Mechanical Hazards and Machine Guards

Mechanical hazards are those associated with power-driven machines, whether automated or manually operated.

Concerns about such hazards date back to the Industrial Revolution and the earliest days of mechanization.

- Failure to provide proper machine guards and enforce their use can be costly for companies
  - Mechanical hazards that are not properly guarded are implicated in thousands of workplace injuries every year.
  - Small gains in productivity obtained by willfully bypassing mechanical safeguards on machines can cost companies huge fines & medical bills.
COMMON MECHANICAL INJURIES

In industrial settings, people interact with machines designed to drill, cut, shear, punch, chip, staple, stitch, abrade, shape, stamp, and slit.

If workers fail to follow safety precautions, these procedures can happen to humans, instead of workpieces.

Strains/Sprains, Cuts, Shearing Injuries

A **strain** results when muscles are overstretched or torn, a **sprain** results from torn ligaments in a joint.

Strains and sprains can cause swelling and intense pain.

A **cut** occurs when a body part comes in contact with a sharp edge.

Seriousness of cutting or tearing depends on damage done to skin, veins, arteries, muscles, and even bones.

Power-driven **shears** for severing paper, metal, plastic, elastomers & composites are widely used.

Such machines often amputated fingers & hands when operators reached under the shearing blade, and activated the blade before fully removing their hand.
Crushing Injuries

Crushing injuries occur when a part of the body is caught between hard surfaces that progressively move together—crushing anything between them.

- Two categories: squeeze-point types & run-in points.
  - **Squeeze-point** hazards exist when two hard surfaces, at least one of them moving, push close enough together to crush objects between them.
  - **Run-in point** hazards exist where two objects, at least one of which is rotating, come progressively closer together.

- Body parts can also be crushed in other ways.
  - A heavy object falling on a foot; A hammer hitting a finger.

Meshing gears and belt pulleys are examples of run-in point hazards.
Breaking

Machines used to deform engineering materials in a variety of ways can also fracture—break—bones.

A *simple fracture* is a break that does not pierce the skin.

A *compound fracture* is a break that has broken through the surrounding tissue and skin.

A *complete fracture* divides the affected bone into two or more separate pieces.

An *incomplete fracture* leaves the affected bone in one piece but cracked.

A *transverse fracture* is a break straight across the bone.

An *oblique fracture* is diagonal.

A *comminuted fracture* exists when the bone is broken into a number of small pieces at the point of fracture.

Puncturing

Puncturing results when an object penetrates straight into the body and pulls straight out.

Creating a wound in the shape of the penetrating object.

• The greatest hazard is potential for damage to internal organs.
SAFEGUARDING DEFINED

The National Safety Council (NSC) defines safeguarding as...

*Machine safeguarding is to minimize the risk of accidents of machine-operator contact.*

Safeguards can be broadly categorized as point-of-operation guards, point-of-operation devices, and feeding/ejection methods.

OSHA REQUIREMENTS FOR MACHINE GUARDING


**Types of guarding** - One or more methods of machine guarding must be provided to protect people from such point of operation hazards.

**General requirements** - Where possible, guards should be affixed to the machine in question, or in the most feasible location and method away from the machine.

- Affixed in such a way that they do not create a hazard.

**Guarding point of operation** - Any point of operation that might expose a person to injury must be guarded.

- Guarding devices must comply with all applicable standards.
- In absence of standards, designed, constructed, and installed in such a way as to prevent danger to the machine operator.
OSHA REQUIREMENTS FOR MACHINE GUARDING


– **Machines requiring point of operation guards.**
  - Guillotine cutters, shears, power presses, milling machines.
  - Power saws, jointers, portable power tools, forming rolls.

– **Exposure of blades** - Fans must be guarded when the periphery of the fan blades is less than seven feet above the floor or working level—no openings that exceed 1/2”.

– **Anchoring fixed machinery** - Machines designed to be fixed in one location must be securely anchored to prevent movement.

RISK ASSESSMENT IN MACHINE OPERATION

Risk assessment should be structured, systematic, and answer four specific questions:

*How severe are potential injuries?*

*How frequently are employees exposed to the potential hazards?*

*What is the possibility of avoiding the hazard if it does occur?*

*What is the likelihood of an injury should a safety control system fail?*
RISK ASSESSMENT IN MACHINE OPERATION

The most widely used risk-assessment technique is the decision tree, coupled with codes representing these four questions and defined levels of risk.

\[ S = \text{Severity} \quad F = \text{Frequency} \quad P = \text{Possibility} \quad L = \text{Likelihood} \quad RL = \text{Risk Level} \]

REQUIREMENTS FOR ALL SAFEGUARDS

Machine motions present in modern industry involve mechanisms that rotate, reciprocate, or do both.

Tools, bits, chucks, blades, spokes, screws, gears, shafts, belts, and a variety of different types of stock.

Safeguards can be devised to protect workers while allowing work to progress at a productive rate.
REQUIREMENTS FOR ALL SAFEGUARDS

NSC requirements for safeguards:

**Prevent contact** - Safeguards should prevent human contact with any potentially harmful machine part.

**Be secure and durable** - Workers cannot render them ineffective by tampering with or disabling them.
  - Durable enough to withstand the rigors of the workplace.

**Protect against falling objects** - Shield moving parts from falling objects, which can hurl out, creating a projectile.

**Create no new hazard** - Safeguards should overcome the hazards in question without creating new ones.
  - Sharp edges, unfinished surfaces, or protruding bolts.

**Create no interference** - Safeguards that interfere with progress of work are likely to be disregarded or disabled by workers feeling the pressure of production deadlines.

**Allow safe maintenance** - More frequently performed maintenance tasks (lubrication, etc.) accomplished without the removal of guards.
POINT-OF-OPERATION GUARDS

Single-purpose safeguards are typically permanently fixed and nonadjustable.
Because they guard against only one hazard.

Multiple-purpose safeguards are typically adjustable.
They guard against more than one hazard.

POINT-OF-OPERATION GUARDS

Fixed guards are suitable for many specific applications,
can be constructed in-plant,
require little maintenance & suitable for high-production,
repetitive operations.

Disadvantages can include limited visibility,
limitation to specific operations & inhibiting normal cleaning and maintenance.
POINT-OF-OPERATION GUARDS

Interlocked guards shut down the machine if not securely in place, or if they are disengaged. These guards require careful adjustment and maintenance and, in some cases, can be easily disengaged. Allows safe access to remove jams or to conduct routine maintenance without taking off the guard.

Adjustable guards provide a barrier against a variety of hazards that are associated with different production operations. They do not provide as dependable a barrier as other guards do, and require frequent maintenance & careful adjustment. Advantage is flexibility.
POINT-OF-OPERATION GUARDS

Series 12 PRO-TECH-TOR GATE GUARD used on an open-back power press. 
Courtesy PROTECH SYSTEMS.

POINT-OF-OPERATION GUARDS

Series 17 CHECKMATE RIVET GUARD used on a foot-operated riveting machine. More modern models have light beam protection. 
Courtesy PROTECH SYSTEMS.
POINT-OF-OPERATION GUARDS

When the doors are opened, the milling tool stops automatically.

POINT-OF-OPERATION GUARDS

In order for this shearing machine to cut, both foot pedal and hand button must be engaged.
POINT-OF-OPERATION GUARDS

This door protects the operator in the event of an exploding or shattering grinding wheel.

POINT-OF-OPERATION GUARDS

The safety door on this machine must be closed or the drill will not operate.
POINT-OF-OPERATION DEVICES

- Photoelectric devices are optical devices that shut down the machine whenever the light field is broken.
- Limitations include:
  - They do not protect against mechanical failure.
  - They require frequent calibration.
  - They can be used only with machines that can be stopped.
  - They do not protect workers from parts that might fly out of the point-of-operation area.

Radio-frequency devices are capacitance devices that brake the machine if the capacitance field is interrupted by a worker’s body or another object.
With the same limitations as photoelectric devices.

POINT-OF-OPERATION GUARDS

Series 25 EAGLE EYE INFRA-RED LIGHT BARRIER. A point-of-operation guarding system on a roller press machine. Courtesy of PROTECH SYSTEMS.
POINT-OF-OPERATION DEVICES

Electromechanical devices are contact bars allowing only specified movement between worker & hazard.

If the worker moves the contact bar beyond the specified point, the machine will not cycle.
- Requiring frequent maintenance and careful adjustment.

Pullback devices pull the operator’s hands out of the danger zone when the machine starts to cycle.
They limit operator movement, must be adjusted for each individual operator & require close supervision.

Restraint devices hold the operator back from the danger zone—with little risk of mechanical failure.
They also limit the operator movement, must be adjusted for each individual operator, and require close supervision.

POINT-OF-OPERATION DEVICES

Safety trip devices include trip wires, trip rods, and body bars, which stop the machine when tripped.
While simple, all controls must be activated manually.
Two-hand controls require the operator to use both hands concurrently to activate the machine.
Ensures that hands cannot stray into the danger zone.
- Some can be tampered & made operable using only one hand.

Gates provide a barrier between the danger zone and workers.
They can obscure the work, making it difficult for the operator to see.
MACHINE GUARDING SELF-ASSESSMENT

Questions for machine guarding self-assessments:

Are all machines that might expose people to rotating parts, nip points, flying chips, sparks, flying particles, or other similar hazards properly guarded?

Are all mechanical power transmission belts and the nip points they create properly guarded?

Are all exposed power shafts located less than seven feet above the working level properly guarded?

Are hand tools regularly inspected on a systematic basis for burred ends, cracked handles, and other potentially hazardous conditions?

Are power saws & similar equipment properly guarded?

Are the tool rests within 1/8” or less of grinding wheels?

MACHINE GUARDING SELF-ASSESSMENT

Questions for machine guarding self-assessments:

– Do all employees who handle and store gas cylinders and valves know how to do so without causing damage?
– Are all compressed gas cylinders inspected regularly and systematically for obvious signs of defects, deep rusting, or leakage?
– Are all air receivers periodically and systematically inspected, including safety valves?
– Are all safety valves tested regularly, systematically, and frequently?
– Is compressed air used to clean tools, machines, equipment, and parts reduced to less than 30 pounds per square inch (psi)?
FEEDING AND EJECTION SYSTEMS

Automatic feed systems feed stock to the machine from rolls, eliminating need for operators to enter the danger zone.

Limited in the types & variations of stock they can feed.

- Typically require an auxiliary barrier & frequent maintenance.

Semiautomatic feed include chutes, moveable dies, dial feeds, plungers, and sliding bolsters.

Same advantages/limitations as automatic feed systems.

FEEDING AND EJECTION SYSTEMS

Automatic ejection systems eject work pneumatically or mechanically—operators don’t reach into the danger zone.

Restricted to use with relatively small stock.

- Potential hazards include blown chips or debris and noise.

Semiautomatic ejection systems eject work using mechanisms activated by the operator.

Require auxiliary barriers and can be used with a limited variety of stock.
ROBOT SAFEGUARDS

Hazards associated with robots are:
- Entrapment of a worker between a robot & a solid surface.
- Impact with a moving robot arm.
- Impact with objects ejected or dropped by the robot.

- The best guard is a physical barrier around the entire perimeter of a robot’s work envelope.
  - Various types of shutdown guards can also be used.
- Robots can be deceptive—a non-moving robot may simply be at a stage between cycles.
  - It might make sudden, rapid movements without warning that could endanger any person inside the work envelope.

CONTROL OF HAZARDOUS ENERGY

OSHA 29 CFR 1910.147 is often referred to as the “lockout/tagout” standard.

To protect people from hazardous energy while performing service/maintenance on machines, tools, and equipment.

Before service or maintenance are performed, the machines or equipment in question must be disconnected from their energy source.

The energy source must be either locked or tagged out, to prevent accidental or inadvertent activation.
Lockout/Tagout Language

**Affected employee** - Employees who perform their jobs in areas in which the procedure in question is implemented and service/maintenance operations are performed.

- Do not implement energy control procedures unless authorized.

**Authorized employee** - Employees who do machine service/maintenance & use lockout/tagout procedures.

**Capable of being locked out** - A device is capable of being locked out if it...

- has a hasp to which a lock can be attached
- has another appropriate integral part through which a lock can be attached
- has a built-in locking mechanism
- It can be locked without permanently dismantling, rebuilding, or replacing the energy-isolating device.

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Lockout/Tagout Language

**Energized** - Machines, equipment & tools are energized if they are connected to an energy source, or contain stored or residual energy even after being disconnected.

**Energy-isolating device** - Any mechanical device that physically prevents release or transmission of energy.

**Energy source** - Any source of power that can activate a machine or piece of equipment.

- Electrical, mechanical, hydraulic, pneumatic, chemical, thermal.

**Energy control procedure** - Written document containing all information needed to properly control hazardous energy when shutting down a machine or equipment.

**Energy control program** - Program to prevent accidental or inadvertent energizing of machines during service.

- Sometimes called the organization’s lockout/tagout program.
Lockout/Tagout Language

- **Lockout** - Placing a lockout device on an energy-isolating device to prevent accidental or inadvertent energizing of a machine during servicing.

- **Lockout device** - Any device that uses a positive means to keep an energy-isolation device in the safe position to prevent accidental/inadvertent energizing.

Lockout/Tagout Language

- **Tagout** - Placing a tag on an energy-isolation device to warn people so that they do not accidentally or inadvertently energize a piece of equipment.

- **Tagout device** - Any prominent warning device that can be affixed to an energy-isolation device to prevent the accidental energizing of a machine.
Provisions of the Standard

**Energy control program** - Organizations must establish energy control programs with documented procedures, provide employee training & ensure periodic inspections.

**Energy control procedure** - Procedures must contain at least the following elements:
- A statement on how the procedure will be used.
- Procedural steps to shut down/isolate/block/secure equipment.
- Steps designating safe placement/removal/transfer of lockout/tagout devices and who has responsibility for them.
- Specific requirements for testing machines or equipment to verify the effectiveness of energy control measures.

**Energy-isolating devices** - Organizations must have appropriate energy-isolating devices for preventing the accidental or inadvertent release of energy.
- The preferred type of device is one that can be locked out.

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Provisions of the Standard

**Requirements for lockout/tagout devices** - Must be:
- Durable enough to withstand environment to which exposed.
- Standardized in terms of color or size and print and format.
- Substantial enough to avoid accidental/unauthorized removal.
- Identifiable in terms of the employee who affixed them and the warning message.

**Employee training** - Organizations must provide initial training & retraining as necessary and certify training has been given to all employees covered in the standard.

**Periodic inspections** - Inspections must be performed at least annually to ensure the energy control program is up-to-date and being properly implemented.

**Application of controls & lockout/tagout devices** - All such devices must be applied properly.
Provisions of the Standard

**Removal of locks or tags** - Before removal:
- Inspect work area to ensure nonessential items are removed & the machine is capable of operating properly.
- Notify affected employees immediately after removing the energy control devices and before energizing the machine.
- Ensure that energy control devices are removed by the individual who affixed them.

**Additional safety requirements** - OSHA allows for special circumstances as set forth in this subsection.
- Organizations must ensure outside personnel are fully informed about energy control procedures.
- In group lockout/tagout situations, each employee must be protected by his/her own personal energy control device.
- Organizations must have specific procedures for ensuring continuity in spite of personnel and shift changes.

Evaluating Lockout/Tagout Programs

Lockout/tagout violations are frequently cited by OSHA during on-site inspections.

Some questions used to evaluate programs:
- Is machinery/equipment capable of movement required to be de-energized/disengaged & blocked/locked out during cleaning, servicing, adjusting, or setting up operations?
- Where electrical circuits are not able to be disconnected, are appropriate electrical enclosures identified?
- If the power disconnect for equipment does not disconnect the electrical control circuit, is means provided to ensure the control circuit can be disconnected and locked out?
GENERAL PRECAUTIONS

All operators should be trained in the safe operation and maintenance of their machines.
All machine operators should be trained in emergency procedures to take when accidents occur.
All employees should know how to activate emergency shutdown controls.
  - Knowing where the controls are and how to activate them.

Inspection, maintenance, adjustment, repair & calibration of safeguards should be carried out regularly.
Supervisors should ensure that safeguards are properly in place when machines are in use.
Employees who disable or remove safeguards should be disciplined appropriately.

GENERAL PRECAUTIONS

Operator teams of the same system should be trained in coordination techniques, and proper use of devices that prevent premature activation by a team member.
Operators should be trained/supervised to dress properly:
  - No long hair, loose clothing, neckties, rings, watches, etc.

Shortcuts that violate safety principles & practices should be avoided.
Pressures of deadlines should never be the cause of unsafe work practices.
Employees who work around machines—but do not operate them—should be made aware of emergency procedures to take when an accident occurs.
BASIC PROGRAM CONTENT

Machine safeguarding should be organized, systematic, and comprehensive.
Safeguarding policy that is part of a broader company-wide safety and health policy.
Machine hazard analysis.
Lockout/tagout (materials and procedures).
Employee training.
Comprehensive documentation.
Periodic safeguarding audits (at least annually).

TAKING CORRECTIVE ACTION

What should be done when a mechanical hazard is observed?

The only acceptable answer is immediate corrective action, and specific action depends on the problem.

<table>
<thead>
<tr>
<th>Problem</th>
<th>Action</th>
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</thead>
<tbody>
<tr>
<td>Machine is operating without the safety guard.</td>
<td>Stop machine immediately and activate the safety guard.</td>
</tr>
<tr>
<td>Maintenance worker is cleaning a machine that is operating.</td>
<td>Stop machine immediately and lock or tag it out.</td>
</tr>
<tr>
<td>Visitor to the shop is wearing a necktie as he observes a lathe in operation.</td>
<td>Immediately pull the visitor back and have him remove the tie.</td>
</tr>
<tr>
<td>An operator is observed disabling a guard.</td>
<td>Stop the operator, secure the guard, and take disciplinary action.</td>
</tr>
<tr>
<td>A robot is operating without a protective barrier.</td>
<td>Stop the robot and erect a barrier immediately.</td>
</tr>
<tr>
<td>A machine guard has a sharp, ragged edge.</td>
<td>Stop the machine and eliminate the sharp edge and ragged burns by rounding it off.</td>
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PART 4

HAZARD ASSESSMENT, PREVENTION, AND CONTROL

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