

Machine Guarding

University of Tennessee Safety Guide GS-060

Document Contact: EHS-General Safety

Date effective: January 1, 2009

Revision Date: April 1, 2014

Purpose

According to OSHA there are approximately 18,000 amputations, lacerations, crushing injuries, and abrasions per year. There are also 800 deaths per year that are associated with improper or no machine guarding. The majority of these types of injuries and deaths could have been prevented by having proper machine guarding in place. A good rule to remember is: Any machine part, function, or process which may cause injury must be safeguarded

The purpose of this document is to provide guidance on the need and solutions to proper machine guarding in the workplace.

Scope and Applicability

This guideline shall apply to university-owned equipment, both fixed and portable. This guideline shall also apply to equipment that is leased and under the control of UT.

This guideline does not apply to energized (electrical) parts, pneumatic, chemical, steam, heated surfaces covered under the university's lockout/tagout plan, nor does it apply to major construction and renovation projects under the exclusive control of contractors.

Abbreviations and Definitions

Abbreviations

MPTE: (mechanical power transmission equipment) - parts of a machine where mechanical motion and kinetic energy is transferred. Examples include belts, screw drives, drive shafts, chains, sprockets, gears, flywheels, etc.

ANSI: American National Standards Institute

EHS: Environmental Health and Safety

PPE: Personal Protective Equipment

PI: Principal Investigator

MH: Mechanical Hazards

Definitions

Mechanical hazards: (MH) the locations where work occurs in a machine. Examples include crush points, nip point, run-in, shearing, boring, cutting, slicing, compressing, grinding and similar mechanical forces and motion.

Belts: Belts include all power transmission belts, such as flat belts, round belts, v-belts, etc.

Belt Shifter: A belt shifter is a device for mechanically shifting belts from tight to loose pulleys or vice versa or for shifting belts on cones of speed pulleys.

Enclosures: Guarding by fixed physical barriers that are mounted on or around a machine to prevent access to moving parts.

Exposed to Contact: An object or part is exposed to contact if it is located in such a way that a person is likely to come into contact with it and be injured

Fixed Shop Machinery: Fixed shop machinery is defined as any piece of machinery designed to perform work on material such as a drill press, bench grinder, table saw, or lathe which is mounted or fixed to the floor or a table.

Flywheel: Flywheels include flywheels, balance wheels, and flywheel pulleys mounted and revolving on crankshaft platform used for oiling, maintenance, running adjustment, or repair work, but not as a passageway.

Guard: An engineering control that uses either fixed or adjustable barriers to prevent personnel from contacting the moving parts of machinery or equipment.

Interlocking: A type of guard that, when opened or removed, causes the machine's cycling mechanism or power to automatically shut off or disengage; the machine cannot be cycled or started until the guard is back in place.

Machine: An assemblage of parts that transmit forces, motion, and energy in a predetermined manner for performing a task.

Nip-Point Belt and Pulley Guard: A nip-point belt and pulley guard is a device that encloses the pulley and is provided with rounded or rolled edge slots through which the belt or pulley passes.

Point of Operation: The area on a machine where work is actually being performed upon the material being processed. On some machines, there may be more than one point of operation.

Power transmission equipment: Horizontal or vertical belts or shafts, pulleys, gears, sprockets, couplings, chains, clutches, connecting rods, flywheels, and other such equipment.

Prime Movers: Include steam, gas, oil, and air engines, motors, steam and hydraulic turbines, and other equipment used as a source of power.

Roles and Responsibilities

Employees shall:

- i. Replace or restore all guards and safety features that prevent accidental contact with MPTE following equipment set up or repair.
- ii. Report any missing or defective guards or safety features to their immediate supervisor.
- iii. Inspect equipment periodically to ensure the guard and safety features are functioning as designed.
- iv. Report machine guard problems to supervisors immediately
- v. Not use equipment that has been tagged out of service by EHS or that represents a serious safety hazard.

- vi. Inspect equipment periodically to ensure the guard and safety features are functioning as designed.
- vii. Follow UT's Lockout/Tagout policy when working on machinery.
- viii. Wear PPE as required for use with the machine (i.e. respirator, ear protection, etc.)

Environmental Health and Safety shall:

- i. Inspect facilities and equipment annually to identify equipment that may be improperly guarded or lack guards and safety features.
- ii. Note deficiencies found during the annual inspection with regards to machine guarding and communicate this information to the appropriate individual.
- iii. Tag equipment out of service if it represents a serious hazard to life or limb.
- iv. Notify the appropriate individual of the equipment that presents a serious hazard has been tagged out of service.
- v. Provide training on machine guard safety upon request.
- vi. Provide technical assistance to departments that have MPTE questions.
- vii. Investigate complaints and accidents involving machine guarding.

Department heads and Supervisors shall:

- i. Ensure the employees and students are furnished with equipment having proper guards and safety features.
- ii. Prohibit the use of equipment that is not adequately guarded.
- iii. Ensure employees and students are properly trained.
- iv. Ensure machine guards remain in place and are functional.
- v. Immediately correct machine guard deficiencies.
- vi. Ensure employees have required PPE and demonstrate how to properly wear the ppe

Contractors and visitors shall

- i. Follow the UT Machine Guarding Policy and all OSHA and state regulations concerning machine guard safety.
- ii. Follow UT's Lockout/Tagout policy and OSHA requirements.

Guidance

Machine guarding is the method used to prevent body parts and unwanted objects from coming into contact with moving or dangerous parts of machinery. If machine guarding is not in place, serious bodily harm or death could occur. Machine guarding is required by OSHA for any machine part, function, or process that has the potential of causing an injury. Machine guarding also differs for every machine due to the varying physical characteristics and the operator's involvement in how the user operates the machine. Machine guards can be purchased from the manufacturer or fabricated. Always check with the manufacturer of the machine to see if they also produce safeguards for that particular machine before fabricating a guard. Guards designed and installed by the builder/manufacture offer two main advantages:

- They usually conform to the design and function of the machine.
- They can be designed to strengthen the machine in some way or to serve some additional functional purposes.

Employees often work with job specific types of machines long enough that it becomes second nature to operate the machine. This can become potentially hazardous since:

- Continuous repetition can lead to a lack of concentration when operating the machine.
- The operator believes that they are skillful enough with the piece of equipment that the machine guard is not needed and they proceed to remove the guard.
- A dangerous situation is created in both of these scenarios for the operator and employees that may be working around the machine during the time of operation.
- Never take for granted the security of working with the same machine. Remember to always be alert and conscious of all moving machine parts no matter how simple the operation of the machine may be.

Hazardous activities are considered to be situations that may present a potential hazard to the operator or employees working around the machine during operation. Examples of hazardous activities while operating any machine includes:

- Normal production operations
- Set-up/threading/preparation
- Inspection
- Clearing jams
- Adjustments
- Cleaning
- Lubricating
- Maintenance

Do not wear loose clothing or jewelry, the material may become entangled or caught in the machine. Once caught, these items can cause the employee to become entangled in or pulled into the machine.

A machine consists of three basic mechanical components:

- **Point of Operation:** Where work is performed on the material. Points of operation must be machine guarded. (i.e. - Cutting, forming, etc.)
- **Power Transmission Devices:** This is the mechanical component that transmits energy to the part of the machine that performs the work. (e.g. flywheels, pulleys, belts, connecting rods, etc.)
- **Operating Controls (Other Moving Parts):** Are all of the parts on a machine that move while the machine is operating. (i.e. - Reciprocating, rotating, etc.)

****Note:** Even though machines have these three basic components, this does not mean that every machine has the same machine guarding.

There are 4 types of hazardous motions that are associated with machines:

1. **Rotating Motion** is a circular motion that is generated from a variety of mechanisms on machines. Rotating parts on a machine can 'grab' an employee through minor contact which can force the hand, arm, or any other body part into a dangerous position. The danger increases when projections such as set screws, bolts, nicks, abrasions, and projecting keys are exposed on rotating parts. The danger also increases if loose clothing is being worn or if an employee has long hair. Collars, couplings, cams, clutches, flywheels, shaft ends, spindles, meshing gears, and horizontal or vertical shafting are some examples of common rotating mechanisms which may be hazardous.
2. **Reciprocating Motions** is a back-and-forth or up and-down motion that can strike or pin an employee between a moving part and a fixed object.

3. **Transverse motion:** This refers to movement in a straight and continuous line. This type of motion creates a hazard because a worker may be struck or caught in a pinch or shear point by the moving part. An excellent example of a transverse motion would be a conveyor belt or belt sander.
4. **In-Running Nip Points:** Pinch points develop when two parts move together and at least one moves in a circular motion. In-running nip points occur when machine parts move toward each other or when one part moves past a stationary object. (ex. Gears, rollers, belt drives, and pulleys)

The 4 types of hazardous actions that are associated with machines are:

1. **Cutting Action:** May involve rotating, reciprocating, or transverse motion. The danger of cutting action exists at the point of operation where finger, arm, and body injuries can occur, and where flying chips or scrap material can strike the head, face, and eyes. Hazards are present at the point of operation when cutting wood, metal, or other materials. Several examples of mechanisms involving cutting hazards include band saws, circular saws, boring and drilling machines, turning machines (lathes), and milling machines.
2. **Punching Action:** Results when power is applied to a slide (ram) for the purpose of blanking, drawing, or stamping metal or other types of materials. The danger of this type of action occurs at the point of operation where stock is inserted, held, and withdrawn by the employee. Examples of machines used for punching operations are power presses and iron workers.
3. **Shearing:** Action happens when power is applied to a slide or knife that is used to trim or shear metal or other materials. The hazard occurs at the point where the employee inserts, holds, or withdraws the stock by hand. Examples of machines used for shearing operations are mechanically, hydraulically, or pneumatically powered shears.
4. **Bending Action:** occurs when power is applied to a slide in order to draw, turn, or stamp metal or other materials into a specified shape. A hazard occurs at the point of operation where stock is inserted, held, and withdrawn. Equipment that uses bending action includes power presses, press brakes, and tube benders.

Guarding should:

- Protect the operator and other employees in the machine area from hazards such as those created by the point of operation, ingoing nip points, rotating parts, flying chips, and sparks.
- Be attached to the machine or secured elsewhere if attachment is not possible.
- Not pose an accident hazard in itself.
- Conform to applicable government and industry standards. In the absence of such standards, it must be designed and constructed to prevent the operator and other employees from having any body part in the danger zone during the machine's operating cycle.
- Be secured by means not easily removed.
- Facilitate machine inspection as practical
- Permit maximum visibility of the point of operation
- Allow for safe lubrication
- Protect from falling objects. The guard must ensure that no objects fall on moving parts.

Below is a table illustrating the OSHA Maximum Permissible Openings for Guards:

Distance of Opening from Point of Operation (inches)	Maximum Width of Openings (inches)
1/2 to 1 1/2	1/4
1 1/2 to 2 1/2	3/8
2 1/2 to 3 1/2	1/2
3 1/2 to 5 1/2	5/8
5 1/2 to 6 1/2	3/4
6 1/2 to 7 1/2	7/8
7 1/2 to 12 1/2	1 1/4
12 1/2 to 15 1/2	1 1/2
15 1/2 to 17 1/2	1 7/8
17 1/2 to 31 1/2	2 1/8
Over 31 1/2	6

General machine guarding policies are as follows:

- A guard shall be attached to each machine, if possible, and be designed so it does not offer an accident hazard.
- A guard device shall prevent the operator from having any part of the body from contacting the moving parts of machinery or equipment during the operating cycle.
- Special hand tools provide supplemental protection for employees when placing and removing material. They permit easy handling of materials and eliminate the need for operators to place a hand in the danger zone. Such tools do not replace guarding.
- All revolving drums, barrels and containers shall be guarded by an enclosure that is interlocked with the drive mechanism.
- All revolving shafts, wheels, pulleys and other revolving parts shall be guarded to prevent an employee from coming in contact with the moving part.
- If the periphery of blades of a fan is less than seven feet above the floor or working level, the blades shall be guarded. The guard shall have openings that are no larger than 1/2 inch.
- Machines designed for a fixed location shall be securely anchored to prevent walking, moving, and tipping.
- All MPTE and MH shall be adequately guarded to prevent accidental contact.
- Guards provided by the factory shall be used where possible.
- Where guards are not available from the equipment manufacturer, they shall be fashioned with material of suitable strength, durability and in accordance with ANSI standards
- Guarding may be omitted where MH and MPTE hazards are not accessible.
- Loose clothing or jewelry should not be worn, because the material may become entangled or caught in the machine.
- Power transmission equipment whose location is not readily apparent, but could be accessed by any part of the human body shall be guarded.
- Where it is infeasible to guard an MH or MPTE conspicuously displayed signs shall be posted.

Inspection:

Employees who are assigned to machine operations or maintenance shall inspect machines before working

with them.

Machinery Maintenance and Repair

A preventative maintenance program shall be implemented to maintain the reliability of the machines and their guards. The manufacturer should be consulted to develop to frequency and method of preventative maintenance.

- Machine design should permit lubrication and adjustment without removal of guards. If machine guards must be removed, the maintenance and repair crew must always replace them prior to re-energization.
- Maintenance work shall not be performed until the machine is disconnected and locked out, consistent with UT's Lockout/Tagout policy and OSHA regulatory requirements.
- All woodworking machines will be maintained in good condition. This includes replacing dull blades, cutting heads, and damaged or unserviceable parts.
- Equipment blade changes or adjustments will be performed only when the power source has been disconnected to comply with the lockout/tagout standard.
- Equipment in which guards cannot be installed shall be removed from service. This includes older equipment which never had factory-installed guards.
- All bearings will be lubricated and any debris removed from their surface to prevent fires.
- All adjustments will be made by an employee who is trained and knowledgeable about the particular piece of equipment being adjusted.
- Power-transmission apparatus (shafting, flywheels, pulleys, belts, chain drives, etc.) less than 7 feet from the floor or working platform must be guarded.
- For grinders, work rests on offhand grinding machines must be kept adjusted closely to the wheel with a maximum opening of 1/8-inch to prevent the work from being jammed between the wheel and the rest, which may result in wheel breakage. The distance between the wheel periphery and the adjustable tongue must never exceed 1/4-inch. Immediately before mounting, all wheels shall be closely inspected and sounded by the user (ring test) to make sure they have not been damaged in transit, storage, or otherwise. The spindle speed of the machine shall be checked before mounting of the wheel to be certain that it does not exceed the maximum operating speed marked on the wheel. Wheels should be tapped gently with a light nonmetallic implement, such as the handle of a screwdriver for light wheels, or a wooden mallet for heavier wheels. If they sound cracked (dead), they shall not be used. This is known as the "Ring Test".

Good Housekeeping is important to minimize injuries when performing maintenance work on machines and when using machines.

- Remove slip, trip and fall hazards from areas around machines
- Use drip pans when oiling equipment
- Remove waste material as it is generated
- Make work area large enough for machine operation and maintenance
- Place machines away from high traffic areas to reduce worker distraction

Training

Training will be required on the proper use of guards before employees and students are allowed to use equipment. The supervisor should maintain a list of all employees and students authorized to use the specific machine.

Training should include the following elements:

- Ensure understanding of: proper operation, safety procedures, hazard recognition and emergency shutdown procedures for each machine they are assigned to operate.
- Identify multiple energy sources and explain machine-specific lockout and tagout procedures to all personnel assigned to work on the machine.
- Identify personal protective equipment required and demonstrate how to properly wear the PPE

Recordkeeping

Training records and self-inspection checklists should be documented will be maintained by the supervisor or Principal Investigator. EHS will maintain inspection records of areas on campus where machines are inspected.

References

ANSI - various

OSHA 29 CFR 1910 (General Industry) – Various sections OSHA 29 CFR 1926 (Construction) –Various sections

OSHA Machine Guarding Standard – 29 CFR 1910.212

OSHA 1910.213 (Woodworking Machinery Requirements)

OSHA 1910.215 (Abrasive Wheel Machinery)

OSHA 1910.217 (Mechanical Power Presses)

OSHA 1910.217 App. A – D (Non-mandatory and Mandatory Guidelines for Various Machines/Safeguards.)

OSHA 1910.218 (Forging Machines)

OSHA 1910.219 (Mechanical Power Transmission Apparatus)

UT's Lockout/Tagout Policy

Appendices

Appendix A: Self-Inspection Checklist

Disclaimer

The information provided in these guidelines is designed for educational use only and is not a substitute for specific training or experience.

The University of Tennessee Knoxville and the authors of these guidelines assume no liability for any individual's use of or reliance upon any material contained or referenced herein. The material contained in these guidelines may not be the most current.

This material may be freely distributed for nonprofit educational use. However, if included in publications, written or electronic, attributions must be made to the author. Commercial use of this material is prohibited without express written permission from the author.

Appendix A

OSHA Self-Checklist for Inspecting Machine Guards

Requirements for All Safeguards	Yes or No. If No, explain how issue can be resolved
Do the safeguards provided meet the minimum OSHA requirements?	
Do the safeguards prevent workers' hands, arms, and other body parts from making contact with dangerous moving parts?	
Are the safeguards firmly secured and not easily removable?	
Do the safeguards ensure that no objects will fall into the moving parts?	
Do the safeguards permit safe, comfortable, and relatively easy operation of the machine?	
Can the machine be oiled without removing the safeguard?	
Is there a system for shutting down the machinery and locking/tagging out before safeguards are removed?	
Is there a system for shutting down the machinery and locking/tagging out before safeguards are removed?	
Mechanical Hazards: The Point of Operation	Yes or No. If No, explain how issue can be resolved
Is there a point-of-operation safeguard provided for the machine?	
Does it keep the operator's hands, fingers, body out of the danger area?	
Is there evidence that the safeguards have been tampered with or removed?	
Could changes be made on the machine to eliminate the point-of-operation hazard entirely?	
Mechanical Hazards: Power Transmission Apparatus	Yes or No. If No, explain how issue can be resolved
Are there any unguarded gears, sprockets, pulleys, or flywheels on the apparatus?	
Are there any exposed belts or chain drives?	
Are there any exposed set screws, key ways, collars, etc.?	
Are starting and stopping controls within easy reach of the operator?	
If there is more than one operator, are separate controls provided?	

Mechanical Hazards: Other Moving Parts:	Yes or No. If No, explain how issue can be resolved
Are safeguards provided for all hazardous moving parts of the machine, including auxiliary parts?	
Non-Mechanical Hazards:	Yes or No. If No, explain how issue can be resolved
Have appropriate measures been taken to safeguard workers against noise hazards?	
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	Yes or No. If No, explain how issue can be resolved
Is the machine installed in accordance with National Fire Protection Association and National Electrical Code requirements?	
Are there loose conduit fittings?	
Is the machine properly grounded?	
Is the power supply correctly fused and protected?	
Do workers occasionally receive minor shocks while operating any of the machines?	