is impractical but it is necessary to ensure that the operator is outside of, and unable to reach the danger zone. Two handed control devices should incorporate the following features:

- located a sufficient distance from the danger zone to ensure the operator cannot reach the danger zone after releasing the controls until the danger has passed
- shrouded buttons to prevent accidental operation or operation from an unsafe position (*i.e.* between the controls and the machine)
- controls sufficiently separated to prevent being operated with one hand only or being bridged by a tool
- hold to operate controls – *i.e.* the machine stops if one or both controls are released
- simultaneous operation required, *i.e.* the controls must be operated within 0.5 seconds of each other to start the machine.

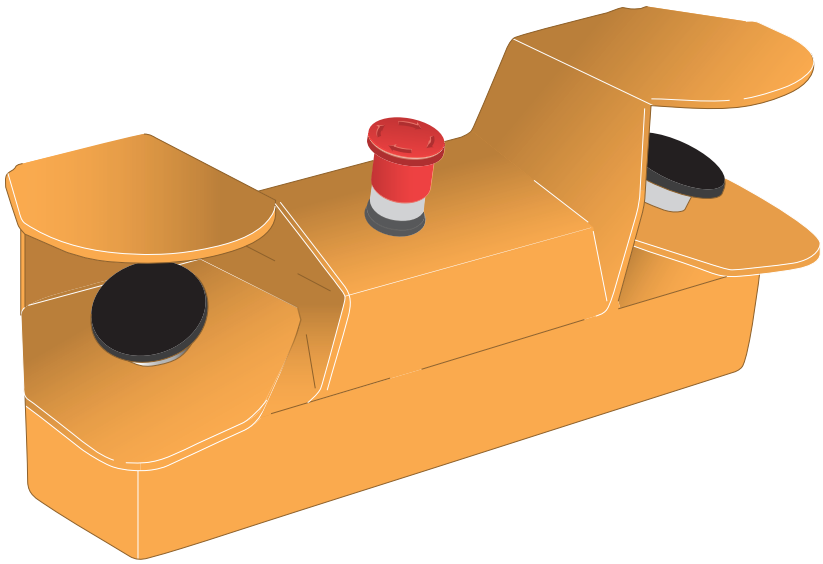

*Figure 9.11: two handed control*

The advantages and disadvantages of two handed controls are presented in Table 9.5.

| Advantages | Disadvantages |
|---|---|
| • Ensures the operator is in a safe position | • Only protects the operator<br>• Can be defeated |

*Table 9.5: Advantages and disadvantages of two handed controls*

## Hold to run control

A hold to run control only allows machinery movement when the control is held in the on position. As soon as the control is released it should automatically switch the machine off.

The hold to run control offers slightly less protection than a two handed control and has the same limitations.

## Sensitive protective equipment (trip devices)

Sensitive protective equipment (trip devices) operates when a person approaches a danger area. Once the device is triggered, it *'trips'* the machine, which either stops or otherwise becomes safe.

### Electro-sensitive protective equipment (ESPE)

Electro-Sensitive Protective Equipment (ESPE) uses Active Opto-electronic Protection Devices (AOPD) for safeguarding machinery, either alone or in combination with other safeguards.

An AOPD is a light curtain and / or light beam device.

An AOPD operates on the principle of the detection of an obstruction in the path taken by a beam or beams of light. If the light beam is broken, *e.g.* by an operator approaching a danger zone, the protected machinery is stopped.

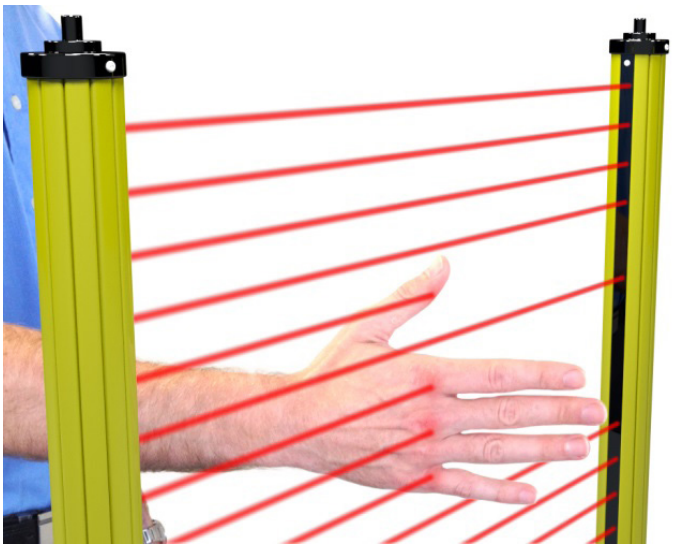

*Figure 9.12: Light curtain*

The advantages and disadvantages of light beam devices are presented in table 9.6

| Advantages | Disadvantages |
|---|---|
| • Allow an unobstructed view of the machine | • Not suitable in all environments, *e.g.* dust may trigger false positive trips<br>• No physical barrier therefore no protection from ejections or non-mechanical hazards<br>• Do not protect anyone working inside the danger zone |

*Table 9.6: Advantages and disadvantages of light beam devices*

Other Sensitive Protective Equipment includes:

- Pressure Sensitive Mats
- trip bars
- probes *e.g.* D.C. injection trip devices on drilling machines.

## Protection appliances

Protection appliances are devices that are used to hold a work piece and safely present it to a cutting tool while keeping the operators body clear of the danger zone. Examples include jigs, push sticks and holders.

They are commonly used on manually fed woodworking machines where it is not possible to fully guard the cutting tool.

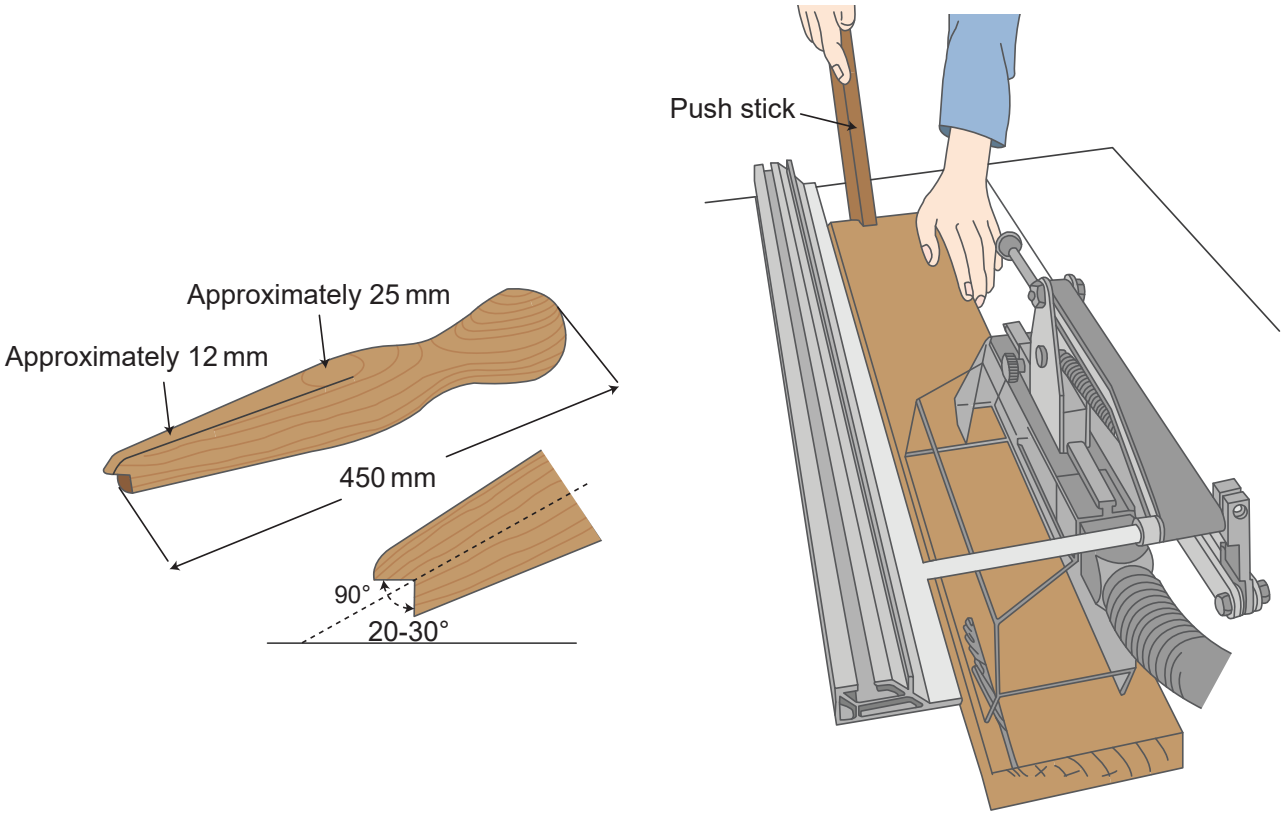


*Figure 9.13: Push-stick feeding a circular saw*

## 9.5 Specified equipment

The NEBOSH certificate syllabus requires an understanding of the mechanical and non-mechanical hazards posed by the following range of equipment, and suitable control measures:

| | |
|---|---|
| **Manufacturing / maintenance machinery** | • Bench-top grinder<br>• Pedestal drill |
| **Agricultural / horticultural machinery** | • Cylinder mower<br>• Strimmer<br>• Brush cutter<br>• Chain-saw |
| **Retail machinery** | • Compactor |
| **Construction machinery** | • Cement mixer<br>• Bench mounted circular saw |

# Benchtop grinder


### Mechanical hazards

- contact with rotating wheel
- trap between wheel and tool rest
- entanglement around axle
- ejection of parts of work piece or from burst wheel.

### Non-mechanical hazards

- dust
- sparks / fire
- electricity
- noise
- vibration
- stability of machine
- positioning / working posture.

### Control measures

- wheel enclosed as much as possible
- adjustable guard over exposed part of wheel
- wearing of eye protection
- bolted securely to workbench
- electric wiring insulated and enclosed in machine casing
- regularly inspected for general and electrical safety
- maintained in accordance with manufacturers recommendations
- local exhaust ventilation (LEV)
- used only by competent, authorised personnel.

# Pedestal drill

### Mechanical hazards

- puncture from drill bit
- entanglement
- traps in belt drive
- ejection of work piece, broken drill bit, or chuck key
- cutting from work piece edges or swarf
- impact / crushing from work table.

### Non-mechanical hazards

- manual handling of work piece
- heat generated by drilling
- electricity
- noise
- vibration
- dust (if drilling timber)
- cutting fluid – mineral and synthetic oils are irritants
- stability of pedestal drill.

### Control measures

- belt drive protected by fixed guard (machine case), access via interlocked door
- adjustable guard around spindle
- trip device (whisker guard) to stop drill in case of entanglement
- work clamps provided to work table
- pedestal to be securely bolted to floor
- operator to wear eye protection and suitable coveralls (no loose cuffs etc.)
- subject to regular inspections including electrical inspection and testing
- maintained in accordance with manufacturers recommendations
- only to be used by competent authorised operators.

# Cylinder mower

### Mechanical hazards

- entanglement with rotating cylinder blades
- cut by blades
- shearing between the rotating cylinder and the bottom blade
- drawing in to transmission machinery such as belts and pulleys and gears
- ejected materials
- impact with the moving mower

### Non-mechanical hazards

- engine noise
- vibration through the machine handles
- heat from the exhaust
- electrical or petrol related hazards (fuel handling / exhaust fumes
- manual handling of mower
- cut grass pollen
- environmental hazards – weather.

### Control measures

- guarding of cylinder blades
- motor and drive mechanism encased
- grass box positioned to prevent access to bottom blade shearing trap
- hold to operate controls
- safe systems for storing and handling of petrol, or Inspection and testing of electrical equipment
- regular maintenance
- avoidance of manual handling with ride on machinery
- wearing of hearing protection if first action level likely to be exceeded.

# Strimmer / brushcutter

### Mechanical hazards

- impact / cutting from strimmer cutting line
- trapping in motor and drive shaft
- entanglement around rotating part
- ejection of stones and other debris.

### Non-mechanical hazards

- manual handling
- noise
- vibration
- electricity or petrol
- biological hazards (animal faeces).

### Control measures

- fixed top guard over
- encased motor and drive mechanism
- appropriate personal protective equipment – eye / face protection, toe protection, leg protection, hearing protection, all weather clothing as necessary
- harness to support and balance weight
- hold to operate controls
- safe systems for storing and handling of petrol, or Inspection and testing of electrical equipment
- regular maintenance
- specified low vibration characteristics
- safe systems for changing cutting line
- safe systems for equipment cleaning.

# Chainsaw

### Mechanical hazards

- cutting / severing by chainsaw blade
- saw kicking back from timber being cut
- entanglement in chain drive mechanisms
- ejected wood chippings.

### Non-mechanical hazards

- manual handling
- noise
- vibration
- electricity
- petrol hazards – storage handling
- hot engine and exhaust
- environmental hazards – weather, work at height, overhead obstructions
- falling branches.

### Control measures

- operators to be certificated as competent
- other than saw blade all moving parts encased
- specified low vibration / low noise equipment
- regularly maintained – blade kept sharp
- two handled design – hands in safe position
- hold to operate control
- brake mechanism fitted to top handle
- safe systems for storage and handling of petrol (refuelling)
- electrical units should be double insulated and used with an RCD
- appropriate PPE to be worn – need for chainsaw jacket, leggings, boots, gloves and helmet depends on risk assessment, face protection, hearing protection.

# Compactor / baler

## Mechanical hazards

- crushing beneath compacting ram
- trap (shear) between ram and case sides
- high pressure injection from failure of hydraulic hoses.

## Non-mechanical hazards

- manual handling during loading and unloading
- electrical
- biological hazards from contaminated waste.

## Control measures

- drive mechanism guarded by machine case
- access to compactor by interlocked door
- double handed controls
- emergency stop
- regular inspection and maintenance
- trained operators
- manual handling aids.

# Cement mixer

### Mechanical hazards

- trap between drum and fixed parts of mixer
- entanglement in mixing paddles if present
- entanglement with drive motor and drive mechanisms
- ejection of cement slurry.

### Non-mechanical hazards

- cement dust (respiratory) and cement slurry (dermatitis)
- ergonomic considerations – manual handling and shovelling of materials
- electricity
- environment – weather
- stability of machinery.

### Control measures

- motor and drive mechanism guarded by casing with interlocked access
- electrical equipment regularly inspected and tested, used with RCD
- petrol operated equipment only operated in open air
- safe systems for storage and handling of petrol
- appropriate PPE – likely to include eye protection, hearing protection, and hand and foot protection.

# Bench mounted circular saw (table saw)


### Mechanical hazards

- cutting / severing from saw blade
- trapping in drive machinery
- ejection of work piece.

### Non-mechanical hazards

- manual handling
- noise
- vibration
- electricity
- heat generated by cutting
- dust – respiratory and fire hazards
- environment – weather
- stability of machinery.

### Control measures

- fixed guards to drive mechanisms and to exposed blade beneath bench
- adjustable top guard over the blade
- riving knife behind blade to hold cut timber open
- braking mechanisms
- work guides
- push stick used to present timber to blade
- LEV for dust
- emergency stop
- good housekeeping around saw
- appropriate PPE – eye protection, hearing protection, dust mask and gloves
- regular maintenance, including blade sharpening
- regular inspection and testing of electrical equipment.

## Drones

The main concern from the use of drones (small unmanned aircraft/SUA) is the mechanical impact hazard of a collision with people, property or aircraft. The potential for harm relates directly to the weight and speed of the drone. Part of the concern relates to the malicious use of drones to interrupt business as part of a protest or terror campaign.

The main controls are personal responsibility and competence of the drone pilot; keeping the drone in sight, keeping away from airfields, property and people and keeping away from aircraft.

The Civil Aviation Authority's *'Drone Code'* recommends the following separation distances.

- Below 120 m
- > 50 m away from people and property
- > 150 m away from crowds and built up areas, with no overflying
- *'Well away'* from airports and airfields

*Figure 9.14: Industrial drone*

## Driverless/autonomous vehicles

Many cars on the roads today already include many semi-autonomous features, like assisted parking and self-braking systems. Completely autonomous vehicles are expected to be on our roads in the early 2020's.

The main hazard is the mechanical impact hazard of collisions with other vehicles, pedestrians or property. Recent EU research has suggested that 94% of road traffic incidents were attributable to *'human error'.* It will be interesting to see the impact that new technologies have on incident numbers.

A combination of three technologies: sensors, connectivity and software/control algorithms are being used to make driverless vehicles a reality, with many different systems currently in development.

Sensors using radar, lidar, ultrasonics and camera technology provide information for safe navigation; connectivity (the internet of things) allows real time access to weather data, traffic conditions etc which helps the car to anticipate future conditions; and software/control algorithms capture the data from sensors and connectivity and make decisions on steering, braking, speed, and route guidance.

Currently there are many concerns about the safety and reliability of autonomous vehicles, including their vulnerability to *'hacking'*.


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