
MACHINE SAFETY

Introduction

In Ontario today people are still becoming injured, sick or killed as a result of hazards around machinery and equipment in every industry. Many of these accidents are caused by human error.

There are numerous potential hazards around machinery and equipment, such as cutting edges, gears, chains, revolving shafts, rotating blades and levers.

Safety Hazards

- Contact with moving parts
- Contact with electricity, heat, fire, cold, other energies
- Contact with pressurized gas or liquid

Health Hazards

- Contact with harmful chemicals
- Contact with harmful noise, radiation, vibration
- Lack of adequate workplace ergonomics: handling and process design
- Harmful actions to the environment and community

Safety Hazards

Where?

- At the controls: starting or stopping, set-up, adjusting.
- Where you feed materials into the machine: loading, cleaning.
- Where the machine cuts, turns, drills, shapes, punches, or moves in any way: cleaning and maintenance, trouble shooting and repair, adjusting, setting up.
- At the gears, wheels, cylinders, belts, rollers, chains, cables, sprockets, cams: cleaning and maintenance, trouble shooting and repair, adjusting, setting up.
- Around lift trucks, tractors, harvesters and moving equipment.
- Around conveyors, elevators, and shredders.
- Around any machinery and equipment that can release energy (e.g., hydraulic systems).

MACHINE SAFETY

Types of Machine Motion

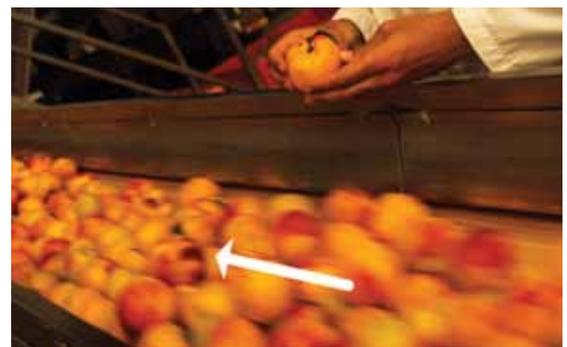
The diagrams to the left show **rotational motion hazards** with various machinery parts and equipment: pulley, drill, circular saw, rollers, grinding wheel, lathe, shaft, router, milling, boring machine, gear and chain, pulley and belt, **nip points**, roller/gear **in-running nips**, etc.



The diagrams to the left show **reciprocating motion hazards** with various machinery parts and equipment: at press, jig saw, drill press, cutters, shears, stitching and sewing machines, guillotine blades, shear action of cutting die, punch action of press, power hammer, riveter, robotic arm, etc.



The diagram to the left shows **transverse motion hazards** with various machinery parts and equipment: at conveyor belt, band saw, belt sander, lift truck, robots, press, etc.



MACHINE SAFETY

What Can happen?

These motions have different actions and can therefore result in one or several types of injury.

Motion	Action	Type of Injury
Rotating	Cutting/Trapping	Laceration/ Amputation/Suffocation
Back and Forth, Up and Down	Impact/Struck by/Crushing	Fracture/Amputation/Death
Straight Line	Entanglement/Pulled by	Sprain/Strain Fracture Amputation Death

Contact with Electricity, Fire, Heat, Cold, other Energies

Where?

You can contact electricity, heat, fire, or cold:

- at power panels, electrical circuits, power lines, ovens, and heating elements
- around chemical containers, vats, pipes, pumps, and compressors
- around cranes, hoists, other lifting devices
- during service and repair jobs

What Can Happen?

Without protective guards and devices on machines, without following safe work procedures, or having the right personal protection:

- you could get hurt if you make contact with: **electricity (e.g., faulty ground), flames, hot or cold materials**, and surfaces around machinery
- you can suffer **burns – and in some cases freeze injuries** – around welding, soldering jobs, freezing equipment, electrical panels and circuits, molten, baking, heating, steaming, extruding, plating jobs
- you can be burned if fuel catches fire and chemical equipment explodes
- you can get hurt if **equipment or materials fall** due to uncontrolled gravitational or mechanical energies, such as problems with incorrectly slinging/rigging or lifting loads by crane or hoist, inadequate stacking and loading

MACHINE SAFETY

- Some machines store energy which, if unexpectedly released, can cause serious injury, e.g., springs, hydraulic systems, pneumatic systems
- Freewheeling parts of machines can keep moving after the machine is shut off, e.g., flywheels, fans, rotary motor blades, grinders

Contact with Pressurized Gas or Liquid

Where?

You can contact high pressure liquid or gas:

- at nozzles of pressurized cleaning and painting spray lines, air jets
- around injectors, autoclaves, extruders, chemical containers, vats, pipes, pumps and compressors
- during cleaning, service, and repair jobs
- any hydraulic or pneumatic lines

What Can Happen?

Without guards on machines, without following safe work procedures, or having the right personal protection:

- you could get hurt if you make contact with high pressurized gas or liquid
- pressurized gas or liquid can **puncture skin, cut, and blind** you
- pressurized air or liquid can inject you with **harmful chemicals or bacteria**

Contact with Harmful Chemicals

Where?

You can contact harmful chemicals at or around machinery and equipment. Chemical liquids, dusts, fumes, vapours and gases can travel throughout the workplace:

- at or near production and paint jobs, welding, soldering, cutting, boring, grinding, tapping, reaming, lapping, drilling, broaching
- machine lubricants, degreasers, coolants, protectants, releasing agents, paint, fuel, cleaners

MACHINE SAFETY

- at plating jobs, vats, tanks
- during service and repair jobs
- piping systems, valves, sumps, reservoirs

What Can Happen?

Without guards on machines, without following safe work procedures, or having the right personal protection – especially complying with specific WHMIS requirements:

- you could get hurt if you make contact with splashed chemical liquids, powders, dusts, fumes, vapours, mists, and gels or grease used around machinery
- you could contact harmful chemicals that can burn, explode, corrode, poison, or irritate, e.g., metal working fluids, lubricants

Contact with Harmful Noise, Radiation, Vibration

Where?

You can contact harmful noise or radiation at or around machinery and equipment. Sound waves and radiation energy can travel throughout broader zones in the workplace:

- at stamping, sawing, grinding, polishing operations
- at welding, cutting operations
- at finishing, curing operations
- at any job that involves operation of heavy machinery

What can happen?

Without guards on machines, without following safe work procedures, or having the right personal protection:

- some equipment can release harmful noise or radiation that can destroy your hearing, blind you, burn, or damage your internal organs (e.g., certain kinds of radiation)
- some equipment vibrations can injure soft body tissues, joints

MACHINE SAFETY

Harmful Lack of Adequate Workplace Ergonomics: Handling and Process Design

Where?

- Excessive repetition of tasks
- Excessive force used in tasks
- Prolonged and repetitious, **awkward postures** during work
- Mechanical stress, excessively stressful handling
- Vibration
- Excessive and prolonged cold, heat, poor lighting, noise
- Any of the above, not excessively necessarily, but in combination

Awkward Handling Postures alone may include:

- elbows raised above wrist height
- excessive wrist bending/deviation
- pinching materials/products/tools constantly or constant hammering
- forearm rotation or twisting constantly
- extreme elbow bending/flexion
- back bending/flexion, twisting or lateral bending excessively

Inadequate Workplace Design alone may include:

- improperly designed hand tools: for any user, or specific individual
- improperly designed workstations/surfaces: forces worker to adapt against body design
- improperly measured working heights/levels
- improper process: excessive specialization or excessive line speed: lack of job physical variety or muscle relief for any user, or specific individuals
- improper work flow design

MACHINE SAFETY

What Can Happen?

- Soft tissue injury: e.g., sprain can happen
- Injury causes accident: e.g. sprain can cause fall or dropping, then set off another accident
- Trigger Finger: repeated finger flexion, prolonged gripping
- Carpal Tunnel Syndrome: repeated wrist extension or flexion, ulnar deviation, excessive pinch force
- Raynaud's Phenomenon: in fingers due to prolonged use of vibrating tools
- Tenosynovitis: forceful pinching, ulnar deviation, prolonged gripping
- Epicondylitis: prolonged and excessive rotation of the forearm
- Tendinitis: in biceps from forceful flexion of the forearm
- Rotator Cuff Tendinitis: from working repeatedly with arms above shoulder level

Legislation

Workplace machine safety law in Ontario is based on the *Occupational Health and Safety Act* and Regulations for Industrial Establishments (R.R.O. 851/90).

In the *Act*, the sections dealing with responsibilities of employers (s.25, 26), supervisors (s.27) and workers (s.28) set out general duties with respect to machine safety.

Making protective devices ineffective (must provide temporary adequate protective device) (s.28(2)(a))

The Industrial Establishments Regulations (IER) has the following more specific provisions:

- **Preventing Access to Exposed Part:** guards must protect person from moving part. (IER, s.24)
- **In-running Nip Hazard, Any Part of a Machine or Device:** guards must protect person from access to pinch points. (IER, s.25)
- **Waste Stock and Protection:** guards must protect person from processed materials, production or waste stock not just the moving machinery/equipment parts. (IER, s.26)
- **Emergency Stop on Machine:** must be easy to see and reach. (IER, s.27)
- **Operating Control for Machine:** control that acts as a guard must be in safe zone for operator, cannot be operated accidentally, and must not be made ineffective, e.g., tied down. (IER, s.28)

MACHINE SAFETY

- **Start Up Warning Devices:** all parts of conveyor or other machinery not visible from control area must give a warning before it starts passing over workers (IER, s.33)
- **Conveyors:** provision of guards. (IER, s.34)
- **Lockout:** lockout requirements (IER, S.42, 42.1)
- **Stopping and Blocking Machine:** the machine must be motionless and moving parts blocked before any cleaning, oiling, adjusting, repairing or maintaining work is done on any part of the machine. (IER, s.75)
- **Starting a Machine:** controls and other control mechanisms must be locked out as well as other precautions (e.g., blanking off, energy release) where starting the machine or equipment may endanger the worker. (IER, s.76)

There are also separate standards which apply:

- **Canadian Standards Association (CSA)**
 - CAN/CSA-Z432-04 (R2009) Safeguarding of Machinery (focus in this guideline).
 - CAN/CSA-Z434-03 (R2008) Industrial Robots and Robot Systems – General Safety.
 - CAN/CSA-Z142-02-10 Code for Punch Press and Brake Press Operation: Health, Safety, and Guarding Requirements.
 - CAN/CSA-Z460-05 Control of Hazardous Energy – Lockout and Other Methods

Controls

There are several means for controlling machine hazards:

- Safety Guards and Devices
- Safety Procedures and Practices
- Personal Protective Equipment

MACHINE SAFETY

Safety Guards and Devices

- Guards and safety devices can help protect you from dangerous contact.
- Guards, barriers, and safety devices must prevent your fingers, arms – or your whole body – from getting into a danger zone.
- Guards must be designed and placed correctly: right size opening and distance to person.
- Guards must work well and fit the machine right – always.

Types of Guards

- Fixed Barriers
- Interlocking Guards: electrical, mechanical
- Adjustable and Self-adjusting Guards

Types of Safety Devices

- Pullbacks and Holdbacks
- Presence-sensing Devices
- Two-hand Control
- Safety Blocks (interlocked)
- Tools: Feeding/Holding Tools

Safety Procedures and Practices

Safety practices and procedures include:

Proper Lockout Procedure

Use lockout procedures before service, maintenance, or repair jobs on machines/equipment.

Job/Task Standard Operating Procedures

Safe work steps to check, set up machines, start, and finish job or task.

MACHINE SAFETY

Inspection And Maintenance

For the machinery, guards, and your entire work area, regularly and often.

Emergency Preparation and Regular Drills

To be prepared and able to respond effectively to unexpected occurrences.

Human Factor Planning

To allow you regular relief and change from repetitive tasks on production lines, to avoid fatigue, strains, sprains, and other injuries or accidents through regular breaks and task variety.

Training

WHMIS and chemical health and safety, inspecting your workplace and housekeeping, emergency response.

Lockout Procedure

A proper lockout procedure has seven steps:

1. **Prepare for shutdown:** gather required materials, notify appropriate personnel.
2. **Shut down the equipment:** Disconnect power/shut down (electricity, gravity, air/fluid/steam pressure, springs or mechanical).
3. **Isolate the equipment:** Isolate the system from all energy sources.
4. **Attach locks/locking devices and tags:** Sign and attach warning tag(s).
5. **Control stored energy:** Use safety blocks between dangerous parts that could move and injure. Dissipate any stored energy.
6. **Verify isolation of equipment:** Test controls to see that the machine can't go and has no built-up energy left.
7. **Release from lockout control:** This will ensure safe return to service for all workers.

Job/Task Analysis

Job/task analysis provides a process for developing actual working procedures – how the job is performed – with appropriate controls in place for health, safety and environmental protection.

MACHINE SAFETY

Inspections

Types of Inspections:

- Pre-start up, pre-operational
- Monthly plant inspection (JHSC)
- Manufacturer's recommendations
- Supervisory/management inspection
- Maintenance
- MOL inspection

Summary

Effective and efficient inspections are procedures meant to verify that work is being carried out according to predetermined safe standard operating procedures.

*Also, inspections verify the state of appropriate, safe physical conditions with effectively controlled components, process equipment, and materials.

*Standard Operating Procedures are developed through the use of Job/Task Analysis. Owner's/Manufacturer's recommended procedures are helpful, especially for high priority processes and critical tasks.

Emergency Preparation

The company should have an emergency policy and procedure contained in an emergency plan.

- **Know the signs** of possible emergencies
- **Know how to shut down** your equipment in case of emergency
- **Know where to find** the fire extinguishers.
- **Know when and how to use** the fire extinguishers
- **Know where to find** the first aid area and first aid kit
- **Know whom to call** for help in a health or safety emergency
- **Know where to go** in case of emergency
- **Practice** emergency procedures

MACHINE SAFETY

Human Factors Planning

Human factors planning is part of workplace machine safety and health. A significant number of Ontario injuries involve not only amputations and similar trauma, but many less dramatic strains, sprains, and related overuse/repetitive task injuries, which are, however, serious.

The following checklist questions can be used to identify work activity “symptoms” that may have potential for developing into real problems that require control. (“Yes” answers indicate a concern that needs follow up and correction, e.g., professional advice for control.)

Human Factors Checklist

	YES
1. Is the worker exposed to unrelieved repetitive movements in the job process?	
2. Does the worker’s task demand moving too frequently, with excessive force, or too long?	
3. Is the worker’s body position, e.g., arms, legs, back, neck in poor alignment/awkward postures?	
4. Is the workstation/ equipment improperly placed /disorganized causing poor movement?	
5. Are tools and other equipment designed to prevent healthy working positions?	
6. Are processes and workstations designed to force long reaches , stretches, deep bends?	
7. Is the worker uncomfortable during any tasks or procedures of the job?	
8. Can any body part get caught in moving parts , between objects, have harmful contact?	
9. Is the worker exposed to slips, falls, trips , strains from lifting, pulling, pushing, heat/cold?	
10. Is excessive noise or vibration, poor lighting , or adverse weather affecting performance?	
11. Is the worker exposed to any risk of falling or from falling objects?	
12. Is the worker exposed to possible contacts with electricity, toxic, corrosive chemicals, dusts, fumes, vapours, gases, mists, etc.?	

MACHINE SAFETY

Machine Safety Checklist

Mechanical Hazards	Yes	No
The point of operation		
1. Is there a point-of-operation safeguard provided for the machine?		
2. Does it keep the operator's hands, fingers, body out of the danger area?		
3. Is there evidence that the safeguards have been tampered with or removed?		
4. Could you suggest a more practical, effective safeguard?		
5. Could changes be made on the machine to eliminate the point-of-operation hazard entirely?		
Power transmission apparatus		
1. Are there any unguarded gears, sprockets, pulleys, or fly-wheels on the apparatus?		
2. Are there any exposed belts or chain drives?		
3. Are there any exposed set screws, key ways, or collars?		
4. Are starting and stopping controls within easy reach of the operator?		
5. If there is more than one operator, are separate controls provided?		
Other moving parts		
1. Are safeguards provided for all hazardous moving parts of the machine, including auxiliary parts?		
Non-mechanical hazards		
1. Have appropriate measures been taken to safeguard workers against noise hazards?		
2. Have special guards, enclosures, or personal protective equipment been provided, where necessary, to protect workers from exposure to harmful substances used in machine operation?		
Electrical hazards		
1. Is the machine installed in accordance with appropriate standards and codes?		
2. Are there loose conduit fittings?		
3. Are there any openings on switch or junction boxes?		
4. Is the power supply correctly fused and protected?		
5. Do workers occasionally receive minor shocks while operating any of the machines?		

MACHINE SAFETY

Mechanical Hazards	Yes	No
Training		
1. Do operators and maintenance workers have the necessary training in how to use the safeguards and why?		
2. Have operators and maintenance workers been trained in where the safeguards are located, how they provide protection, and what hazards they protect against?		
3. Have operators and maintenance workers been trained in how and under what circumstances guards can be removed?		
4. Have workers been trained in the procedures to follow if they notice guards that are dangerous, missing, or inadequate?		
5. Could changes be made on the machine to eliminate the point-of-operation hazard entirely?		
Protective equipment and proper clothing		
1. Is protective equipment required?		
2. Have operators and maintenance workers been trained in where the safeguards are located, how they provide protection, and what hazards they protect against?		
3. Is the operator dressed safely for the job (that is, no loose fitting clothing, long hair or jewelry)?		
Machinery maintenance and repair		
1. Have maintenance workers received up-to-date instruction on the machinery they service?		
2. Do maintenance workers lock out/tag out the machine from its power sources before beginning repairs?		
3. Where several maintenance persons work on the same machine, are multiple lockout devices used?		
4. Do maintenance persons use appropriate and safe equipment in their repair work?		
5. Is the maintenance equipment itself properly maintained?		
Other items to check		
1. Are emergency stop buttons, pull cords, or bars provided?		
2. Are the emergency stops clearly marked and coloured red?		
3. Are there warning labels or markings to show hazardous areas?		

*Checklist courtesy of University of North Carolina at Bowling Green.

MACHINE SAFETY

Key Personal Controls

Use Personal Protection

- Use the right protective equipment and clothing for the job.
- Practice proper hygiene practices.

Follow Authorized Use Procedure

- Do not operate, service, maintain, or repair a machine unless trained and authorized to do it.

Report Any Problems

- Report to supervisor/manager any problems around machines and guards, for example:
Broken or **missing** guards and devices.
- **Loose** parts, **unusual** noise, leaks, or vibration.
- **Unfamiliar** odours, heat, smoke, dust, fumes, vapours.
- **Messy** work area and floor, inadequate light.
- **Damaged** or **dirty** personal protective equipment (PPE) or PPE that fits poorly.
- **Unhealthy** reactions, skin rashes, dizziness, hearing problems.

© Workplace Safety & Prevention Services 2013. Workplace Safety & Prevention Services (WSPS) grants permission to approved end users to reproduce this document in whole or in part, provided its intended use is for non-commercial, educational purposes and that full acknowledgement is given to the WSPS. Approved end users are firms registered with the Workplace Safety and Insurance Board. WSPS reserves the right to extend this permission to other stakeholders and interested parties by express written permission upon application. WSPS extends no warranty to materials amended or altered by the end user. Under no circumstances is this document, or any portion thereof, to be duplicated for purposes of sale or for external reproduction or distribution.

Revised: February 2011