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Workplace Safety and Health Guidelines

Safe Use of Machinery



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1. Introduction

1.1 Scope and Objective

Every year, the manufacturing industry sees a significant number of workers incurring bodily injuries from the use of machines, in particular, machines with exposed moving parts. Be it a life lost or an arm severed, every injury is a stark reminder of the importance of working safely. It is therefore important that workers receive the relevant workplace safety and health (WSH) training and are sufficiently competent to carry out proper WSH risk assessment for all work activities involving machines.

This publication is intended for companies that use machines with moving parts such as milling machines, band saws, drills, shears, slitting machines, food mincers or cutters. For power presses and press brakes, readers may refer to *Technical Advisory for Safe Use of Power Presses and Press Brakes*. Hazards from the use of machines will be highlighted in this publication along with good WSH practices and suggested control measures to ensure the safe use of machines.

Note:

This set of guidelines replaces *Technical Advisory for Safe Use of Machinery* published by the WSH Council in July 2008.

1.2 Life Cycle of Machines

The life cycle of a machine begins when it is acquired, installed and commissioned. This is followed by operational use, machine maintenance and final disposal (see Figure 1).

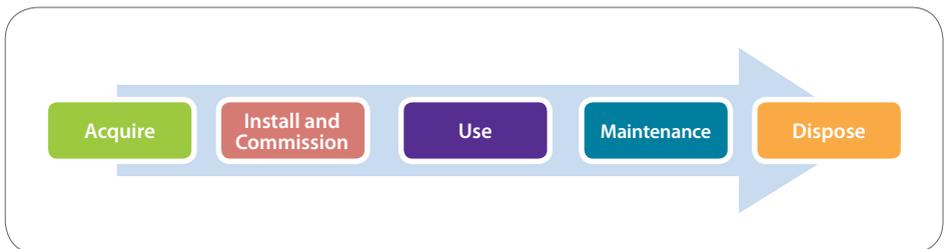


Figure 1: Life cycle of a machine.

This publication provides recommendations on suitable risk control measures that can be adopted for each stage in a machine's life cycle. Readers may refer to the relevant sections of this publication for specific advice for each of the stages seen in Figure 1.

1.3 Legislation on Machine Safety

Workplace Safety and Health Act

The Ministry of Manpower's WSH Act was passed on 1 March 2006 and extended to all workplaces on 1 September 2011. The Act stipulates the WSH obligations to be fulfilled as well as the responsibilities of every person at work.

Under the Act, the subsidiary legislation applicable to safe use of machinery includes:

- WSH (Risk Management) Regulations;
- WSH (General Provisions) Regulations; and
- WSH (Noise) Regulation.

Together, the WSH Act and its subsidiary legislations spell out the requirements for employers, principals and self-employed persons in all workplaces to:

- conduct risk assessments (RA) to identify and control WSH risks;
- provide safe work facilities and arrangements for workers;
- ensure safety in machines, equipment, substances used and work activities carried out;
- provide adequate instruction, information, training and supervision to workers; and
- implement risk control measures for dealing with emergencies.

The WSH (General Provisions) Regulations include provisions for protecting workers and employed persons when using machines. Under the law, it is the duty of the occupier of a workplace to ensure that every dangerous part of any machine in the workplace is securely fenced unless it is placed in a safe position; made safe by construction; or other effective means when the dangerous part is in motion or in use. The law also requires lock-out tag-out (LOTO) procedures to be established and implemented during machine inspection, cleaning, repair and maintenance. This is because a machine, if inadvertently activated or energised, is liable to cause bodily injury to any person at work.

Machines may generate noise in workplaces. To protect persons at work from being exposed to excessive noise, the WSH (Noise) Regulations require the occupier of the workplace and the responsible person to implement measures to reduce or control the noise emitted from any machines.

Other relevant regulations include:

1. WSH (First-Aid) Regulations

The Regulations stipulate the requirement for every workplace to be provided with a sufficient number of adequately equipped first-aid boxes. It is also compulsory for every person who is appointed a first aider in a workplace to complete the Occupational First Aid Course.

2. WSH (Incident Reporting) Regulations,

Under the Regulations, it is the duty of the employer or occupier to report any (i) workplace accident leading to fatality or injury, (ii) incidence of occupational disease, or (iii) any dangerous occurrence to the Ministry of Manpower via www.mom.gov.sg/ireport

For more information on the WSH Act and its regulatory framework, see: www.mom.gov.sg/workplace-safety-health/wsh-regulatory-framework/

2. Risk Management for Machines

WSH Risk Management (RM) is a systematic way to identify, evaluate, control and monitor WSH risks associated with any work activity or trade, and to communicate these risks to employees, contractors and other relevant parties.

As stipulated in the *Code of Practice on WSH Risk Management*, the key components of the RM process are: Preparation, Risk Assessment, Implementation, Record-keeping and Review (see Figure 2).

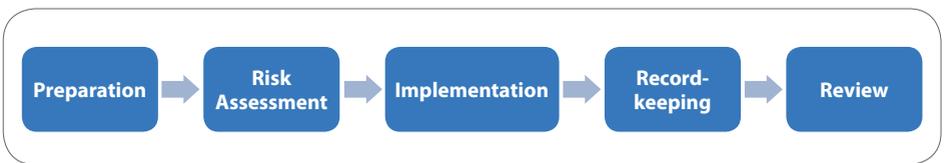


Figure 2: **The risk management process.**

RM not only involves RA for any work activity or trade, it includes on-site implementation of control measures, hazard communication to workers and regular inspections and audit.

RA refers to a careful examination of factors that could cause harm to workers' safety or health. The objective of RA is to find ways to mitigate or adequately control risks posed by hazards as far as reasonably practicable.

By carrying out RA prior to starting work, hazards may be identified and risk control measures put in place to minimise the exposure to risks while working with machines.

For more information on the RM process, see *Code of Practice on Workplace Safety and Health Risk Management* at www.wshc.sg/rmcp

2.1 Risk Assessment

The first two components of a RM process are Preparation and Risk Assessment (see Figure 2). Before conducting RA, adequate preparation must be done. A RA team, consisting of personnel in charge of various aspects of the work activity, should be formed. In this case, supervisors and machine operators should be part of the RA team to provide insight on the challenges faced at work. Relevant information such as the machine operating manual provided by the manufacturer or supplier should be collated to facilitate better understanding of the work process. In particular, the limits of the machine (as defined by the machine manufacturer) should be made available to facilitate hazard identification.

Limits of a Machine

These limits can be:

- machine specifications (e.g., raw materials to be used, maximum production rate, what is to be produced);
- physical machine boundaries and expected place of use;
- machine operational environment (e.g., recommended temperature and humidity);
- planned service life;
- intended function(s) and operating modes;
- malfunctions and faults to be expected;
- person(s) who would have to come into contact with the machine at different stages of its life cycle (e.g., levels of training, experience or ability of users);
- correct use and any reasonably foreseeable misuse of the machine.

This is followed by conducting RA for machines.

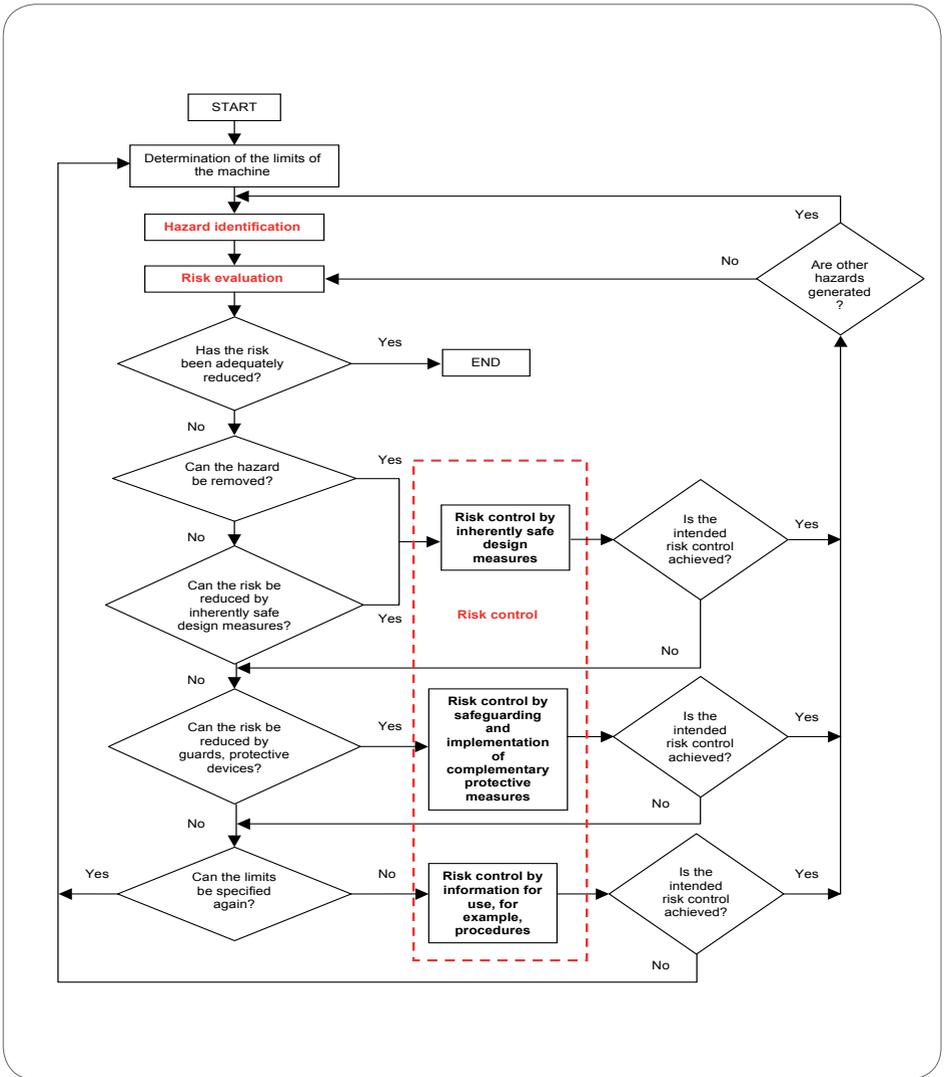


Figure 3: Risk assessment process for machines.

*Adapted from SS 537: Part 1: 2008
Code of Practice for Safe Use of Machinery

RA comprises of three key steps (see Figure 3). They are:

- Step 1: Hazard identification
- Step 2: Risk evaluation
- Step 3: Risk control

Key aspects to consider for each step:

Step 1: Hazard Identification

Hazard identification involves identifying hazards associated with each work activity (e.g., during routine work, non-routine work and emergency situations) involving a machine along with potential accidents or ill-health that could occur. It also identifies the person(s) who may be at risk as a result of being exposed to the hazards.

Additionally, the personal health risk factors of employees working with machines (e.g., colour blindness, asthma) should be considered during hazard identification and suitably addressed during RA.

Techniques for hazard identification include brainstorming, reviewing past incidents and injury records, conducting a physical site inspection, carrying out a Job Safety Analysis (JSA), performing a Failure Mode and Effects Analysis (FMEA), and so on.

A good way of identifying hazards for complex work processes is to first break down the processes of major work activities and then analyse each work activity to determine the hazards and potential accidents and/or adverse health effects that may arise from inadequate control of each hazard.

In the case of machines, the hazards encountered can be broadly classified into two major hazard categories—mechanical and non-mechanical hazards.

See Chapter 3 for more insight on these hazards.

Step 2: Risk Evaluation

Risk evaluation is the process of estimating the risk level of each work activity involving the machine and determining whether the estimated risk level is acceptable. The results of risk evaluation are used as the basis for prioritising risk control actions to minimise safety and health risks.

Risk evaluation is made up of three components:

1. Assessing the potential SEVERITY of the machine hazard;
2. Determining the LIKELIHOOD of the incident or ill-health that could occur while working with the machine; and
3. Estimating the risk level of the work activity based on its SEVERITY and LIKELIHOOD.

For more information on risk evaluation for work involving machines, see:

- *Code of Practice on WSH Risk Management*;
- *WSH Guidelines on Managing Safety and Health for SMEs in the Metalworking Sector*; and
- *SS 537: 2008 Code of Practice for Safe use of machinery- Part 1, Section 5.2.5 (Risk Estimation)*.

Step 3: Risk Control

Based on the results of risk evaluation in Step 2, risk controls should be selected to reduce the potential risk to an acceptable level.

As recommended in Figure 3, risk control measures should be observed, wherever possible, in the following order:

- risk control by inherently safe design measures;
- risk control by safeguarding and implementation of complementary protective measures; and
- risk control by information for use.

Risk control by inherently safe design measures

Inherent safety can be achieved through inherently safer design. Inherently safer design occurs when machine hazards are excluded at source by designing out the risk(s) a worker faced when he or she works with the machine. Machines can be made safer by manufacturer design through hazard avoidance or risk reduction by choosing safe design features for the machine or minimising the interaction between man and machine.

Some inherently safe design measures include:

- introduce machine automation;
- substitute a toxic machining fluid with a less hazardous one;
- reduce the mechanical force or energy exerted by the machine;
- design to block access to moving parts; and
- eliminate equipment pinch points.

See Section 5.1 for more information on risk control by inherently safe design measures.

Risk control by safeguarding and implementing complementary protective measures

These controls are add-on protective measures put in place to reduce the likelihood of occurrence or severity of the consequence of a mishap. These include erecting a physical safeguarding barrier to interrupt the accident transmission path between a worker and a hazard. Examples of physical barriers include installing a machine guard to protect workers from moving equipment parts or enclosing a noisy machine to protect the workers' hearing.

See Section 5.2 for more information on risk control by safeguarding and implementation of complementary protective measures.

Risk control by information for use

These controls help to further reduce exposure to hazards by adherence to safe work procedures (SWPs) or instructions. They should be considered after risk reduction by inherently safer design measures and appropriate safeguarding or implementation of complementary protective measures. Procedure documentation should emphasise the correct steps to be taken and the administrative controls necessary to carry out the work activity safely. Information on hazards and necessary safety precautions to be taken at specific work areas, especially when working with a hazardous machine should be communicated to workers via safety signs. In addition, information for use includes guidance on selecting the appropriate personal protective equipment (PPE) for the task at hand.

See Section 5.3 for more information on risk control by information for use.

For more information on risk management, see

- *Code of Practice on WSH Risk Management*;
- *WSH Guidelines on Managing Safety and Health for SMEs in the Metalworking Industry*;
- *A Step-by-Step Guide on Risk Management for Metalworking Sector*;
- *SS 537: Part 1: 2008 Code of Practice for Safe Use of Machinery - General requirements*; and
- *SS 537 Part 2: 2009 Code of Practice for Safe Use of Machinery - Woodworking machinery*.

2.2 Risk Management and Management of Change

Risk Management

Risk assessment is followed by implementing the risk control measures and reviewing them after they are physically implemented and communicated to all personnel. These measures are also audited for conformance and periodically reviewed for their effectiveness. In the event where work-related ill-health, near misses or an accident occurs, an immediate review of the risk assessment is necessary. Otherwise, all risk assessments should be reviewed at least once every three years by default.

Risk management includes record-keeping of all relevant records (e.g., RA training sessions, RM implementation audits and RM process management reviews) for a minimum period of three years.

Management of Change

As changes to a machine or its operation may occur after the initial RA is completed (e.g., relocation of machine; new settings and operating procedures; machine modifications and upgrades), it is important to subject any changes under consideration (whether minor or major, temporary or permanent) to RA. Conducting a RA will ascertain the impact of the change on employees' safety and health before changes are being implemented. Written procedures to manage changes should be established and implemented.

Considerations to be addressed prior to any change to the machine and its operation includes technical basis for the proposed change, update of hazard communication and operating procedures required as a result of the change, necessary time period for the change to be effected, and authorisation requirement for the change. All personnel whose job tasks will be affected by the change must be made aware of it and receive the necessary training to handle the change before it is implemented.

3. Identifying Machine Hazards

Risk assessment begins with hazard identification. Machine hazards can be divided into mechanical and non-mechanical hazards.

3.1 Mechanical Hazards

Many machines have moving parts. Machine parts may move in a linear, reciprocating, rotary, or oscillating motion, individually or in combination. In many cases, the action of these moving parts can exert sufficient force to cause injury to workers operating the machine. See below for examples of common mechanical hazards.

3.1.1 Entanglement Hazards

Entanglement may arise in the course of work when part of a worker's body (e.g., hand or foot) or loose items worn by him/ her (e.g., clothing or gloves) comes into direct contact with a moving machine part.

In general, entanglement may involve:

- Contact with a single rotating surface such as couplings, spindles, chucks, leadscrews, mandrels, bars or any rotating work piece (see Figure 4)
- Being caught by projections or in gaps such as fan blades, spoked pulleys, chain wheels, gear wheels and flywheels, mixers and beater arms, spiked cylinders, belt fasteners, projecting keys, set screws, cotter pins on shafts or slat conveyors (see Figure 5)
- Hands being caught in between counter-rotating parts, for example, gear wheels, rolling mills, mixing rolls and calendars, or materials being drawn between two rolls (see Figure 6)

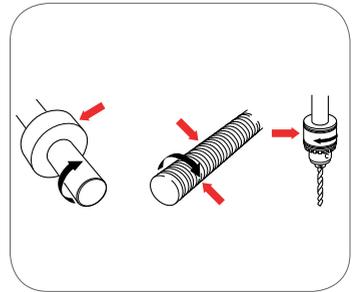


Figure 4: Entanglement caused by contact with a single rotating surface.

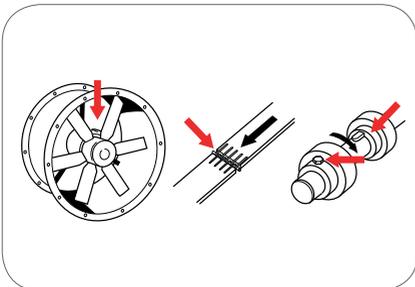


Figure 5: Entanglement caused by being caught by projections or in gaps.

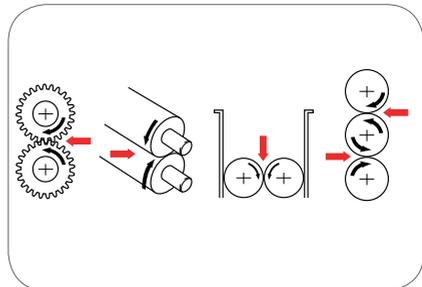


Figure 6: Entanglement as a result of being caught in between two counter-rotating parts.

3.1.2 Cutting Hazards

Cutting hazards are present in machines used to cut wood, metal or other materials at the point of operation. Examples of cutting hazards include all kinds of cutting tools, milling cutters, circular saws, handsaw blades, rotary knives, disc blades, or the sharp edges of a moving sheet of material (see Figure 7). Machines or tools with moving cutting elements are particularly dangerous as they have the capability to cause severe injury (e.g., deep cuts, amputations) due to its own momentum when they come into contact with a worker's body. The severity becomes magnified when the body part is trapped in a stationary position and the worker is unable to move away from the cutting element. Cutting hazards also occur when materials are ejected from a machine (e.g., flying metal chips or scrap material) and strike the machine operator.

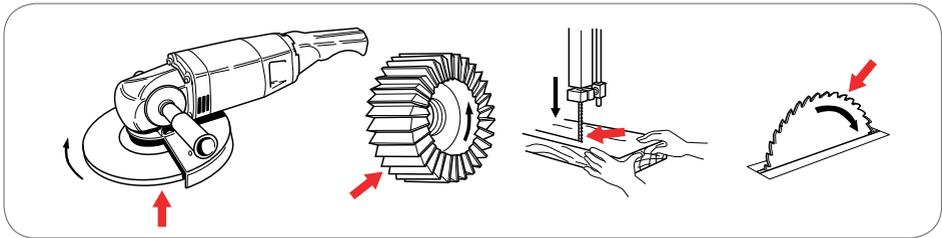


Figure 7: Examples of cutting hazards. From left: disc blades, sharp edges, band saw, circular saw.

3.1.3 Crushing Hazards

Crushing occurs when a body part is caught:

- between a fixed and moving part of a machine (e.g., between bed and tool of a power press);
- between a moving machine part and a fixed structure (e.g., between a machine counterweight and floor; see Figure 8, left); and
- between two moving parts of a machine (e.g., between support arms of a scissor lift platform; see Figure 8, right).

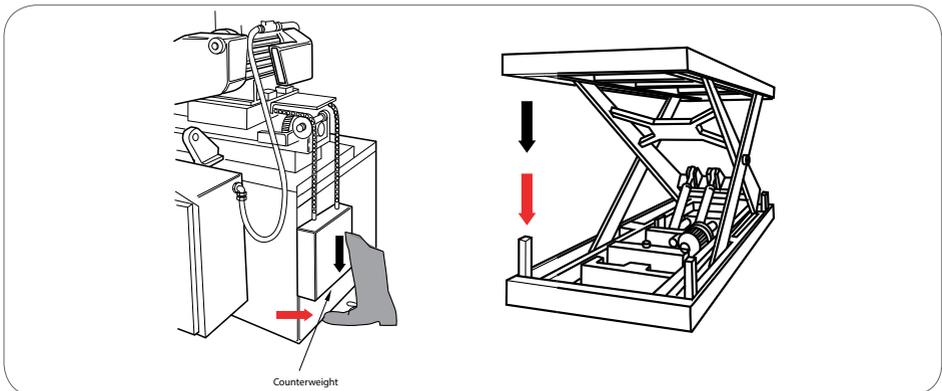


Figure 8: Examples of crushing hazards.

3.1.4 Impact Hazards

Impact hazards relate to objects that strike the human body, but do not penetrate it. The severity of an impact hazard depends on the speed, force and inertia of the moving machine part(s), material(s) being processed during machine operation or upon ejection from the machine (see Figure 9, left). Some examples of impact hazards include being struck by the rotating arm of a robot (see Figure 9, right), or being exposed to a high pressure jet of air or water. Impact hazards often result in serious injury such as abrasion and bruises.

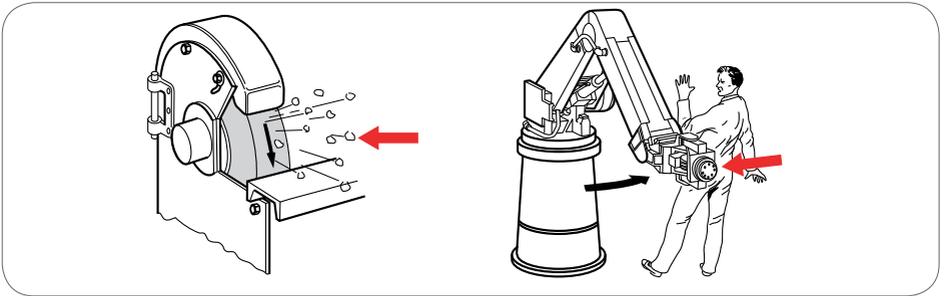


Figure 9: Examples of impact hazards.

3.1.5 Shearing Hazards

Parts of machines that move past each other or stationary objects can cause a shear point resulting in a crushing or cutting action. In general, shearing hazards are present:

- between two machine parts (e.g., a power press punch and die); and
- between a machine and a work piece (e.g., transfer mechanism [see Figure 10, left]; tool of a broaching machine and its work piece [see Figure 10, right]).

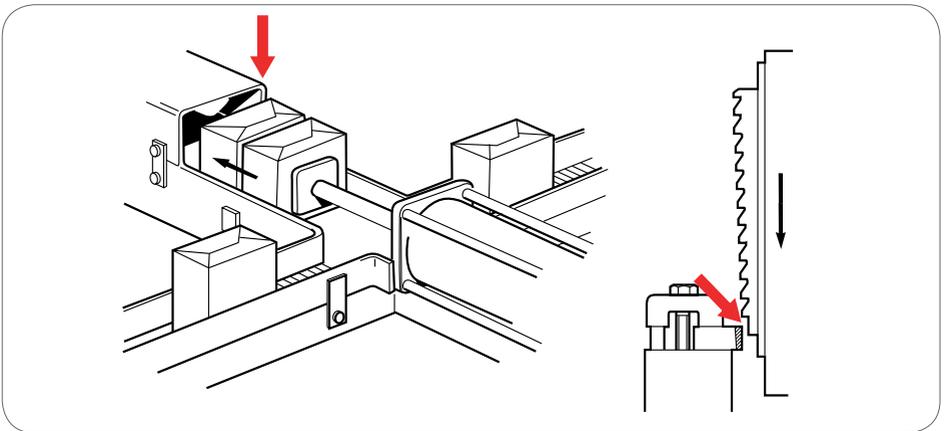


Figure 10: Examples of shearing hazards.

3.1.6 Draw-in Hazards

Injuries can occur when a body part is drawn-in by in-running nip points formed by two counter-rotating parts or between rotating and tangentially moving surfaces (see Figure 11).

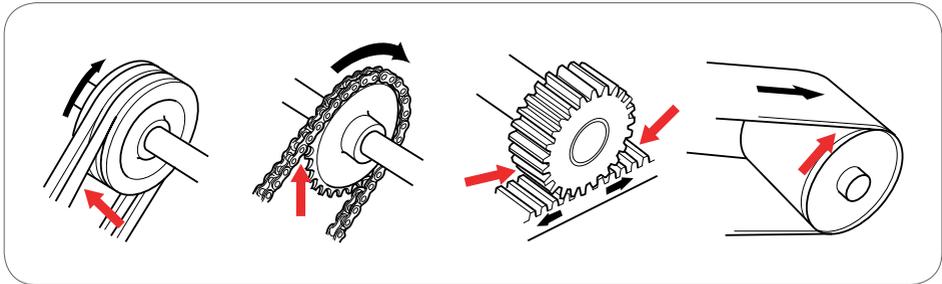


Figure 11: Examples of draw-in hazards between rotating and tangentially moving surfaces.

Recommended Practices:

- The WSH risk posed by a machine hazard may be significantly reduced through adequate risk control (see Figure 3) in the following order of priority:
 1. risk control by inherently safe design measures;
 2. risk control by safeguarding and implementation of complementary protective measures; and
 3. risk control by information for use.

See Chapter 5 for more information on practical measures for each risk control strategy.

- Access to industrial machines should be strictly restricted to authorised personnel.
- New machine operators must be sufficiently trained and supervised till they are competent to operate the machine on their own.
- All machines must be regularly serviced, maintained and checked to ensure that they are in good working condition.
- Appropriate PPE (including overalls, head, eyes, hand and foot protection) must be properly worn when working with machines. Loose clothing is not allowed and all jewellery (e.g., bracelets, necklaces and rings) must be removed before starting work. Long hair should also be neatly tied up and preferably tucked into a suitable head wear to prevent entanglement.

3.2 Non-mechanical Hazards

When identifying non-mechanical machine hazards, we should consider how machines can affect the work environment. See below for some common non-mechanical hazards.

3.2.1 Fall from Heights Hazards

When workers are required to work at heights (e.g., working on top of a machine during maintenance), fall protection should be put in place. Falls from heights can lead to sprains or broken bones and in more serious cases, head injuries or even death.

Recommended Practices:

- Provide safe means of access, secure handholds and footholds for workers if they are required to climb on top of machines.
- Ensure that there are adequate barricades at all open sides and openings.
- When barricade is removed, use appropriate fall prevention equipment such as travel restraint system or personal fall arrest system.
- Use safe height access equipment such as platform ladder.
- Fall Prevention Plan to include prevention of falls from machines during maintenance and operation.

For more information on working safely at heights, see:

- *Workplace Safety and Health (Work at Heights) Regulations 2013*; and
- *Code of Practice for Working Safely at Heights*.

3.2.2 Noise Hazards

Noise is often generated during machine operations and work activities. Prolonged exposure to excessive noise can cause noise-induced hearing loss, leading to noise-induced deafness (NID).

To prevent hearing loss, a worker should not be exposed to noise levels exceeding 85 dB (A) for 8 hours a day or its equivalent. Where the permissible exposure level is exceeded, measures must be taken to reduce the noise exposure.

Sound Pressure Level dB(A)	Maximum Duration per Day
85	8 hours
88	4 hours
91	2 hours
94	1 hour
97	30 minutes
100	15 minutes
103	7.5 minutes
106	4 minutes
109	2 minutes
111	1 minute

Table 1: Permissible exposure limits for noise [extracted from WSH (Noise) Regulations 2011].

Recommended Practices:

- Specify and request for low noise machines during purchase.
- Replace noisy machines with less noisy ones.
- Relocate noisy machines and processes to a lesser-occupied or non-occupied area of the workplace.
- Locate noise sources away from hard walls or corners.
- Construct suitable noise enclosures or barriers to isolate the source of noise and reduce noise emission.
- Minimise the number of noisy machines running at any one time.
- Provide workers with hearing protectors and ensure that they are properly used.

For more information on protecting workers' hearing at work, see:

- *WSH (Noise) Regulations 2011*; and
- *WSH Guidelines on Hearing Conservation Programme*.

3.2.3 Heat-related Hazards

Workers are often exposed to heat when they operate machines that run in hot environments. Contact with hot surfaces of machines can cause severe skin burns. Operations involving high temperatures, radiant heat sources, high humidity or strenuous physical activities have a high potential for causing heat-related illness (e.g., heat exhaustion or, in severe cases, heat stroke).

Workers need to be made aware of the heat-related hazards associated with the task at hand and the preventive measures to be taken before starting work.

Recommended Practices:

- Insulate all hot machine surfaces whenever possible.
- Install warning signs and labels to alert workers of the presence of a hot surface.
- Provide workers with heat-resistant gloves when they need to perform work involving hot machines.
- Improve the ventilation of the work area.
- Ensure that workers get sufficient rest and drink enough water to stay hydrated throughout the work activity.
- Rotate job function among workers so that it minimises exertion and control their exposure to heat.
- Workers should be aware that the use of certain PPE can increase the risk of heat-related illness (e.g., certain types of respirators and impermeable clothing).
- Thermally-conditioned clothing may be used for work in extremely hot conditions.

For more information on managing heat stress, see *WSH Guidelines on Managing Heat Stress in the Workplace*.

3.2.4 Electrical Hazards

Workers may be exposed to electrical hazards in their daily operations, for example, during electrical installations or when machines or power tools are in use. Accidents involving contact with electricity can happen when an electrical machine failed, electric circuits are overloaded (see Figure 12) or short-circuited, or when one comes into contact with a live wire (e.g., as a result of worn out insulation).

To prevent such accidents, it is important that electrical machines and equipment are regularly inspected by a Licensed Electrical Worker (LEW) to ensure that they remain in good working condition. Extreme care should be taken in workplaces where workers come into contact with fluids that are good conductors of electricity.



Figure 12: Haphazard electrical connections can lead to overloading and electrocution.

Recommended Practices:

- Use only power sockets, plugs and cables registered with SPRING Singapore. Under the Consumer Protection (Safety Requirements) Registration Scheme, products that meet the required safety standards will bear the "SAFETY Mark".
- Conduct visual inspections on electrical machines before starting daily operation. Any electrical plugs, cords and wires found damaged or exposed should not be used.
- Ensure that electrical machines are properly grounded.
- Engage only electrical workers who are licensed by the Energy Market Authority (EMA) to carry out electrical work.
- Establish LOTO procedures for any work involving repair and maintenance of electrical machines.
- Do not clean electrical machines with flammable solvents.
- Do not overload electrical power points.
- Ensure that electrical machines are protected by over-current or overload protective devices.
- Keep power cords away from heat, water and oil.
- Always pull the electrical plug, not the cord.

3.2.5 Chemical Hazards

Workers carrying out work involving a machine may come into contact with chemicals in their daily activities as many machines rely on the use of chemicals for normal function. Some examples include:

- portable electrical generators require diesel as fuel;
- equipment with moving parts require lubricants to ensure their smooth operation;
- vehicles require hydraulic fluids in their braking mechanism;
- refrigerators and air-conditioners require a refrigerant to achieve cooling;
- wafer fabrication requires acids for wet etching; and
- machine maintenance requires specialty cleaning agents.

When working with a machine, chemical contact with the skin is possible, for example, during cleaning operations, preparing or draining of machine fluids, handling of work pieces, and changing and setting of tools.

Inhalation is another possible route for chemical exposure. This can occur when one is working near a machine that generates a chemical mist, aerosol or vapour, where the machine is not enclosed and when ventilation of the work area is inadequate. Prolonged exposure to chemicals can lead to skin disorders (e.g., dermatitis) and poor respiratory health (e.g., asthma).

Occupational exposure due to ingestion is less common but can take place when employees do not wash their hands properly before drinking, eating or smoking, and when they eat or drink in contaminated work areas. A harmful chemical, if swallowed, can cause extensive damage to the inner lining of one's mouth, gullet and stomach.

In the metalworking industry, machining fluids are necessary to reduce friction and heat generated between the cutting tool and work surface. The use of chemicals (machining fluid) is critical as it not only helps to improve the machine's performance but it also prolongs the life of the cutting tool. Such fluids can splash onto a worker during machine operation if there are no splashguards.

The use of chemicals, therefore, poses significant workplace risks as they can be toxic, flammable, corrosive and/ or highly reactive. It is important to control this risk in order to protect workers from the chemical hazard(s) associated with machine operation.



Figure 13: Use of chemicals during machining.

Ideally, hazardous chemicals should be eliminated or substituted with something less hazardous. However, if this is not possible, the use of engineering controls (e.g., a fixed splashguard), administrative controls (e.g., SWPs and safety signs), and PPE (e.g., chemical-resistant aprons and face shields) is strongly recommended to minimise one's exposure while working with a machine.

Recommended Practices:

- Eliminate or substitute hazardous chemicals wherever possible.
- Install enclosed splashguards to protect workers from splashing due to machine operation.
- Minimise the extent of splashing and mist generation by controlling the volume and delivery rate of the machining fluid to the cutting tool.
- Develop SWPs for any work involving hazardous chemicals.
- Install safety signage to warn machine users of presence of a chemical hazard.
- Ensure that work area is sufficiently ventilated. The use of local exhaust ventilation (e.g., a fume extraction chamber) is recommended for any machine work where chemical mist, vapours and/ or aerosols are emitted.
- Provide workers with appropriate PPE for the task, for example, chemical-resistant aprons and gloves, safety goggles or face shields, respirators.
- Train workers to keep the inside of the gloves clean when they are putting or taking them off.
- Provide hand washing facilities and encourage workers to wash their hands regularly especially before eating or drinking. Advise workers to pay particular attention to washing the skin under rings and watch straps when they are washing their hands.
- Provide laundry service for company-issued work attire so that workers do not bring contaminated clothing home.

For more information on working safely with chemicals, see:

- *WSH (General Provisions) Regulations*; and
- *WSH Guidelines on Management of Hazardous Chemicals Programme*.

3.2.6 Ergonomic Risk factors

When using machines, there are ergonomic health risks that can lead to sprains and strains to one's back and other parts of the body. Workplace factors associated with musculoskeletal disorders include:

Awkward postures

The human body functions best in natural postures. Prolonged awkward body postures increases the stress on muscles and ligaments, leading to muscular fatigue, discomfort and increased risk of injury. Examples of awkward postures include workers having to bend low for maintenance work or operators having to stretch uncomfortably to operate machines.

Recommended Practices:

- Reposition worker or location of work to avoid awkward posture.
- Redesign work activities that require workers to reach over their shoulders or below their knees.
- Ensure that new machines are positioned within easy reach for all workers, including maintenance staff.
- Locate tools within easy reach.
- Encourage employees to do simple stretching exercises at their workstations.

Repetitive Movements

Many machines are designed to achieve industrial efficiency by breaking down manufacturing processes into simple steps that machines can carry out. While some steps can be fully automated, the requirement for man-machine interaction usually remains for key operating steps like loading of raw material, quality inspection and final assembly. These steps may require repetitive movement by the machine operator.

These repetitive movements may become detrimental to workers' health leading to chronic musculoskeletal disorders. This usually happens when the same joints and muscle groups perform the same action often, quickly and strenuously over an extended period without giving the body sufficient time to rest and recover.

Recommended Practices:

- Automate repetitive tasks wherever possible.
- Plan work schedules so that workers can take regular breaks (breaks can be short but regular).
- Practice job rotation. This can include rotating workers through different work activities during their shifts to reduce the extent and duration required for the repetitive movement.

For more information on ergonomics at the workplace, see *WSH Guidelines on Improving Ergonomics at the Workplace*.

3.2.7 Fatigue

Fatigue is a state of tiredness leading to reduced mental and physical performance that can endanger workplace safety and workplace health. Long working hours and poorly planned shift work can result in employee fatigue, leading to reduced productivity. Fatigue can also lead to near-miss incidents, serious injuries and even fatal accidents due to reduced concentration and alertness.

In general, fatigue can be caused by:

- long working hours without rest;
- intense and sustained physical exertion;
- intense and sustained mental effort;
- working during part of or all of the natural time for sleep; and
- lack of adequate rest and sleep.

Recommended Practices:

- Schedule complex tasks to be performed only during the day.
- Plan shift schedules ahead of time and communicate them to workers.
- Limit shift work to not more than 12 hours including overtime.
- Keep night shift work to a minimum.
- Ensure that there is sufficient recovery time between shifts.
- Encourage employees to take scheduled breaks to relieve fatigue.
- Provide facilities for breaks such as pantry and shower facilities.
- Provide after-work transportation for employees working long or night shifts.
- Introduce shift rotation.

For more information on fatigue at the workplace, see *WSH Guidelines on Fatigue Management*.

4. Controlling Risks: From Acquisition to Disposal

A new machine brings along with it new WSH risks, therefore, it is important to identify these risk before bringing it on-site. Buyers need to bear in mind that a machine's life cycle starts with its acquisition (see Section 1.2).

4.1 Acquisition of Machines

Injuries associated with machines may occur when the wrong machine is selected for the job. Consider the following before purchasing a new machine:

- the intended purpose of the machine;
- the environment and location the machine would be placed;
- the training and competency requirement for the machine operator;
- WSH risks arising from the use of the machine;
- how risks are controlled by different manufacturers; and
- how the residual risks can be addressed.

The information above can help buyers decide which machine may be more suitable, after taking into account WSH considerations.

When acquiring new machines, the recommended practices are:

- Do a background check on the specific machine model to ascertain if there are existing WSH concerns;
- Ensure that adequate inherently safe design measures have been included in the design of the machine (see section 5.1);
- Ensure that the manufacturer or supplier has provided a "Declaration of Conformity";
- Ensure that the machine manufacturer or supplier has conducted RA on the machine;
- Ensure that an operating manual with instructions for safe machine use, assembly, installation, commissioning, repair and maintenance is supplied;
- Ensure that technical drawings of the machine and its various parts are available;
- Ensure that information on any residual risks is provided together with the safety precautions needed to deal with them; and
- Request for certified safety marks as evidence that the machine conformed to applicable local and/ or international standards.

Along with the above recommendations, machine buyers may also consider working closely with the machine manufacturer or supplier to include user training sessions (for operation and in-house maintenance personnel), and regular servicing and maintenance of equipment as part of the machine's cost.

See Annex 1 for a sample checklist on acquiring new machines.

Declaration of Conformity

A declaration of conformity is a formal declaration by a manufacturer or supplier, that the machine meets all local safety requirements and relevant international standards applicable. The declaration assures that the machine has been designed and constructed to conform with relevant safety requirements and has gone through the appropriate conformity assessment processes. A declaration of conformity, however, is not a certificate of quality nor a guarantee for safety.

A declaration of conformity typically includes:

- name and address of the manufacturer (or, where appropriate, the authorised representative);
- information on machine model, type and serial number;
- applicable safety requirements and standards the machine conforms to; and
- identity and signature of the person empowered to draw up a declaration on behalf of the manufacturer (or the authorised representative).

Acquisition of Used Machines

Under the pressure to reduce business cost, companies may not see the need to invest in new machines. Instead, companies may prefer to acquire used equipment that meet their daily operation requirements.

It is recommended that buyers of second-hand machines ensure that:

- Machine safe guards and safety devices are present and functioning;
- Equipment warning signs are visible and easy to understand;
- Spare machine parts are available if they need to be replaced; and
- Modified or retrofitted machine are certified safe for use.

These are recommended practices on top of those listed for new machines.

Additionally, second-hand machines should be subjected to a pre-operational functionality test. The tests should include functional checks on each of the machine's safety feature (e.g., safety interlock, emergency stops).

A competent person (e.g., a professional engineer or third-party inspector) may be engaged to assist with an independent and objective safety evaluation. The evaluation would assess the machine for conformance to industry standards and local WSH requirements. As a result of the evaluation, companies will have the necessary information before making the purchasing decision.

Upon acquiring a second-hand machine, it is the owner's duty to ensure that the second-hand machine is suitable for the selected work; safe for use; and maintained in a safe condition.

See Annex 1 for a sample checklist on acquiring second-hand machines.

4.2 Installation and Commissioning of Machines

4.2.1 Installation

Installation refers to the process in which a machine is assembled, placed in position, connected, and made ready for use.

WSH considerations for installation of machines include:

- All on-site assembly work and installation, including electrical wiring, should be performed by the machine manufacturer, authorised agent or competent person;
- RA must be conducted prior to the installation of the machine;
- There should be sufficient space for unloading and temporary storage of the machine and its components;
- Debris or waste material generated from the unpacking and installation process should be consolidated for proper disposal; and
- Machine location and factory layout:
 - Machines should be installed in a location that do not obstruct fire exits, emergency escape routes, access to firefighting equipment and building access route for firefighting operations;
 - Sufficient space should be provided for workers to safely work around each machine and for a safe passage for workers to move past (or through) groups of machines;
 - Individual machines would require sufficient space to allow workers to conduct their daily work and activities such as cleaning and maintaining the machine; and
 - Machines with moving parts should be located a safe distance from any fixed structure.

For more information on factory layout, see *SS 567: 2011 Code of Practice for Factory layout - Safety, health and welfare considerations*.

4.2.2 Commissioning

Commissioning is the stage where a machine moves from static completion (completely installed) to being fully operation. Machines should be tested and commissioned by their manufacturers, authorised agents or competent persons before they are handed over to the machine buyers or owners.

When commissioning a machine, the recommended practices are:

- Carry out a RA to identify residual hazards and ascertain if the control measures in place are sufficient to ensure that the machine is safe for use;
- Ensure that the machine is on even ground and positioned securely on the floor;
- Barricade the machine and display warning signs during the commissioning and testing stages;
- Thoroughly inspect the machine for machine faults or defects, before it is switched on. In particular:
 - Check the appearance of each machine part, making sure that there are no abnormalities (e.g., cracks, dents);
 - Inspect the machine for foreign or missing items;

- Check that all parts are properly fastened (e.g., nuts and bolts are secured, all machine belts and chains tensioned); and
- Ensure that the machining fluid (e.g., lubricant oil, coolant, grease, etc) used are recommended by the manufacturer.
- Confirm that the power voltage supplied to the machine is correct before switching on the power supply;
- Check that there is no leakage of oils or coolants, and that the machine operating pressure is within the acceptable range with no abnormal noise emissions after the machine is switched on;
- Subject all safety devices to a functional check before the machine can be declared safe for use. These safety devices include:
 - machine guards;
 - sensors and interlocking devices of machine guards, gates, doors, and so on;
 - presence-sensing device;
 - two-handed control device;
 - emergency stop button;
 - warning device; and
 - circuit breakers.

All inspection, testing and commissioning results should be properly documented for future reference.

4.3 Use of Machines

Workers who operate machines must be trained, competent, and/or suitably supervised, so that they do not put themselves or others at risk while at work.

Before starting an operation, it is important to:

1. obtain the latest copy of the completed RA, understand the hazards posed by the machine and identify the control measures implemented; and
2. carry out pre-operation functionality checks on all machine safety devices (e.g., machine guards, presence-sensing device, two-handed control devices, interlocking devices and emergency stop button).

When using machines, operators are expected to:

- Ensure that the engineering control measures are in place (see section 5.2);
- Adhere to SWPs (see section 5.3.1);
- Put on the appropriate PPE (see section 5.3.4) such as safety glasses or goggles if there is a risk of materials being ejected during operation. Hearing protectors must be worn should there be excessive exposure to noise [above 85 dB(A) over an 8 hours period] while working at the machine.

Employers should also consider and address risks that may arise from repetitive tasks (see Section 3.2.6) and workers' fatigue (see Section 3.2.7).

WSH Training

Employers need to ensure that workers are adequately trained and competent in machine operation and maintenance prior to assigning work. Training may include formal classroom training, on-the-job coaching, and specific work instructions to individuals or groups. All training should be properly documented (e.g., date of training, participant list and topics covered).

WSH training should be conducted:

- during orientation of new employees;
- periodically for existing employees;
- whenever new machines or processes are introduced; and
- when an employee is transferred to another department or job function.

Once workers have received training in WSH, they should be able to:

- follow SWPs and operate the machines safely;
- use PPE correctly;
- exercise due diligence to report accidents, incidents, near misses or any workplace hazards to their supervisors;
- carry out emergency response procedures; and
- participate in WSH management activities.

Retraining is necessary, when:

- new machines are installed or modifications are made to existing machines;
- changes are made to SWPs; and
- RA forms are updated.

4.4 Maintenance of Machines

In general, machines must be regularly maintained for optimal performance. Regular maintenance is also necessary to prevent breakdowns and ensure that the machine remains safe for use. Machines must be maintained and repaired according to manufacturer's specifications or, in the absence of such specifications, in accordance with a competent person's recommendations.

As with all work activities, a site specific RA must be carried out before maintenance work is attempted.

4.4.1 Maintenance Programme

An effective maintenance programme should be established for all machines and equipment used. This will help prevent accidents from happening due to machine or equipment failure.

A maintenance programme should include:

- a listing of all machines and equipment used within each worksite;
- inspection and maintenance schedules and records for each machine and equipment; and
- a system for employees to report any defective or damaged machine in the course of their work.

If the machine is not functioning properly, only trained and authorised personnel may be tasked to diagnose its problem. Replacement parts and devices recommended by the manufacturer should be used to maintain the integrity and continued safe use of the machine. The replacement parts need to be properly matched to the machine series, model, serial number and revision of the machine. If original replacement parts are not available, consult the manufacturer for recommendations on suitable alternatives.

4.4.2 Training for Maintenance Workers

Authorised personnel performing servicing and maintenance need to be trained to:

- Recognise hazardous energy sources and understand the magnitude of the energy source at hand;
- Identify and properly operate the applicable energy-isolating devices;
- Carry out the LOTO procedure; and
- Safely apply and remove lock-out devices.

Machine operators need to be trained to:

- Recognise when lock-out activities are in progress; and
- Understand the purpose of the energy lock-out and the importance of not tampering with the lock-out devices encountered at the workplace.

4.4.3 Lock-out Tag-out Procedure

All energy sources (whether electrical, mechanical, pneumatic, hydraulic or in any combination) must be securely isolated before any machine repair or maintenance is attempted. This is to ensure that the machine does not move or accidentally start up due to an unexpected release of an energy source. The steps necessary to isolate all forms of hazardous energy is termed the LOTO procedure.

See Section 5.3.2 for more information on Lock-out Tag-out procedure.

4.5 Disposal of Machines

A machine has reached the end of its life cycle when it has broken down beyond repair, been rendered obsolete in relation to more advanced machines available in the market, or has been displaced by an upgraded or more efficient machine.

Disposal of machines typically involves scrapping or reselling. If the machine is to be resold, the recommended practices are:

- Conduct a final RA and pass the results to the buyer;
- Provide buyer with the operating manual and SWPs which include instructions for safe assembly, installation, commissioning, handling, repair and maintenance;
- Ensure that safe guards and safety devices are functional and in place;
- Check that warning signs are visible and in good condition; and
- Ensure that information on any residual risks and the additional precautions needed are documented and passed on to the buyer.

Some machines, however, may not be suitable for resale as a result of contamination by hazardous substances or wastes. In such situations, the machine may have to be scrapped. The officer in-charge of hazardous waste disposal should engage a licensed toxic industrial waste (TIW) collector and communicate the relevant disposal requirement(s) to the collector. A licensed TIW collector will be able to assist with the removal and disposal of hazardous waste residues from the machine before it is sent for scrapping.

An updated list of TIW contractors licensed by the National Environment Agency (NEA) under the Environmental Public Health (Toxic Industrial Waste) Regulations can be found at NEA's website (www.nea.gov.sg) under Anti-Pollution & Radiation Protection > Chemical Pollution > Toxic Industrial Waste.

For more information on disposal of hazardous waste, see *CP 100: 2004 Code of Practice for Hazardous Waste Management*.

5. Control Measures

There are three basic approaches to applying risk control measures for machines:

1. risk control by inherently safe design measures;
2. risk control by safeguarding and implementation of complementary protective measures; and
3. risk control by information for use.

5.1 Risk Control by Inherently Safe Design Measures

Inherently safe design measures are the first and most important step in the risk control process. This is because protective measures inherent to the characteristics of the machine are more likely to be effective in risk reduction than a safeguard or protective measure (which can fail or be intentionally violated) or information for use (which may not be understood or closely adhered to by the machine operator).

Aspects of inherently safe design can be applied to the machine and/or the interaction between the machine and operator at risk. Inherently safe design can be achieved through safer machine design and reducing the interaction between man and machine.

5.1.1 Safer Machine Design

The objective of inherently safe machine design is to avoid hazards or reduce the risk of exposure to hazards. This can be achieved via good machine design and intentionally designing for safety:

- **Avoid sharp edges, corners and protruding parts**
Accessible parts of the machine should be designed with no sharp edges, sharp angles, rough surfaces, or any protruding parts likely to cause injury. The machine's preliminary design should also be reviewed to remove openings that can trap parts of the body or clothing. Sheet metal edges should be deburred, flanged or trimmed, and any open ends of tubes which can cause trapping should be capped.
- **Avoid crushing, shearing and entanglement points**
The relative location of mechanical parts should be taken into consideration to avoid any point(s) that can cause crushing, shearing or entanglement. This can be made possible by increasing the minimum gap between moving parts so that the part of the body under consideration (e.g., one's fingers) can safely move through the gap or reducing the gap so that no part of the body can enter it.
- **Limit the actuating force**
In some cases, the actuating force exerted by moving machine parts can be limited to reduce harm to the operator. By limiting the actuating force to a sufficiently low value, the impact of the force generated can be reduced to the point where the mechanical hazard no longer exists. This can be achieved by limiting the mass and/or velocity of the movable parts of the machine.

- **Design to eliminate the need for protective measures**

This involves incorporating innovative features into the machine design so that work activities can be made inherently safe thus eliminating the need for a safeguard or protective device. Examples where the reliance on safeguards may be eliminated include:

- locating grease inlet points on the opposite side of a machine which has hot parts; and
- locating lubrication points away from parts of the machine which has moving parts.

- **Consider machine ergonomics**

Incorporating ergonomic principles in the man-machine interface by applying anthropometric (human body) measurements in machine design can help reduce exposure to ergonomic risks (e.g., leading to musculoskeletal disorders) and the likelihood of errors during machine use. The anthropometric measurements are important as they will influence, for example, the dimensions of the machine necessary for maintenance, routine work and comfortable access.

For more information on safer machine design, see:

- *ISO 13854: 1996 Safety of Machinery – Minimum gaps to avoid crushing of parts of the human body;*
- *ISO 13857:2008 Safety of machinery – Safety distances to prevent hazard zones being reached by upper and lower limbs;* and
- *ISO 14738: 2002 Safety of Machinery – Anthropometric requirements for the design of workstations at machinery.*

5.1.2 Reduced Man-machine Interaction

Machines can be made safer once the requirement for man-machine interaction is reduced. There are two key approaches to achieve this:

1. Automation

Automation can be accomplished, for example by industrial robots or automatic handling devices and transfer mechanisms. Through automation, the requirement for man-machine interaction during daily operations can be effectively reduced. It is important to understand that while automation can prevent accidents, the deployment of automated machines may create new dangers especially when equipment faults or operating problems occur. A thorough RA should be undertaken to identify residual hazards post-automation and suitable control measures implemented to control the risk (e.g., equipment safeguards, safety interlock systems).

2. Reliable machine components

Reliable components are, in general, parts that are well-made and of good quality. They can withstand stresses associated with machine operation for an extended period with a low probability of failure or malfunction. The increased reliability of the machine as a whole will significantly reduce the frequency of incidents requiring man-machine intervention (e.g., incidents requiring repair or overhaul), thereby reducing exposure to machine hazards which will, in turn, prevent accidents.

5.2 Risk Control by Safeguarding and Implementation of Complementary Protective Measures

In cases where risk control by inherently safe design measures is not possible, the use of engineering controls (e.g., the use of machine guards and other physically implementable protective measures) becomes the next critical approach to risk reduction.

5.2.1 Machine Guards

Machine guards are rigid physical barriers that enclose dangerous machine parts and restrict operator access to danger areas. Machine guards often partially cover the point of operation while allowing limited or no access. The guard must be designed to take into consideration:

- all the intended uses of the machine;
- the reasonably foreseeable incorrect use of the machines; and
- all voluntary and involuntary movements of the operator.

It is important to note that machine guards must be positioned in a manner that does not obstruct the operator's view and interfere with the normal operation of the machine. If the guarding has to be removed from the machine during servicing or maintenance, ensure that energy lockout measures (see Section 5.3.2) are in effect before starting work. Machine guards must be immediately re-installed once the servicing or maintenance work is completed.

See below for key aspects of a machine guarding programme.

1. Machine Guard Inspection, Maintenance and Audit

Machine guards should be affixed with screws, bolts and lock fasteners that are not easily removed or bypassed. This is to prevent the guard from being tampered with or inadvertently dislodged.

To ensure effective guarding against machine hazards, employers must:

- Train operators to verify that machine guards are functional and securely in place before using the machine;
- Schedule supervisors to conduct periodic inspections to verify that workers are using the machine guards as intended;
- Assign engineers to verify that any new or modified operation is properly guarded before the machine can be declared ready for use;
- Hold maintenance personnel responsible for ensuring that machine guards are properly maintained and placed on a preventive maintenance programme;
- Assign the safety manager or safety committee to audit the effectiveness of the machine guarding programme, and resolve any outstanding guarding issues; and
- Encourage the plant manager to show support and give recognition when audits show that the machine guards are properly used.

Factors to consider when determining the frequency of machine inspections include:

- likelihood of a machine guard being removed,
- complexity of the machine guard or guarding device, and
- severity of the injury should a machine guard go missing.

2. Machine Guard Education and Training

As part of the machine guarding programme, operators will need to receive training on the various types of machine guarding and their respective application. This will help operators understand the basics of machine guarding and how it provides physical protection from machine hazards.

Fixed Guards

A fixed guard is a physical barrier that is permanently attached (e.g., with screws) to a machine to prevent access to the danger zone from any direction (see Figure 14). Fixed guards are typically designed so that they are difficult or impossible to remove without the aid of a specific tool. This makes fixed guards safer than other types of guards as they are harder to remove. In general, fixed guards are preferred due to their relative simplicity and permanence. Fixed guards are commonly used to cover power transmission units.

Adjustable Guards

An adjustable guard is one that can be moved or reconfigured to the dimension of the work at hand. Adjustable guards will allow a machine to handle a wide variety of material sizes while protecting users from the danger zone. It is important that any manual guard adjustment is carried out by a trained and competent person. An example of an adjustable guard is the guard covering the point of operation of a circular band saw (see Figure 15).

Self-adjusting Guards

A self-adjusting guard is one that covers the danger zone until a work piece is pushed into the point of operation and moves the guard. The gap between a self-adjusting guard and the danger zone is therefore determined by the movement of the work piece. As the operator moves the work piece into the danger area, the guard is pushed away, providing a clearance large enough to admit only the work piece. Once the work piece is removed, the



Figure 14: Fixed guard to prevent access to danger zone from all directions.

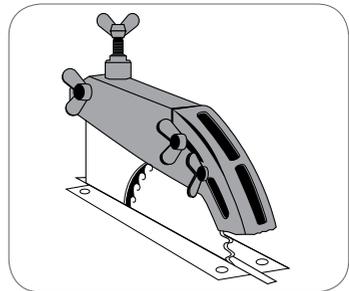


Figure 15: Circular table saw fitted with adjustable guard.

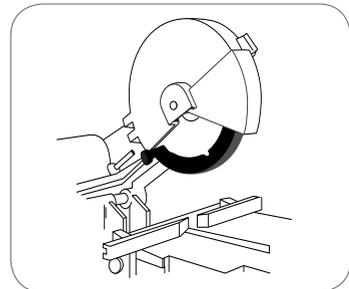


Figure 16: Saw fitted with self-adjustable guard.

guard will automatically return to its neutral (safe) position. An example of a self-adjusting guard is the guard covering the point of operation of a radial arm saw (see Figure 16).

Interlocking Guards

An interlocking guard is one that shuts down or disengages the power to the machine whenever it is opened or pushed out of position. Once the interlocking guard is disengaged, the switch or interlock will automatically stop the dangerous operation or motion. The machine can only be manually restarted when the interlocking guard is returned to its original position. Interlocking guards are commonly used to protect the operator of a milling machine (see Figure 17).



Figure 17: Flour mixer installed with interlocking guard.

For more information on machine guards, see:

- *SS 537: 2008 Code of Practice for Safe use of machinery - Part 1: General requirements;*
- *SS 537: 2009 Code of Practice for Safe use of machinery - Part 2: Woodworking machinery;*
- *ISO 12100: 2010 Safety of Machinery – General Principles for Design – Risk Assessment and Risk Reduction;*
- *ISO 13855: 2010 Safety of Machinery – Positioning of safeguards with respect to the approach speeds of parts of the human body;*
- *ISO 14120: 2002 Safety of machinery -- Guards -- General requirements for the design and construction of fixed and movable guards; and*
- *ISO 14119: 2013 Safety of Machinery – Interlocking devices associated with guards – Principles for design and selection.*

5.2.2 Presence-sensing Safety Devices

A presence-sensing device will not prevent access to dangerous points of operation, but it can detect a person once any part of his or her body enters the identified danger area. When this happens, the machine can be automatically programmed to raise an alarm, reduce the speed of its moving parts, or be stopped immediately. Examples of presence-sensing safety devices include light curtains and laser scanners.

It is important to note that the use of presence-sensing devices alone may not provide sufficient physical protection from machine hazards. Additional safeguards (e.g., a suitable fixed barrier or machine guard) may be used in combination with a presence-sensing device to offer increased levels of protection. When installing a presence-sensing device, careful positioning is required so that the sensors do not detect false or stray signals from other transmitting devices or equipment in the vicinity.

Safety Mat

The use of pressure-sensitive safety mats is a simple method for protecting workers working around a hazardous machine (e.g., the rotating arm of an industrial robot). This is achieved by laying safety mats around the machine. The safety mat contains a normally-open switch. When a weight is applied onto the safety mat (e.g., if a machine operator steps on the mat), the switch closes and sends a signal to immediately stop the machine. See Figure 18 for an example of a pressure-sensitive safety mat.

Safety Light Curtain

Light curtains (available as a photoelectric transmitter and receiver pair) emit a harmless “curtain” of infrared light beams directly in front of the danger area of a machine (see Figure 19). When any of the light beams are “broken” (e.g., blocked by any part of a person’s body), the machine’s stopping mechanism will be immediately activated so that it stops before the operator crosses into the danger zone. The advantage of light curtains is that it offers protection at the point of operation (hazardous point protection) or around the perimeter (access protection) of a hazardous work area with minimal impact on routine machine operation.

Safety Laser Scanner

Laser scanners combine pulsed infrared laser and time-of-flight technology to precisely calculate the location of any detected person or object within a danger area. This location is then compared with the safety and warning zones defined in the device. If the person or object is present inside the warning zone, audible and visible signals can be triggered. If intrusion of the safety zone occurs, the scanner can be programmed to promptly send a stop signal to the hazardous machine.

The laser scanner can be deployed in stationary (mounted on a fixed object) or in mobile (mounted on a moving object) applications. The advantage of laser scanners is that it can safeguard all points within the perimeter of the danger area. The predefined danger area can be configured to protect areas that are rectangular or circular in shape as well as areas that are irregularly shaped. See Figure 20 for an example of a safety laser scanner.



Figure 18: Example of a pressure-sensitive safety mat.



Figure 19: Machine equipped with a safety light (picture courtesy of Omron STI).



Figure 20: Example of a safety laser scanner.

Safety Camera

Safety camera systems are electro-sensitive protective devices based on three-dimensional image processing technology (see Figure 21). In contrast to simple sensors, a safety camera system is able to continuously monitor a danger area and record or analyse detailed information concerning the entire area being monitored. The detection zone of a safety camera is typically divided into warning and danger zones. If a person or object enters the warning zone, the system can be programmed to sound the alarm and slow down the hazardous machine. Should the person or object approach the danger zone, the system would promptly trigger an emergency stop command to shut down the machine.

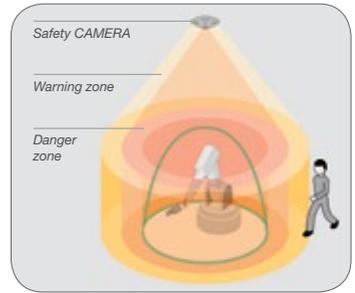


Figure 21: Example of a safety camera system.

For more information on presence-sensing safety devices, see:

- *SS 537: 2008 Code of Practice for Safe use of machinery - Part 1: General requirements;*
- *SS 537: 2009 Code of Practice for Safe use of machinery - Part 2: Woodworking machinery;*
- *ISO 13856-1: 2013 Safety of machinery – Pressure-sensitive protective devices – Part 1: General principles for design and testing of pressure-sensitive mats and pressure-sensitive floors;*
- *ISO 13856-2: 2013 Safety of machinery – Pressure-sensitive protective devices – Part 2: General principles for design and testing of pressure-sensitive edges and pressure-sensitive bars;*
- *ISO 13856-3: 2013 Safety of machinery – Pressure-sensitive protective devices – Part 3: General principles for design and testing of pressure-sensitive bumpers, plates, wires and similar devices;*
- *ISO 13856: 2013 Safety of Machinery – Presence-sensitive protective devices; and*
- *IEC 61496-1: 2014 Safety of Machinery – Electro-sensitive protective equipment.*

5.2.3 Two-handed Control Device

A two-handed control device is one that requires the operator to use both hands to operate the machine (see Figure 22). The two-handed control buttons must be located away from the hazardous point of operation and are spaced apart from each other to prevent simultaneous one-hand operation. The machine will stop immediately so long as any one of the control buttons is released.

It is important to note that while the use of a two-handed control device may be effective in protecting the hands of the machine operator, it does not offer protection for anyone else who may be near the hazardous point of operation. Two-handed control devices should therefore be used in conjunction with other guarding types in order to protect all workers in the vicinity as far as practicable.



Figure 22: Example of a two-handed control device on a power press.

5.2.4 Emergency Stop Device

Emergency stop devices are designed for use in reaction to an incident or hazardous situation. In an emergency, all sources of energy should be immediately and safely disconnected. Emergency stop devices allow deliberate action from the operator to bring the hazardous motion of the machine to a stop once danger is recognised by the operator.

All hazardous machines should be equipped with at least one emergency stop device (see Figure 23). The emergency stop device should be located and mounted such that it is readily accessible by the operator in an emergency. Note that, in general, emergency stop devices would need to be manually reset before the machine can be restarted. Examples of emergency stop devices include emergency stop button, emergency stop pull-cords, emergency stop foot pedals.

For more information on emergency stop devices, see:

- *SS 537: 2008 Code of Practice for Safe use of machinery – Part 1: General requirements*; and
- *ISO 13850: 2006 Safety of Machinery – Emergency stop- Principles for design*.



Figure 23: Example of an emergency stop device.

5.2.5 Warning Device

Appropriate warning devices can be installed on machines to indicate that a predefined condition has been detected, or a hazardous situation exists. Warning signals may be audible (e.g., sirens), visual (e.g., flashing lights) or a combination of both. This is to ensure that workers in the vicinity are made aware of the situation and can either effect the necessary remedy action or adopt a safe position away from the machine.

5.3 Risk Control by Information for Use

If risk control by safeguarding and implementation of complementary protective measures is insufficient to reduce the risk to the desired safe level, further risk control can be achieved through the provision of information for use (e.g., via warning signs and SWPs). Such information will serve to alert machine operators of the residual risks and administrative control measures put in place to keep the work activity safe.

5.3.1 Safe Work Procedures

A SWP is much more than a Standard Operating Procedure (SOP).

A SWP is a working risk control document that describes the safest and most efficient way to perform a certain work activity. A SWP generally lists the hazards involved in performing a work activity, the PPE required, and the operating steps necessary to complete the activity without incident.

A good SWP document should contain detailed information on:

- hazards of the machines, equipment and material used;
- inherent risks associated with the work activity;
- operating steps or a sequence to carry out work safely;
- risk control measures implemented including the PPE to be used; and
- residual risks and action to be taken to address the risks while carrying out the work activity.

See Annex 7 for guidance on how to set up a SWP.

To ensure safe use of machines, all operators must familiarise themselves with the SWP and adhere closely to it at all times. Procedures should be kept clear and simple so that they are easy to understand and remember.

SWP documents are most effective when they are developed in consultation with workers. SWPs are also useful tools for workplace training and supervision. SWP documents will need to be reviewed if there is a workplace incident and especially when changes occur in the workplace (e.g., when new machines or processes are introduced).

5.3.2 Energy Lock-out Tag-out

A LOTO procedure ensures that all hazardous energy sources (whether electrical, mechanical, pneumatic or hydraulic) of a machine are isolated, disconnected or discharged prior to commencing work like maintenance, repair, and installation of machine. This is to prevent the machine from being inadvertently activated or energised while the work activity is in progress.

Below are five recommended steps for effective LOTO for hazardous machines.

1. Announce the shutdown

Notify all affected workers that the machine is to be shut down.

2. Shut down the machine

Proceed to shut down the machine via normal procedure. Ensure that all moving parts have come to a complete stop and the act of shutting down the machine does not cause a hazard to other workers.

3. Disconnect all energy sources

Disconnect all sources of hazardous energy supply (whether electrical, mechanical, pneumatic or hydraulic) to the machine. Energy-isolating devices such as manually operated circuit breakers or isolating switches or valves are commonly used for disconnecting energy sources. Confirm that any stored energy (e.g., found in springs, electrical, hydraulic and pneumatic systems) is dissipated before starting work.

4. Apply lock-out and tagout

Apply a lock-out device (e.g., a padlock; see Figure 23) over each energy-isolating device to ensure that all hazardous energy sources cannot be restored unexpectedly or accidentally. Lock-out devices must be durable and strong enough to prevent accidental removal.

Each lock-out device should be affixed with a durable tag to indicate the identity of the person applying the lock-out. The tag serves as a warning that a work activity involving the machine is in progress and it must not be turned on under any circumstances. Do not use a tag on its own as it is not an energy isolation device.

5. **Verify the isolation and lock-out**

Check that the isolation and lock-out is in use and effective. Test the operating controls by putting (or trying to put) the controls in the “on” position to confirm that the machine is unable to start up. After the test, return operating controls to the “off” position.



Figure 24: Example of a lock-out device.

Once the above steps are completed, it is now safe to proceed with the installation, repair or maintenance work on the machine.

Group Lock-out

In cases where there are workers working on different parts of a large machine, a lock-out hasp (typically with six padlock holes) may be used to allow each worker to affix his or her own lock-out device to the energy-isolating device.

If more workers are involved, a coordinator may be appointed to coordinate the work. A group lock box may be used to facilitate coordination. Once all energy sources have been isolated, stored energy released and locked out, all keys are placed in the group lock box. The coordinator then applies his personal lock on the group lock box. This is to ensure that no one can remove the locks on any energy-isolating device until all workers have finished working on the locked-out machine.

Lock-out devices should be removed only after the machine is fully assembled or re-assembled and all affected workers notified. To ensure that each worker working on the machine is safe and accounted for, it is critical for each lock-out device to be removed by the same person who applied it on the machine.

Continuity of Lock-out

To ensure continued protection of workers during change of personnel (e.g., shift change), both the outgoing and incoming worker should be present to remove the existing lock-out device and apply the new lock-out device respectively. To ensure that the lock-out is in used at all times, the recommended practice is for the outgoing worker to remove the existing lock-out device only after the incoming worker has successfully applied the new lock-out device. Note that the transfer of lock-out device could also be a transfer of a key for the lock-out device.

Steps for Restoring a Machine for Operation

When the repair or maintenance work for a machine is completed, the next step is to restore it to its normal operation. Follow the steps below to ensure workers' safety during machine restoration:

1. Ensure that all tools have been removed from the machine;
2. Confirm that all safeguards and other safety devices are functional and have been returned to their original locations;
3. Check the machine's immediate vicinity to ensure that its start-up will not endanger anyone;
4. Announce that the machine would be turned on;
5. Remove all lockout devices and re-energise the machine. A pre-operational functionality test should be carried out before the actual operation to ensure that the machine is working properly; and
6. Notify affected workers that the machine is now ready to resume normal operations.

For more information on energy lock-out tag out, see *SS 571: 2011 Code of Practice for Energy Lockout and Tagout*.

5.3.3 Safety Signs

Safety signs are important hazard communication tools to alert or remind workers of workplace hazards and the safety precautions to take at specific work areas, especially when working with a hazardous machine (see Figure 24). Safety signs should comprise simple graphics and/or words so that they are easily understood. Safety signs must always be in good condition so that they are legible and can be seen from a distance.

Safety signs are generally classified according to their function.

Mandatory Action

- Signs (blue circle signs) indicate action that must be carried out in specific work areas.

Prohibition

- Signs (with red circular band and a red diagonal bar) indicate an action or activity that is not permitted.

Warning

- Signs (yellow signs with black triangle band) alert workers of a hazard or hazardous condition.

Fire Safety

- Signs (in red with white lettering) indicate the location of fire alarms and fire protection equipment.

Safe Condition

- Signs (in green with white lettering) indicate the location of emergency-related facilities such as exits, first aid, and safety equipment.



Figure 25: Example of safety signs.

General guide to displaying safety signs:

- Signs should be displayed where they are clearly visible and not obstructed.
- In general, signs should be displayed close to the point-of-use so that workers are aware of the hazard, mandatory action and/or emergency facility specific to the particular work location. Some signs, however, need to be placed at a suitable distance before workers arrive at the designated work location, to allow sufficient time for them to heed the warning after viewing the sign.
- A mandatory action sign may be placed next to a warning sign for greater effectiveness. This is so that workers are aware of the hazard and the preventive measures they can take. For example, a mandatory action sign indicating the use of machine guarding may be placed next to a warning sign indicating that a machine is in use. This is more effective than a lone warning sign, which would not explain how the hazard may be avoided.
- Avoid placing too many signs close together as it may be confusing and difficult for workers to distinguish the individual message conveyed by each sign.

For more information on warning signs, see:

- *SS 508: 2013, Graphic Symbols - Safety Colours and Safety Signs*
 - *Part 1: Design principles for safety signs and safety markings*
 - *Part 3: Design principles for graphical symbols for use in safety signs*

5.3.4 Personal Protective Equipment

PPE includes items of protective clothing such as overalls, covered non-slip shoes, heat-resistant gloves, and protective items such as safety eyewear and use of respirators. PPE offers protection from workplace hazards only if it is in good condition, properly selected for the work activity and correctly-fitted to the user.

Workers may be exposed to falling or flying objects, splashing fluids, or harmful dusts, fumes, mists, vapours, or gases when working with a machine. It is therefore important to provide workers with suitable PPE and the information on how to use the PPE correctly to ensure effective protection from the hazards present at the workplace.

As the use of PPE does not eliminate or reduce the hazard, the PPE user is likely to be exposed to the hazard should the PPE fail. Given that PPE should be considered the last level of protection when all other control measures are not feasible, a PPE programme is recommended to ensure that workers are well-protected when PPE is used.

Key elements of a comprehensive PPE programme include:

- PPE selection;
- PPE fitting;
- PPE maintenance and storage; and
- PPE user education and training.

PPE selection

All activities involving the use of machines must be thoroughly evaluated by RA so that suitable PPE can be selected specifically for each activity. Once the hazards are identified, a useful approach is to think from “head-to-toe” on the necessary protection needed to prevent workers from injury.

PPE fitting

For effective protection, PPE (e.g., safety shoes, overalls, etc) has to be correctly fitted to its user.

PPE maintenance and storage

To keep PPE in good condition and ready for use, PPE must be properly stored to prevent material deterioration. PPE should also be subjected to regular maintenance and checks before use. Finally, it is important for PPE to be replaced periodically, depending on the frequency of use, and lifespan of its material.

PPE user education and training

As part of a comprehensive PPE programme, users need to receive training on the proper selection of PPE, choice of appropriate material and the correct method for its use.

Body and Hand Protection

The use of overalls and hand gloves is important to protect workers from physical and chemical hazards when using machines. See Table 2 for a list of common types of gloves.

Type of Gloves	Application
<p data-bbox="103 312 250 338">Leather gloves</p> 	<ul data-bbox="515 312 985 367" style="list-style-type: none">• Used for general protection against mechanical hazards such as abrasion, cuts and punctures.
<p data-bbox="103 679 300 705">Cut-resistant gloves</p> 	<ul data-bbox="515 679 981 705" style="list-style-type: none">• Used when handling sharp or serrated objects.
<p data-bbox="103 1046 358 1072">Chemical-resistant gloves</p> 	<ul data-bbox="515 1046 963 1123" style="list-style-type: none">• Used for protection against chemical hazards such as acids, alkalis, solvents, fats and oils.

Heat-resistant gloves



- Used in activities where there are high temperatures, such as hot work, forging and vulcanising applications, handling of hot castings and smelting works.

Insulated gloves



- Used for protection against electric shock or electrocution.

Cryogenic gloves



- Used for handling ultra-cold materials and containers, such as liquid nitrogen.

Table 2: Types of gloves used to protect workers when working with machines.

Tips on glove selection and use

- It is good practice to check gloves (even new ones) for physical damage (e.g., cuts, tears or holes) before use.
- Select gloves of the correct size and fit. Gloves that are too small will be uncomfortable and may easily tear whereas gloves that are too large may interfere with dexterity.
- When operating a moving machine, there is a risk of one's hand being accidentally caught and drawn into the machine. This may result in an amputation or crushing injury. In such circumstances, the use of gloves is prohibited. Gloves without fingertips may be used for palm protection when operating low-speed moving machines (e.g., plate rolling machine) provided that effective protective and/or emergency stop devices are in place to reduce the risk associated with the hazardous situation.

Eye and Face Protection

When using a machine, examples of eye and face protection to protect one against material ejecting from the machine (e.g., metal or wood dust, sparks and chemicals) include safety glasses, safety goggles and face shields.

In general, safety goggles offer greater protection than safety glasses. A face shield should be used in conjunction with a pair of safety goggles whenever a high probability of eyes and face injury exists. Note that ordinary prescription spectacles do not provide adequate protection against eye injury.

Head Protection

In manufacturing environments where there is a risk of objects falling (e.g., from equipment installed overhead), or in areas where one can walk into hard objects, the use of a safety helmet is essential for basic protection against head injury. A helmet will reduce the impact experienced by its user when an object falls or hit his or her head. In particular for manufacturing environments, the use of a safety helmet is necessary when working with overhead-mounted equipment like a travelling crane.

There are many accessories that can be fitted onto a safety helmet to make it appropriate for different work environments. For example, a chin strap may be attached to keep the helmet in place, a face shield may be attached to protect the user from any materials ejected from a machine, earmuffs may be attached to protect one's hearing in a noisy environment, and a headlamp may be attached for use in a dim working environment. When adding helmet accessories, it is important to ensure that the attachment is compatible with the specific helmet. The use of original manufacturer's accessories is recommended.

Hearing Protection

Many machines generate noise during operation. To protect exposed workers from the adverse effects of noise, every company with noisy machines should implement a Hearing Conservation Programme (HCP) as part of its WSH programme. More information on the implementation of a HCP can be found in *WSH Guidelines on Hearing Conservation Programme*.

As a general guide to the use of hearing protectors, earplugs or earmuffs are used when the noise exposure is between 85 to 100 dB(A). Both earplugs and earmuffs should be used together for noise exposure exceeding 100 dB(A).

For effective noise reduction, at least 75% of the earplug should be inserted into the ear canal.

See Figures 26 to 28 for reference on how to ensure that earmuffs and earplugs are fitted in properly.



Figure 26: To ensure that the earmuffs fit properly: Hair should be brushed away and earmuffs should cover the entire earlobe completely.



Figure 27: To ensure that earplugs fit properly: Pull earlobes back and up with the opposite hand before inserting the earplug.

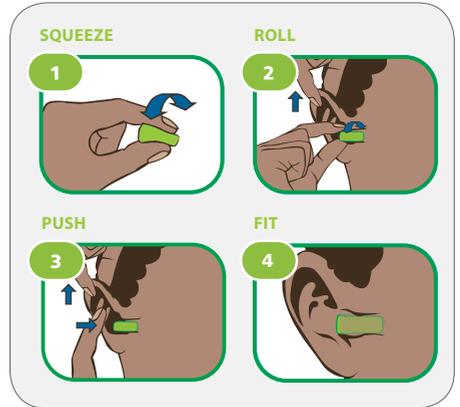


Figure 28: Correct way of wearing disposable foam earplugs.

Respiratory Protection

Some machines generate harmful dusts, fumes, vapours or gases during operation. In such cases, respirators are needed to protect workers from exposure via inhalation.

There are two basic types of respirators:

1. air-purifying respirators (used only when oxygen is abundant in the work environment); and
2. air-supplied respirators (typically used in oxygen deficient environments).

The correct type of respirator should be selected based on the nature of the work environment and hazards present in the workplace. Respirators need to be properly maintained and cleaned in order to retain their effectiveness. Respirator fit-testing should be conducted to ensure adequate protection when in use.

Foot Protection

Safety footwear (e.g., safety boots) is designed to protect the feet from injury. Safety features include protective reinforcement in the toes area (via a steel toe cap) to protect the foot from falling objects (e.g., when worker loses his or her grip while carrying a heavy load) or compression (e.g., when worker's foot get rolled over by a moving machine or vehicle), and a steel mid-sole plate to protect against punctures (e.g., a stray nail) from below. Safety shoes need to have antistatic properties and be durable, water resistant, hot or cold resistant, slip resistant, cut resistant, and electric shock resistant.

To ensure optimum performance, safety footwear should be checked for wear and tear at reasonable intervals. Ideally, safety footwear should be subjected to a quick visual inspection prior to each use. This includes checking for cuts, cracks or holes, separation of boot material, broken buckles or laces. The soles of the boot, in particular, should be checked for pieces of metal, wood or other embedded objects that could affect the integrity or performance of the sole.

For more information on PPE, see:

- *SS EN 420: 2003 Protective gloves - General requirements and test methods*
- *SS 473: 2011 Specification for personal eye-protectors*
 - *Part 1: General requirements*
 - *Part 2: Selection, use and maintenance*
- *SS 513: 2005, Specification for personal protective equipment - Footwear*
 - *Part 1: Safety footwear*
 - *Part 2: Test methods for footwear*
- *SS 548: 2009 Code of practice for selection, use and maintenance of respiratory protective devices*
- *SS 549: 2009 Code of practice for selection, use and maintenance of hearing protectors*
- *WSH Guidelines on Hearing Conservation Programme*

6. Case Studies

6.1 Case Study 1: Worker's Palm Amputated by Power Press

A production operator's left palm was amputated by a descending tool of an 80-ton power press in a metalworking factory. He was retrieving a stamped work piece from the power press.

Investigation Findings

- There was no machine guard (e.g., a fixed guard) on the power press.
- The power press was operated with a single-button activated control mode instead of two-hand activated control.

Lessons Learnt

Risk Assessment	Risk assessment must be carried out prior to any work involving the power press.
Safe Work Procedures	SWPs for specific work activity involving the power press must be developed and implemented.
Equipment and Tools	<p>A suitable guard (fixed, adjustable or interlocked, etc) and/or presence-sensing device need/s to be installed to prevent operator's hands from straying into the danger zones of the power press.</p> <p>For full-revolution type of power press, suitable fixed or adjustable guard shall be provided to guard the tool-and-die.</p> <p>For part-revolution type of power press, a suitable guard (i.e., fixed, adjustable or interlocked) and/or presence-sensing device can be employed.</p> <p>The flywheel, pulley and belt should be adequately guarded.</p> <p>The correct mode of operation for the power press should be two-hand activation control.</p> <p>If foot-operated control is used, it should be adequately shrouded.</p>
Others (process design, etc.)	There should be a regular maintenance and inspection programme to ensure that the machine and its safety devices are functioning properly at all times.

6.2 Case Study 2: Worker's Palm Crushed by Food-cutting Machine

An operator's right palm was crushed by the shaft cutters of an electric food-cutting machine in a food processing factory. He was hosing water down the shaft cutters to dislodge food that was stuck at the rotating cutters when his right hand was suddenly pulled in and crushed by the rotating cutters (see Figure 29).

Investigation Findings

The 31cm-by-17cm mouth of the rotating shaft cutters of the food-cutting machine was not guarded to prevent the operator's hands from coming into contact with the danger zone.

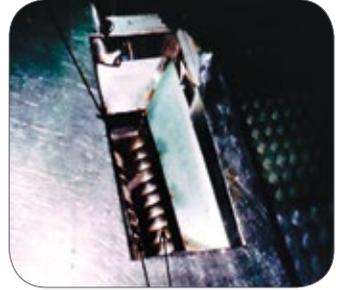


Figure 29: Unguarded rotating shaft cutters that pulled the operator's hand in.



Figure 30: After the accident, shaft cutters were guarded to prevent future mishaps.

Lessons Learnt

Risk Assessment	<p>Risk assessment must be carried out prior to any work involving the food-cutting machine.</p>
Safe Work Procedures	<p>SWPs for the specific work activity involving the food-cutting machine must be developed and implemented.</p> <p>The energy lock-out procedures should be carried out before cleaning the machine.</p>
Equipment and Tools	<p>A suitable fixed guard or presence-sensing device needs to be installed to prevent operator's hands from entering the danger zone of the food-cutting machine (see Figure 30).</p> <p>Provide workers with a plunger of suitable length for reaching into the cutter area during cleaning operation.</p>
Training and Awareness	<p>Workers should be trained on the energy lock-out procedures.</p> <p>Train new workers under the direct supervision of an experienced worker.</p> <p>Use warning and mandatory action signs to alert and remind operators of the machine's danger zone.</p>

6.3 Case Study 3: Worker's Fingers Amputated by Table Saw

A woodworking factory worker's left index and ring fingers were amputated by a rotating circular table saw when he was cutting a piece of timber (see Figure 31).

Investigation Findings

An adjustable guard was installed over the rotating saw blade of the circular table saw. However, the guard was not properly adjusted to ensure that the rotating saw blade was not exposed during the cutting operation.



Figure 31: No safety guard to prevent hand and finger amputations.

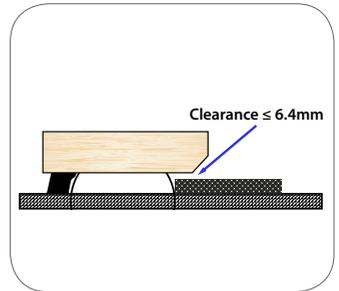


Figure 32: Saw guard must be adjusted as close as possible to the timber before cutting operation.

Lessons Learnt

Risk Assessment	Risk assessment must be carried out prior to any work involving table saw operations.
Safe Work Procedures	SWPs for the specific work activity involving the table saw machine must be developed and implemented.
Equipment and Tools	<p>Where practical, replace the adjustable guard with a self-adjusting one to prevent operator's hands from entering the danger zone (i.e., saw blade) of the table saw machine (see Figure 32).</p> <p>If a manually-adjusted guard has to be used, the adjustment of the guard should be carried out by a competent person. The adjustments have to be made frequently to ensure that the rotating saw blade is not excessively exposed at all times.</p> <p>A push-stick may be used to push pieces of timber through the table saw. The push-stick should be of sufficient length to minimise the possibility of the worker's hand coming into contact with the saw blade.</p> <p>The belt drive and saw blade located underneath the table should be guarded.</p>
Training and Awareness	Allow only trained and competent workers to operate the table saw machine.

6.4 Case Study 4: Worker's Palm Crushed by Die-casting Machine

A worker's palm was caught in between the moving and fixed die of a die-casting machine. His palm was severely crushed when he reached into the machine while it was still in operation to remove a foreign object from the moving die (see Figures 33 and 34).

Investigation Findings

- The machine's sliding door was not fitted with an interlocking guard which could have been programmed to stop the machine once the door was opened.
- The worker failed to stop the machine before opening the sliding door to access the die despite having been trained to do so.



Figure 33: Sliding door was not fitted with an interlocking guard.



Figure 34: Palm was caught in between the moving and fixed die.

Lessons Learnt

Risk Assessment	Risk assessment must be carried out prior to starting any work involving the die-casting machine.
Safe Work Procedures	SWPs for the specific work activity involving the die-casting machine must be developed and implemented.
Equipment and Tools	<p>The machine should be fitted with an interlocking guard to stop the machine once the sliding door is opened.</p> <p>Preventive maintenance of the interlocking device is important to ensure that it remains operational at all times.</p>
Others (process design, etc.)	Operators must be advised on the importance of stopping the die-casting machine before accessing its danger zone.

6.5 Case Study 5: Worker's Thumb Severed by Disc Cutter

A worker's right thumb was severed by a rotating abrasive disc cutter when he was cutting a flat metal bar. This occurred when the worker tried to steady the disc cutter by holding down the metal bar when the machine started to vibrate violently (see Figure 35).

Investigation Findings

- The disc cutter was mounted on four castor wheels and it vibrated violently probably because it was either not balanced or maintained properly.
- The fixed guard covered the top half of the disc cutter and the bottom half of the disc was left exposed for the cutting work.
- The worker knew that the flat bar had to be clamped on the vice before initiating the cutting operation. However, instead of stopping the operation when the machine started to vibrate violently, he decided to hold down the metal bar with his right hand and proceeded with the cutting. This resulted in his right hand coming into contact with the rotating abrasive disc of the cutting machine and subsequent severance of his right thumb.



Figure 35: Rotating abrasive disc cutter.

Lessons Learnt

Risk Assessment	Risk assessment must be carried out prior to any work involving the abrasive disc cutter.
Safe Work Procedures	SWPs for the specific work activity involving the abrasive disc cutter must be developed and implemented.
Equipment and Tools	<p>Grinding or abrasive cutting machines should not be mounted on castor wheels as this will create movement and instability during operation.</p> <p>It is important that grinding or abrasive machines be placed on even ground to avoid vibration during operation.</p> <p>The fixed guard should be designed to cover the disc cutter such that the cutting edge left exposed is minimal. Where practicable, replace the fixed guard with a self-adjusting guard which will expose the cutting edge only when it is needed during the cutting operation.</p>
Training and Awareness	<p>Only trained and competent workers should be allowed to operate the machine.</p> <p>Workers must be trained to stop work once an operation poses a risk and immediately report unsafe working conditions to their supervisors.</p>

7. Annex

Annex 1: Sample WSH Checklist for Acquisition of Machines

Description	Yes	No
Basic checks for acquiring new machines		
Has a background check on the specific model been conducted to ascertain if there are WSH concerns?		
<p>Are these inherently safe design measures included in the design of the machine:</p> <ul style="list-style-type: none"> • sharp edges, corners and protruding parts are avoided in the design; • crush, shear and entanglement points are eliminated in the design; • machine actuating force has been limited; • machine is designed to eliminate the need for protective measures; • machine ergonomics is considered; • highly hazardous machine operations are automated; and • reliable machine components are used? 		
Is the Declaration of Conformity provided by the machine manufacturer or supplier?		
Are the risk assessment documents provided by the machine manufacturer or supplier?		
<p>Does the machine operating manual provide the following instructions:</p> <ul style="list-style-type: none"> • instructions for safe machine use; • instructions for safe assembly; • instructions for safe installation; • instructions for safe commissioning; • instructions for safe repair; and • instructions for safe maintenance? 		

Are detailed technical drawings of the machine provided?		
Is information on machine's residual risks and the safety precautions required provided in a document?		
Is the machine's certified safety marks present as required by the company?		
Can the machine manufacturer or supplier provide machine-specific safety and health training for workers?		
Does the machine manufacturer or supplier offer a servicing and maintenance contract on its machines?		
Additional checks for acquiring used machines		
Are machine safeguards and safety devices present and functioning?		
Are the machine's warning signs clearly visible and easy to understand?		
Is the original manufacturer of the machine still in business?		
Are spare parts still available for the machine?		
Is the machine manufacturer or supplier able to carry out a pre-operational functionality test for each machine safety feature?		
Are the modified or retrofitted machines been certified safe for use?		

Annex 2: Sample WSH Checklist for Installation of Machines

Description	Yes	No
Basic checks for installing a machine		
Is the on-site assembly and installation work performed by the machine manufacturer, authorised agent or competent person?		
Is risk assessment conducted prior to the installation of the machine?		
Is sufficient space allocated for unloading the machine and its components?		
Is sufficient space allocated for temporary storage of the machine and its components?		
Is the machine installed in a location that does not obstruct the following: <ul style="list-style-type: none"> • firefighting equipment; • emergency escape routes; • fire exits; and • building access route for firefighting operations? 		
Is sufficient space allocated for workers to work safely around the machine?		
Is sufficient space allocated for safe passage past or through a group of machines?		
Are machines with moving parts located at a safe distance from fixed structures?		
Is the debris or waste material generated from the machine unpacking and installation process properly disposed?		

Annex 3: Sample WSH Checklist for Commissioning of Machines

Description	Yes	No
Basic checks for commissioning a machine		
Is risk assessment conducted prior to commissioning the machine?		
Is the machine placed on level ground?		
Is the machine suitably barricaded for commissioning and testing?		
Are warning signs in place for machine commissioning and testing?		
Check the following before the machine is powered on: <ul style="list-style-type: none"> • Has the overall machine condition been inspected? • Has the appearance of each machine part been checked? • Are the machine parts properly fastened? • Are the V-belts, timing belts, and chains appropriately tightened? • Is the correct lubricant oil, coolant or grease used? • Is the power supplied to the machine correct? 		
Check the following after the machine is powered on: <ul style="list-style-type: none"> • Is the machine operating pressure within the acceptable range? • Is there abnormal noise emitting from it? • Are oils, coolants or grease leaking from the machine? 		
Have all safety devices been subjected to a functional check? Examples of safety devices: <ul style="list-style-type: none"> • machine guards; • sensors and interlocking devices of machine guards, gates, doors; • presence-sensing device; • two-handed control device; • emergency stop button; • warning device; and • circuit breakers. 		
Are the following data properly documented: <ul style="list-style-type: none"> • inspection results; • testing results; and • commissioning results? 		

Annex 4: Sample WSH Checklist for Use of Machines

Description	Yes	No
Basic checks for using a machine		
Is risk assessment conducted prior to using the machine?		
Has information on the machine hazards, risk control measures and residual risks been communicated to the machine operator?		
Are the following machine safety devices functioning properly: <ul style="list-style-type: none"> • machine guards; • sensors and interlocking devices of machine guards, gates, doors; • presence-sensing device; • two-handed control device; • emergency stop button; • warning device; and • circuit breakers? 		
Is there a Safe Work Procedure (SWP) for operating the machine?		
Is the worker wearing the appropriate personal protective equipment?		
Is the worker adequately trained and competent in operating the machine?		
Is the worker familiar with the emergency response procedure should something go wrong during machine operation?		

Annex 5: Sample WSH Checklist for Maintenance of Machines

Description	Yes	No
Basic checks for maintaining a machine		
Is risk assessment conducted prior to maintenance of the machine?		
Is the person tasked to maintain or diagnose the machine's problem authorised and trained to carry out the maintenance?		
Is the person carrying out the maintenance trained to: <ul style="list-style-type: none"> • recognise hazardous energy sources; • understand the magnitude of the energy source at hand; • identify and properly operate the applicable energy-isolating devices; • carry out the lock-out and tag-out (LOTO) procedure; and • safely apply and remove lock-out devices? 		
Are machine operators at the work site trained to: <ul style="list-style-type: none"> • understand the purpose of energy lock-out; • recognise when lock-out activities are in progress; and • refrain from tampering with lock-out devices? 		
Are replacement parts and devices supplied or recommended by the manufacturer used for the maintenance?		
Basic checks for maintaining a machine		
Have all maintenance equipment and tools been removed from the machine?		
Are all machine safeguards and other safety devices reinstalled and functioning?		
Has the immediate vicinity of the machine been checked to ensure that no one will be endangered by the machine start-up?		
Has a pre-operational functionality check been carried out before the machine is restored to its full operation?		

Annex 6: Sample WSH Checklist for Disposal of Machines

Description	Yes	No
Basic checks for reselling a machine		
Are the risk assessment documents provided to the buyer?		
Does the machine operating manual provide the following instructions: <ul style="list-style-type: none"> • instructions for safe machine use; • instructions for safe assembly; • instructions for safe installation; • instructions for safe commissioning; • instructions for safe repair; and • instructions for safe maintenance? 		
Are the machine safeguards and other safety devices in place and functioning properly?		
Are the equipment warning signs clearly visible and in good condition?		
Is information on any residual risks and the additional precautions needed provided to the buyer?		
Basic checks for scrapping a contaminated machine		
Has a licensed toxic industrial waste (TIW) collector been engaged to assist with the disposal of hazardous waste?		
Have the hazardous waste residues been successfully removed from the machine prior to scrapping?		

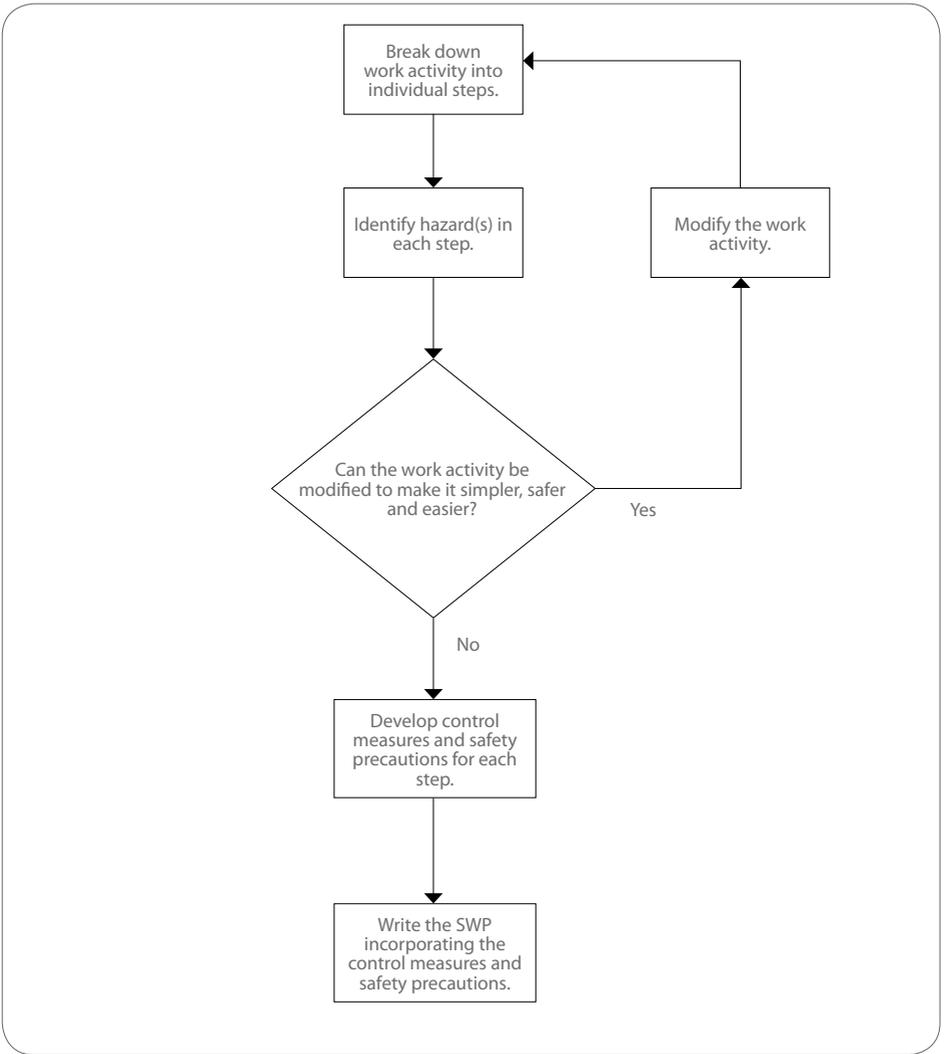
Annex 7: Establishments of Safe Work Procedures

Safe Work Procedures (SWPs) provide a carefully planned step-by-step sequence of actions to carry out a particular work activity. To establish a SWP, Job Safety Analysis (JSA) is normally used to systematically examine the work activity. The process for JSA is as follows:

- Break down work activity into individual steps.
- Identify hazards associated with each step of the work activity.
- Verify that there is nothing else about the work activity can be modified to make it simpler, safer and easier.
- Develop suitable control measures and safety precautions to address each hazard associated with each step of the work activity.
- Write the SWP and the derived control measures and safety precautions based on the JSA.

Once a draft SWP has been written, test it out with a group of workers and seek constructive feedback. The feedback will serve as a useful source of information for the refinement of the SWP.

With the SWP established and successfully rolled out, close supervision and regular audit becomes important to ensure that the SWP is strictly adhered to at all times. Refer to the figure on the next page.



Flowchart for establishment of safe work procedures.

8. References

WSH Council Guidance Materials:

- *Code of Practice on WSH Risk Management*
- *WSH Guidelines on Managing Safety and Health for SMEs in the Metalworking Industry*
- *A Step-by-Step Guide on Risk Management for Metalworking Sector*
- *Code of Practice for Working Safely at Heights*
- *WSH Guidelines on Hearing Conservation Programme*
- *WSH Guidelines on Improving Ergonomics at the Workplace*
- *WSH Guidelines on Fatigue Management*
- *WSH Guidelines on Management of Hazardous Chemicals Programme*
- *Case Studies for Metalworking Industry*

Singapore Regulations:

- Workplace Safety and Health Act and its subsidiary legislations:
- WSH (Risk Management) Regulations
- WSH (General Provisions)
- WSH (Noise)
- WSH (First-Aid)
- WSH (Incident Reporting)
- Workplace Safety and Health (Work at Heights) Regulations 2013

Industry Standards:

- *SS 537: 2008 Code of Practice for Safe use of machinery- Part 1: General requirements*
- *SS 537: 2009 Code of Practice for Safe use of machinery- Part 2: Woodworking machinery*
- *SS 567: 2011 Code of Practice for Factory layout- Safety, health and welfare considerations*
- *SS 571: 2011 Code of Practice for Energy lockout and tagout*
- *CP 100: 2004 Code of Practice for Hazardous waste management*
- *SS 508: 2013 Graphic symbols – Safety Colours and safety signs-
Part 1: Design principles for safety signs and safety markings
Part 3: Design principles for graphical symbols for use in safety signs*
- *SS EN 420: 2003 Protective gloves - General requirements and test methods*
- *SS 473: 2011 Specification for personal eye-protectors
Part 1: General requirements
Part 2: Selection, use and maintenance*
- *SS 513: 2005, Specification for personal protective equipment - Footwear
Part 1: Safety footwear
Part 2: Test methods for footwear*
- *SS 548: 2009 Code of practice for selection, use and maintenance of respiratory protective devices*
- *SS 549: 2009 Code of practice for selection, use and maintenance of hearing protectors*
- *ISO 13854: 1996 Safety of machinery-- Minimum gaps to avoid crushing of parts of the human body*
- *ISO 14738: 2002 Safety of machinery-- Anthropometric requirements for the design of workstations at machinery*
- *ISO 12100: 2010 Safety of Machinery- General Principles for Design- Risk Assessment and Risk Reduction*
- *ISO 13855: 2010 Safety of machinery-- Positioning of safeguards with respect to the approach speeds of parts of the human body*
- *ISO 14119: 2013 Safety of machinery-- Interlocking devices associated with guards-- Principles for design and selection*
- *ISO 13856: 2013 Safety of machinery-- Pressure-sensitive protective devices*
- *IEC 61496-1: 2014 Safety of machinery- Electro-sensitive protective equipment*
- *ISO 13850: 2006 Safety of machinery- Emergency stop -- Principles for design*

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