





# 1. Introduction

This Technical Advisory (TA) is developed to educate employers and workers on the fundamental safety requirements governing the use of machinery and to help them identify common hazards.

## 2. Understanding Hand and Finger Amputations Caused by Machines

Amputations are among the most severe and disabling workplace injuries that often result in permanent disability. More than 160 permanent disability cases have been reported by employers each year under the Workplace Safety and Health (Incident Reporting) Regulations in 2006 and 2007. Of these, about 90% of the cases involved amputations of hands and fingers with a majority occurring in the manufacturing, construction and shipbuilding and ship-repairing industries. The manufacturing industry, metalworking, manufacturing of food products and furniture sectors together accounted for almost half of all cases of hand and finger amputations.

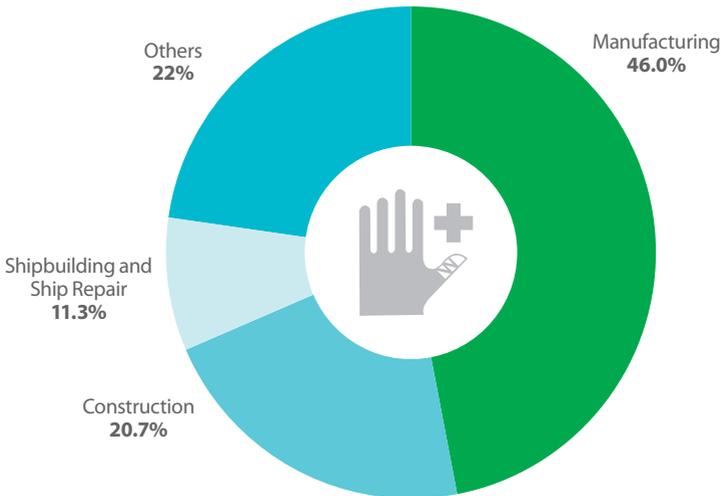


Figure 1: Hand/Fingers Permanent Disablements by Industry in 2007

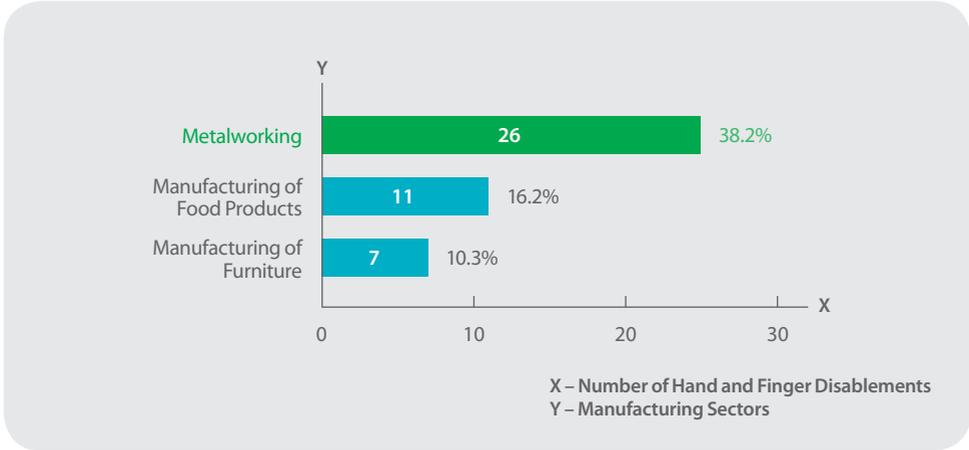


Figure 2: Top 3 Sectors in Manufacturing Contributing to Hand / Finger Permanent Disabilities in 2007

### 3. Machines Commonly Involved in Hand and Finger Amputations

|                       |                  |                        |
|-----------------------|------------------|------------------------|
| Power presses         | Milling machines | Band saws              |
| Press brakes          | Conveyors        | Circular table saws    |
| Printing presses      | Drills           | Slitting machines      |
| Roll forming machines | Bar benders      | Food mincers / cutters |
| Shears                | Radial saws      |                        |

The most common causes for hand and finger injuries by these machines are:

- Failure to carry out proper risk assessment to identify amputation hazards associated with the machine;
- Failure to eliminate or mitigate the amputation risks by adequately guarding the dangerous parts of machines during operation; and
- Failure to implement safe work procedures during operation, inspection, maintenance and repair works associated with such machines.

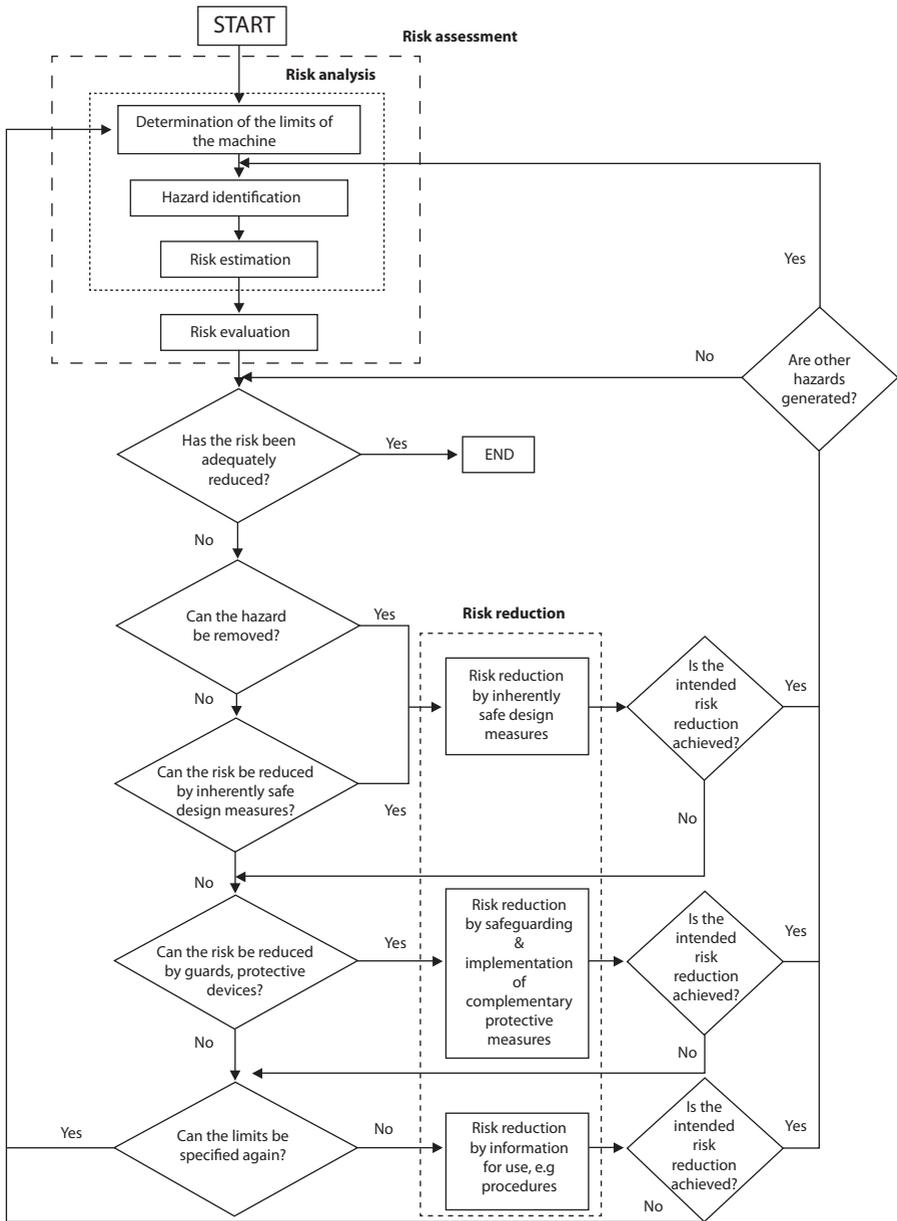
## 4. What Must be Done to Prevent Hand and Finger Injuries by Machines?

Under the Workplace Safety and Health (Risk Management) Regulations, employers must conduct a risk assessment in relation to the safety and health hazards associated with the use and care of all machines at the workplace. The risk assessment should involve the following:

- Conduct risk assessment for all activities involving machines at the workplace. This should include machine operation, inspection, cleaning, repair and maintenance activities.
- Systematically examine all potential hazards associated with machines and evaluate the related risks posed by them.
- Take appropriate safety measures to eliminate the hazards or reduce the risks.
- Implement safe work procedures to prevent accidents including establishing control procedures such as lock-out tag-out procedures (LOTO) for machine inspection, cleaning, repair and maintenance activities.

### Sources for Additional Information

- Workplace Safety and Health (Risk Management) Regulations at [http://www.mom.gov.sg/wsh/risk\\_management](http://www.mom.gov.sg/wsh/risk_management)



**Figure 3: Schematic representation of the iterative process for eliminating hazards and implementation of safety measures**

# 5. Identification of Amputation Hazards on Machines

Rotary, sliding or reciprocating motion or a combination of these machine motions can cause amputation hazards by entanglement, friction or abrasion, cutting, shearing, crushing, or by drawing a person's hands into a position where one or more of these types of injury can occur. Some typical examples of mechanical hazards are given below:

- Entanglement resulting from contact with a single rotating surface such as couplings, spindles, chucks, leadscrews, mandrels, bars or any rotating workpiece.
- Entanglement resulting from 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.
- Entanglement caused by hands being caught in between counter-rotating parts, e.g. gear wheels, rolling mills, mixing rolls and calendars, or materials being drawn between two rolls.
- Cutting, shearing and crushing actions.
- Drawn in by in-running nip points between two counter-rotating parts or a rotating surface and a tangentially moving surface.

Diagrams of these mechanical hazards can be found in 'PD5305 : 2005 Guidance on Safe Use of Machinery'. British Standards can be obtained in PDF or hard copy formats from the BSI online shop: [www.bsigroup.com/Shop](http://www.bsigroup.com/Shop) or by contacting BSI Customer Services for hardcopies only: Tel: +44 (0)20 8996 9001, Email: [cservices@bsigroup.com](mailto:cservices@bsigroup.com).

# 6. Elimination and Mitigation of Amputation Hazards on Machines

Risk of amputation injuries can be eliminated by replacing a hazardous machine with an alternative that is inherently safe. If that is not practicable, an appropriate safeguarding measure must be provided to prevent hands and other parts of a person's body from coming into contact with the amputation hazards of the machine.

## Pointers on safeguarding measures for hazardous parts of machines

- When selecting appropriate safeguarding measures, one has to take the following into consideration:
  - Operating methods and system of work for the equipment;
  - Proximity of operator/personnel to hazardous area/point;
  - Need for access during inspection, cleaning, repair and maintenance activities; and
  - Stopping time/operating cycle of machine.
- Use a fixed guard whenever possible, properly fastened in place with screws or bolts and nuts which needs tools to remove them.
- If a fixed guard is not possible, use an interlocked guard to prevent hands from entering into dangerous zones of the machines during operation.
- In some cases, a photo-electric sensing or laser beam sensing system may be used instead of a fixed or interlocked guard. If necessary, combine a few methods together such as a photo-electric sensing system together with a two-hands control activation system.
- Check that the guards or other safety devices are convenient to use and not easy to defeat, otherwise they may need modification.
- Choose a material for the guard that is robust and not easily damaged.

Examples of suitable safeguards for machines



1 Flour mixer installed with interlocked guard



1 Press brake installed with laser sensing system that has transmitter and receiver mounted below the RAM to cut off power supply to prevent hand and finger injuries (Picture courtesy of Omron STI)

- Make sure the guards are maintenance-friendly i.e. allow the machine to be cleaned and maintained safely.
- Where guards cannot provide full protection, use jigs, holders or a suitable receptacle device to retrieve, move or hold a workpiece during operation.



1 In-running nip of belt and pulley is fully enclosed to prevent hand and finger injuries



1 Rotating part of milling machine is fully guarded to prevent hand and finger injuries

## Sources for Additional Information

- Refer to CP28 : 1984 Code of Practice for the Construction, Care and Safe Use of Shears.
- SS537 Part 1 : 2008 on Code of Practice for Safe Use of Machinery for details on safeguarding measures.

# 7. Administrative Controls

The following administrative controls can be provided to enhance machinery safety:

- Develop and implement safe work procedures for the operation, cleaning, repair and maintenance of machines.
- Establish and implement lock-out tag-out procedures (LOTO) to prevent injuries caused by inadvertent activation of machines during inspection, maintenance or repair works.
- Provide training on safe work procedures for the operation, cleaning, repair and maintenance of machines.
- Reduce the operating limits of speed, temperature, pressure, etc. associated with machines.
- Automate the production or handling process to remove or minimise any human-machine interface. Alternatively, consider controlling or operating the process from a remote safe position.

## Sources for Additional Information

- CP91:2001 on Code of Practice for Lockout Procedure.
- Safety Circular on Lock-out Procedures, OSD/GF/SC001/2000  
[http://www.mom.gov.sg/publish/etc/medialib/mom\\_library/Workplace\\_Safety/bc\\_safety.Par.8290.File.tmp/Lockout%20Procedures.pdf](http://www.mom.gov.sg/publish/etc/medialib/mom_library/Workplace_Safety/bc_safety.Par.8290.File.tmp/Lockout%20Procedures.pdf)

# 8. Personal Protective Equipment (PPE)

Workers handling sharp pieces of metals or metallic materials such as steel plates or sheets can have severe cuts and lacerations if the materials are not handled properly. Hence, such workers must be provided with the appropriate PPE such as safety glasses, gloves and footwear to protect them against possible contact with the sharp edges of these metal objects.

In addition, when operating machines with entanglement or in-running nip risks, the use of gloves with fingertips should be prohibited. This is because the tips can be accidentally caught and drawn into the dangerous operation of machines which may result in serious amputation injuries. Where there is a genuine need for hand protection, palm protection should be sufficient.

# 9. Don't Let These Happen at Your Workplace

## Case Study 1

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

### Investigation Findings

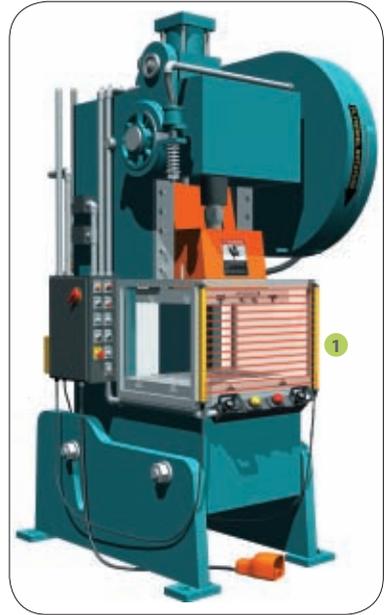
- The power press was not provided with any effective guards such as a fixed guard.
- The power press was operating in a single button activated control mode instead of a two-hand activated control.
- The two-hand activated control was also not synchronised.

### Lessons Learnt

- Risk assessment should be conducted to identify the hazards of power press operation.
- A suitable and effective fixed guard or safety devices to prevent hands from coming into dangerous zones should be provided.
- Mode of operation should be a two-hand activation control.
- There should be a regular maintenance and inspection regime to ensure that the machine and its safety devices are functioning effectively.

### Some Common Causes of Power Press Accidents

- No safety guard.
- Inadequate safeguard such as a guard with wide opening that allows hands to encroach into the danger zone.
- Defective safety devices.
- Safety devices being defeated or by-passed to speed up production.



1 Part Revolution Power Press equipped with a safety light curtain, fixed enclosure guard, two-hands activation control and an emergency stop. (Picture courtesy of Omron STI)



Light curtain not properly positioned to prevent operator's hands and fingers from straying into danger zone of the hydraulic power press

- Incorrect position or non-synchronisation of two-hand control buttons.
- Mechanical failure of press machines such as failure of a single stroke linkage.
- Electrical failure such as control relay failure.
- Pneumatic failure such as loss of air pressure to the clutch and brake.
- Lack of safe work procedures including communication and training on safe work procedures.



Too wide gaps pose a hazard to hands and fingers

## Tips on Power Press Safeguards

- A safe distance from the danger zone of the light curtain and two-hands control activation is crucial to prevent hand and finger injuries.
- Presence sensing devices such as a light curtain cannot be used on a full revolution clutch power press.
- Protect operators with effective barrier guards on a full revolution clutch power press.
- Incorporate a single stroke device and an anti-repeat feature in full revolution clutch power presses.

## Case Study 2

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 the food stuck at the rotating cutters. His right hand was suddenly pulled in and crushed by the rotating cutters.

### Investigation Findings

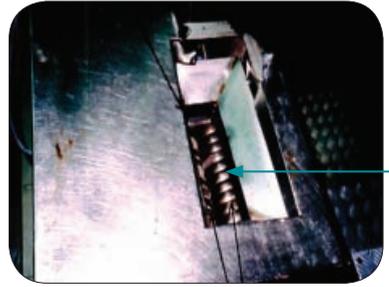
The 31cm-by-17cm mouth of the rotating shaft cutters of the food cutting machine was not guarded to prevent hands from coming into contact with the point of operation.

### Lessons Learnt

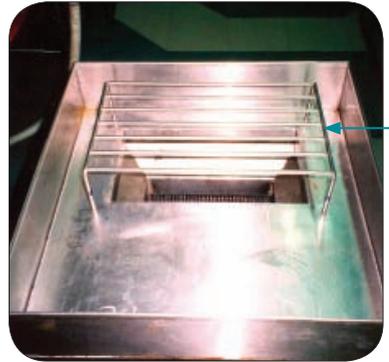
- Risk assessment should be conducted to identify the hazards involving the food processing machine and its operations.
- Eliminate the hazards of being pulled in by the cutters of the machine with the use of a properly designed and suitable safety guard.

### Food Processing Machine Safety

- Implement safe work procedures to ensure guards are in place, and feeding methods are correct.
- Use warning signs to alert workers of the hazardous zones and safety instructions.
- Train workers under the direct supervision of experienced workers.
- Provide workers with properly-sized plungers to feed to the throat area during an operation.
- Instruct operators to operate machines only with feeding trays and throats installed.
- Implement lock-out procedures to eliminate hazardous energy during cleaning, service and maintenance of the machines.



1 Unguarded rotating shaft cutters that pulled operator's hand in and crushed it



1 After the accident, shaft cutters were guarded to prevent future mishaps

## Case Study 3

A woodworking factory worker's left index and ring fingers were amputated by a rotating circular table saw while cutting a timber piece.

### Investigation Findings

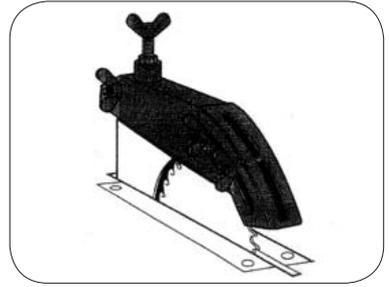
- A metal guard was installed over the rotating saw blade of the circular table saw.
- The guard was not properly adjusted to ensure that the rotating saw blade was not exposed during a cutting operation.

### Lessons Learnt

- Conduct risk assessment for hazards of woodworking machine operations.
- Eliminate the risk of fingers coming into contact with rotating saw blade by fixing a suitable saw guard.

### Woodworking Machine Safety

- Incorporate slots in the extension piece to permit sighting of the line of cut when cutting large panels.
- Fit with a braking device that stops the blades within a few seconds.
- Be informed of the diameter of the smallest saw blade that can be used on the table saw.
- Ensure effective local exhaust ventilation both above and below the saw table.
- Incorporate adequate workpiece support for all operations.
- Use a low fence to aid the use of a push-stick for cutting shallow or angled work.



A circular table saw fitted with an adjustable safety guard

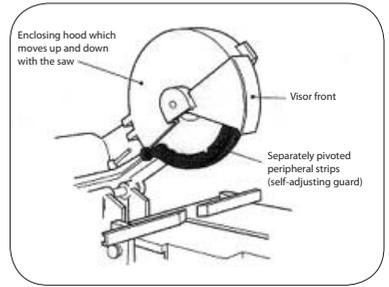


No safety guard to prevent hand and finger amputations



Saw guard must be adjusted as close to the timber piece as possible before cutting operation

- Use a push-stick when making any short cut and for removing the cut piece from between the saw blade and fence.
- Use a demountable power feed whenever possible to reduce the risk of contact with the saw blade.



Guard is lifted by the wood as the saw is lowered and rests on the top of the wood throughout the cut. It falls back automatically when the saw is raised



Defective guard must be repaired or replaced

## Sources for Additional Information

- CP 42: 1988 Code of Practice for Guarding and Safe Use of Woodworking Machinery.
- Health and Safety Executive (HSE) Information Sheet on Circular Saw Benches –Safe Working Practices  
<http://www.open.gov.uk/hse/hsehome.htm>

# 10. Useful References

- SS537 : Part 1 : 2008 on Code of Practice for Safe Use of Machinery.
- Workplace Safety and Health Risk Management : Risk Assessment Guidelines.
- US Department of Labor, Occupational Safety and Health Administration, "Safeguarding Equipment and Protecting Employers from Amputation".
- US Standards (ANSI B11 Standards).
- Technical Advisory for Metalworking Industry.
- Compendium of Typical Hazards Associated with Power Press and their Control Measures in the Metalworking Industry.  
[http://www.mom.gov.sg/publish/etc/medialib/mom\\_library/Workplace\\_Safety/files3/osh\\_compendiums.Par.11524.File.tmp/Metalworking%20Compendium%20\(Power%20Press\).pdf](http://www.mom.gov.sg/publish/etc/medialib/mom_library/Workplace_Safety/files3/osh_compendiums.Par.11524.File.tmp/Metalworking%20Compendium%20(Power%20Press).pdf)
- SS 513 – 1: 2005 on Personal Protective Equipment - Footwear - Safety Footwear.
- US Department of Labor, Occupational Safety and Health Administration.  
<http://www.osha.gov>
- The Health and Safety Executive, United Kingdom.  
<http://www.hse.gov.uk>
- PD5304 : 2005 Guidance on Safe Use of Machinery.

# 11. Acknowledgements

- Figure 3 is reproduced from SS 537 : Part 1:2008 - 'Code of Practice for Safe Use of Machinery, Part 1: General Requirements' with permission from SPRING Singapore. Copyright remains with SPRING Singapore.



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