Machine Guarding

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Location of Mechanical Hazards
- **Point of Operation**: Where work is performed on material
- **Power transmission apparatus**: transmit power (pulleys, belts, etc.)
- **Other moving parts**: all parts of machine which move while machine is working

Basic Machine Hazards
- **Motions**
  - Rotating (including in-running nip points)
  - Reciprocating
  - Transverse
- **Actions**
  - Cutting
  - Punching
  - Shearing
  - Bending

Rotating Motion
- Rotating shafts may grip clothing
- Exposure of projections and sharp edges
- In-running nip points
  - Rolls in contact with one another or stock fed between rolls
  - Rotating and tangentially moving parts
  - Between rotating and fixed parts

Exposure of Projects/Edges

Rotating Shafts – Nip Points
Rotating and Tangentially Moving Part: Nip Points

Reciprocating Motions
- Worker gets caught between a moving and stationary part

Transverse Motions
- Movement in a straight, continuous line

Cutting Action
- Hazard typically at point-of-operation
Punching Action
- Hazard typically occurs at point of operation, where worker holds and withdraws stock

Shearing Action
- Hazard occurs at point of operation, where stock is held

Bending Action
- Hazard occurs at point-of-operation

Common Mechanical Injuries
- Cutting and Tearing
- Shearing
- Crushing
- Breaking
- Strain/sprain
- Puncturing

What is Safeguarding?
- “...machine safeguarding is to minimize the risk of accidents of machine-operator contact”
- Two Basic Principles:
  - Use distance to separate person from hazard
  - Place a physical barrier between the worker and the hazard

Safeguarding
- Three Broad Categories of Safeguarding:
  - Point-of-operation guards
  - Point-of-operation devices
  - Feeding/ejection methods
- OSHA 1910.211-212
Requirements of Safeguards
- Prevent contact
- Be secure and durable
- Protect against falling objects
- Create no new hazards
- Create no interference
- Allow safe maintenance

Guard versus Device
- Guard – physical barrier placed on a machine to prevent access or contact to moving parts
- Device – a system that prevents the operation of a machine when body enters a zone where danger might occur; many possible functions

Point-of-Operation Guards
- Fixed (Enclosure) Guards – provide permanent barrier between worker and point-of-operation
- Interlocked Guards – shut down the machine when guard is not securely in place or is disengaged
- Adjustable Guards – provide barrier against a variety of different hazards associated with different production operations

Fixed Guard
- Safeguarding action: provides barrier
- Permanent part of machine
- Very simple, constructed of sheet metal, screen, wire cloth, bars, etc.

Fixed guard on a power press
Fixed guard enclosing belts and pulleys

Fixed guard on a band saw

Fixed guard on veneer clipper

Fixed guard providing protection from unused portion of die on a press brake
General Rule

- Power transmission apparatus is best protected by fixed guards that enclose danger area

Fixed Guards

- Advantages:
  - Adaptable to many specific applications
  - In-house construction often possible
  - Can provide maximum protection
  - Minimal maintenance
  - Suitable to high production, repetitive operations

- Limitations:
  - May interfere with visibility
  - Can be limited to specific operations
  - Machine adjustment often requires removal – hazard during maintenance

Interlocked Guard

- **Safeguarding action**: Shuts off or disengages power and prevents starting of machine when guard is removed
- May use electrical, mechanical, hydraulic, pneumatic power, or combo

Interlock

- Interlocked guard on automatic bread bagging machine
- Interlocked guard on picker machine (textile industry)
Interlocked Guards

- Advantages:
  - Can provide maximum protection
  - Allows access to machine for removing jams without time-consuming removal of fixed guards

- Limitations:
  - Requires careful adjustment and maintenance
  - May be easy to disengage

Adjustable Guard

- Safeguarding action: provides barrier that may be adjusted to facilitate a variety of production operations
Adjustable Guards

- Advantages:
  - Can be constructed to suit many specific applications
  - Can be adjusted to admit varying sizes of stock

- Limitations:
  - Hands may enter danger area some of the time
  - May require frequent maintenance/adjust
  - May be made ineffective by operator
  - May reduce visibility

Self-adjusting Guards

- Openings of barriers are determined by movement of stock
- As stock moves into danger area, the guard is pushed away to provide an opening only large enough for stock
- Guard returns to rest position
Self-adjusting guard on circular saw

Self-adjusting guard on a jointer

Point-of Operation Devices
- **Photoelectric Device** – shut down machine when light field is broken
- **Radio-frequency Device** – capacitance devices that brake machine if field is interrupted
- **Electromechanical Device** – contact bars that allow specified amount of movement between worker and hazard
- **Pullback Device** – pull the worker's hands away from danger zone

Point-of Operation Devices
- **Restraint Device** – hold worker back from danger zone
- **Safety trip Device** – trip wires, trip rods, and body bars which stop the machine when tripped
- **Two-hand Controls** – require worker to use both hands simultaneously
- **Gates** – provide a barrier between danger zone and workers

Photoelectric Present Sensor
- Uses a system of light sources and controls which can interrupt the machine’s operating cycle
- Used only on machines which can be stopped before worker reaches danger area
Photoelectric presence-sensing device on power press

Radiofrequency Device
- Uses a radio beam
- Machine stops when capacitance field is broken

Electromechanical Device
- Probe or contact bar stops machine if unwarranted contact is made

Pullback Device
- Series of cables attached to operator’s hands, wrists, and/or arms
- Used on machines with stroking action
  - Ram is up → operator can access point of operation
  - Ram starts down → mechanical linkages withdraw operator’s hands
Restraint Device
- Cables or straps attach to operator’s hands, which are given limited space in which to move

Safety Trip Devices
- Quick means for deactivating machine

Two-Hand Control Device
- Requires use of both hands to activate machine
Gates
- Movable barrier that protects worker before machine cycle can be started

Feeding and Ejection Systems
- **Automatic Feed** – stock is fed into machine using rolls
- **Semiautomatic Feed** – stock fed to machine using chutes, movable dies, dial feeds, plungers, etc.
- **Automatic Ejection** – work is ejected pneumatically or mechanically
- **Semiautomatic Ejection** – ejected using mechanisms activated by worker

Automatic Feed Systems
- Eliminates worker exposure to point of operation

Semiautomatic Feed System
- Operator uses mechanism to place piece beneath ram at each stroke
- Examples include: chutes, movable dies, dial feed, and plungers

Automatic Ejection
- Air-pressure or mechanical apparatus remove completed part from press
Semiautomatic Ejection
- When a plunger is withdrawn from die area, ejector leg kicks out finished part

Robots
- Load and unload stock, assemble parts, transfer objects, or perform other tasks otherwise done by an operator
- However, robots create many hazards themselves

Lockout/Tagout
- System to protect against unexpected startup of a machine that is supposed to be powered down for service/maint
- OSHA standard: The Control of Hazardous Energy (Lockout/Tagout)
- Prevents estimated 120 fatalities and 50000 injuries annually

Lockout
- Lockout
  - Padlock is placed in a way to cover or otherwise prevent access to the activating mechanism
  - Prevents unexpected startup of machine that should be powered down
  - “This lock is to be removed only by…”
- Tagout
  - Exactly like lockout system, but uses a tag instead of a padlock

Effective Lock/Tagout Program
- Attention to detail
- Extensive training
- Reinforcement of training
- Disciplinary action

Effects of Automation on Workers
- Reducing amount of physical labor
- Increasing amount of mental work
- Polarizing work: manual vs. mental
- Increase stress level of managers
- Decrease blue-collar
- Decrease loyalty towards employer
- Increase worker feeling of helplessness
Technological Alienation

- Resentment of the impact of technology on the lives of workers:
  - Powerlessness – feeling that worker is less important than the technology
  - Meaninglessness – do not see how their job contributes to the end product
  - Mindlessness – dumbing down of the workplace due to machines capable of performing "mental" work

Robots

- A re-programmable device capable of performing a variety of operations
- Used in applications such as welding, spray painting, and material handling
- Differences from other machinery
  - Ability to acquire intelligence through programming
  - Flexibility and range of motion
  - Speed of movement
  - Power

Types of Robots

- Rectangular Coordinate Robot
- Cylindrical Coordinate Robot
- Spherical Coordinate Robot
- Articulated Arm Robot
- Gantry Robot

Robot Work Envelopes

- Maximum Envelope
- Inverse Kinematics Envelope
- Operating Envelope

Components of a Robot

- Robot Mechanism
- Robot Mechatronics
- Robot Control
- Power Supply

Type of Path Generated

- Point-to-point – programmed to move from point A to point B, which will vary slightly from time to time
- Controlled path – computer calculates a path for movement that is used repeatedly
- Continuous path – coordinates are sampled, monitored, and replicated
“Teach” Mode
- Operator is in close proximity to the robot to teach it the required movements within close tolerance
- Where the highest degree of hazard exists

Principal Robot Hazards
- Being struck by a moving robot while inside the *work envelope* (area within which moving parts move)
- Being trapped between moving part of robot and another object/surface
- Being struck by a work piece, tool, or other object dropped/ejected by a robot