Rowan University

ENVIRONMENTAL HEALTH & SAFETY

Rowan University Machine Guarding Policy for Research & Academic Operations

October 5, 2022

Contents

Rowan University Machine Guarding Policy for Academic & Research Operations

Section 1: Purpose

The Rowan University Machine Guarding Policy for Academic & Research Operations is intended to be a comprehensive machine safety policy. This policy covers machinery operated within academic and research machine shops including but not limited to the sciences, arts, and engineering departments. This policy addresses key aspects of machinery safety including training requirements, engineering controls, administrative controls, personal protective equipment, guarding requirements, and risk assessments. Machinery in use in Rowan University academic and research laboratories must comply at a minimum, with all applicable Occupational Safety and Health Administration (OSHA) Regulations.

Section 2: Policy

2.1 Responsibilities:

Academic Departments are responsible for:

- Ensuring that all machines are equipped with proper safeguards.
- Maintaining machinery and all installed safeguards.
- Inspecting machinery on an annual basis for wear and guarding deficiencies.
- Supplying all necessary PPE.

Principal Investigators, Technicians, and Staff* are responsible for the following:

- Ensuring that machines are not operated with guards removed, malfunctioning, or defeated.
- Providing hands on training to machine operators under their supervision.
- Maintaining records of student training for machine operation.
- Creating written Standard Operating Procedures (SOP) for each machine they are responsible for.
- Ensuring that machine operators follow all applicable procedures for proper machine operation.

Machine Operators are responsible for:

- Inspecting machinery for adequate guarding and proper function prior to operating.
- Reading and following all manufacturer instructions.
- Following and accepting (through a formal signoff) all machine SOPs.
- Always using all safeguards installed on a machine as intended.
- Alerting the machine owner of any identified deficiencies with a machine so that proper repairs can be made.
- Stopping work when a machine is potentially malfunctioning or suspected of being unsafe.

Laboratory Safety is responsible for:

- Assisting machine operators with meeting the requirements of this policy.
- Evaluation of machinery for compliance with OSHA and applicable Industry Standards.
- Assisting in the identification of prospective machine guarding options and contractors.
- Evaluating and assisting in the selection of appropriate PPE.
- Conducting periodic machine guarding safety inspections in academic and research laboratories.

***** Departments may hire experienced and competent student workers to fulfil certain roles identified in this policy.

2.2 Training Requirements

Safety training is an integral component of a comprehensive machine safety program. All users of shop machinery must complete basic machine safety training prior to beginning any work around or with machinery. Completion of safety training must be documented in writing and accompanied by the instructor and machine operator's signature. Records of training must be retained for the duration of a machine operator's enrollment in a program. Training records must be made available by uploading them to the Documents section of BioRAFT. Basic machine safety training must include the following topics:

- Proper selection, use, and care of Personal Protective Equipment (PPE)
- General shop safety (appropriate attire, behavior, housekeeping, etc.)
- Guard use and proper adjustment
- Machine hazard awareness
- Hand tool safety

Refresher training for machine operators is to be administered when, through observations made by a competent PI, Faculty, or Staff member, actions indicate unreasonable risk. Refresher training is mandatory when a machine operator is unable to demonstrate competency in the operation of a machine, when a near-miss occurs, or if any incident occurs.

To be qualified to work in specific research labs, specialized machine training will be required based on the types of machinery present. All machine operators are to receive additional safety and operator training to be qualified to operate specific High-Power machines. See **Appendix A** for a list of some common High-Power machines. Comprehension of additional training must be verified through the successful completion of a written or electronic test/quiz. High Power machine refresher training is required to be taken on an annual basis.

2.3 Standard Operating Procedures

Standard Operating Procedures (SOPs) must be written for all machinery used in academic and research laboratories. Written SOPs ensure that machine operators have readily available documentation to reference which outlines each step of the task(s) they will perform. One SOP is permissible to cover instances where multiple, functionally identical machines, are used in the same location (i.e., One SOP to cover multiple functionally equivalent benchtop drill presses in a single laboratory space). Individual SOPs are necessary where groups of machines differ substantially from one another in ways including but not limited to:

- Operating controls are unique and different from other equivalent machines.
- Safeguarding systems are unique and different from other equivalent machines.
- Machine has been modified or has non-standard features.
- Machine is used in a non-conventional manner or for a purpose not intended by the manufacturer.

Machine SOPs must include details on all tasks* which an operator would be expected to perform. See **Appendix H** for an outline of the basic information that is required on machinery SOPs.

All SOPs for machinery use are to be reviewed at least annually. Updates to written SOPs must be made when any changes to the scope of operation occur. Students must sign off on the SOPs for the machines they will operate to acknowledge that they have read and understand the document. All SOPs and acknowledgement signature records are to be uploaded to BioRAFT so that they are readily accessible.

* **Note:** Standard Operating Procedures do not typically need to go into specific details regarding how a piece of stock will be worked to achieve specific dimensions. As an example, an SOP for a CNC milling machine should be able to address all key elements of operation that an operator would need to perform. The SOP should explain how to load a program, but not how to write the program, or what the finished part will be. Laboratory Safety is available to answer questions and provide assistance regarding what topics should be covered in SOPs.

2.4 Academic Machine Safeguarding Safety Inspections

Rowan University Laboratory Safety will conduct periodic safety inspections of academic and research machine shops on campus. Laboratory Safety will also perform follow up inspections to ensure that any necessary remediation work identified in previous inspections is completed. All inspections of machinery will be performed in BioRAFT using the Machine Guarding Inspection question set. The inspection will consist of a physical review of the shop space and the equipment contained within, to ensure that it follows the requirements of this Policy. Machine Safety Inspections will include verification of written SOPs, signage, machine guarding, machine condition, personal protective equipment use, and general housekeeping. Training records for professional staff and students will also be reviewed, along with the room and tool access policies. Any academic machinery findings, comments, or suggestions will be recorded and submitted to the responsible individual(s) through BioRAFT for review and corrective action.

2.5 General Machine Hazards

Machinery offer a wide range of potential sources of hazardous energy which may result in serious injury or death. Hazardous energy can come from a variety of sources. **Appendix E** provides illustrations and examples of common hazardous machine motions and actions.

Certain common operations performed on machines are particularly hazardous to machine operators. These operations can include but are not limited to lubrication, maintenance, adjustments, inspections, clearing jams or debris, cleaning, and machine setup. These tasks often require an individual to place hands or other body parts within proximity to dangerous machine parts. It is important that workers maintain their focus on the task being performed and follow approved SOPs to prevent dangerous situations from occurring. Workers must also strictly follow the appropriate Lockout/Tagout procedures to ensure that the machine is inoperable prior to commencing any of these types of tasks. See the Rowan University Academic & Research Lockout/Tagout Policy for further information on applicable Lockout/Tagout requirements.

Loose fitting clothing and jewelry must not be worn while operating machinery due to the risk of entanglement. Long hair as well as long beards must be securely tied back to prevent entanglement in moving machine parts. Hair, clothing, and jewelry can become caught in rotating components and pull a person in before they have a chance to react. Incidents such as these often result in serious injuries and in some cases fatalities.

Being distracted or impaired in any way while operating machinery significantly increases the chances of an injury occurring. When working with machinery, it is critical that all attention is focused on the work being performed. Talking with someone in the room, listening to music, or using a cell phone is a distraction that can cause an operator to lose focus on the work task being performed. Distractions can result in ruined work pieces, damaged machines, personal injury, and death. It is critical that individuals who are fatigued, ill, or impaired by a drug or other substance do not perform work with machinery until after they have recovered. At no time may anyone under the influence of alcohol or drugs be admitted to spaces containing machinery. PI's, Faculty, and Staff overseeing machine operation are ultimately responsible for promptly dismissing any student found to be impaired or in any state that places themselves or others at risk.

2.6 General University Machine Guarding Requirements

Machine guarding is the process of identifying hazards and applying risk reduction methodology to mitigate those hazards. All machines are comprised of 3 basic functional areas. These functional areas include the Point of Operation, the Mechanical Power Transmission system, and the Operating Controls. Guards installed on machinery must never be bypassed, disabled, or removed during operation. All guarding devices must remain in place unless a machine is fully locked out/tagged out for service or repair. Bypassing of guarding devices is only permitted under very specific limited circumstances, and only after a very thoroughly documented review process has occurred.

In New Jersey, workplace safety is overseen and enforced by Public Employees Occupational Safety and Health (PEOSH). All Federal OSHA Machinery and Machine Guarding regulations are applicable under PEOSH. Under the Public Employees Occupational Safety and Health Act, employers shall:

a. Provide each of his employees with employment and a place of employment which are free from recognized hazards which may cause serious injury, physical harm, or death to his employees; and
b. Comply with occupational safety and health standards promulgated under this act.

Per N.J.S.A. 34:6A-30 Adoption of Standards, all applicable occupational health and safety standards, amendments, or changes under the authority of the Occupational Safety and Health Act of 1970 shall be adopted. Per New Jersey Administrative Code N.J.A.C 12:100-4.2, the standards contained in 29 CFR Part 1910, OSHA's General Industry Standards are incorporated by reference. OSHA mandates in Title 29 CFR 1910.212 that one or more methods of machine guarding be implemented in

order to protect a machine operator and other workers in the general area from hazards associated with the point of operation, ingoing nip points, rotating parts, flying chips, and sparks. Any element of machine operation that has the potential to cause injury must be guarded. The following requirements apply to all machines:

1. Guards shall be affixed to the machine wherever possible or secured elsewhere if attachment to the machine is not possible. The guard shall not create an accident hazard in itself.
2. Point of operation guarding: The point of operation is the area of the machine where work is being performed. A point of operation on a machine which exposes personnel to a risk for injury shall be guarded.
3. Barrels, containers, and drums: Revolving barrels, containers, and/or drums shall be guarded by an interlocked enclosure which prevents machine operation if the enclosure is not in place.
4. Exposure of blades: When the periphery of fan blades is less than 7 feet above the floor or working level, the blades shall be guarded with openings not larger than ½ inch.
5. Anchoring fixed machinery: Machines designed for a fixed location shall be securely anchored in place to prevent walking or moving.

There are no existing regulatory requirements stating that machines are to be supplied from the manufacturer in full compliance with all applicable regulations and standards. It is common to think that only older machinery is afflicted by a lack of proper guarding, and that newly purchased machines are in full compliance. While some manufacturers do provide some degree of guarding, it is the full responsibility of the purchaser/operator to supply all necessary guards, safeguarding devices, and/or awareness devices. One of the main reasons for variations in manufacturer supplied guarding is because there are often multiple operational uses for a given piece of machinery. One type of guarding may work well for one type of process, but not as well in another. Therefore, the purchaser/operator of the machine is left with the responsibility of determining what type of guard will work best for the work being performed.

New machinery must be evaluated for compliance with safeguarding regulations prior to initial operation. Laboratory Safety should be consulted prior to the purchase of new machinery whenever feasible to assess potential guarding needs ahead of delivery. Early Laboratory Safety involvement in the machine purchasing process will help to ensure that proper safety considerations are made in advance, and that potential operational delays are avoided. The machine's manufacturer should be consulted to see whether they offer or recommend a guarding solution for a particular piece of machinery. Machine manufacturer designed guards often provide effective protection while retaining machine functionality more so than would be possible with generic machine guards. Machine guards may also be purchased through industrial supply companies or fabricated by safeguarding design firms. If determined necessary, Laboratory Safety will assist the machine owner in identifying a machine guarding firm they can hire to create the necessary guarding for the application. Machine owners are strongly encouraged to contact Laboratory Safety for assistance prior to purchasing or installing any guarding devices.

OSHA machine guarding regulations are published in Title 29 CFR Part 1910 Occupational Safety and Health Standards. Subpart A provides basic information on Part 1910 as well as the incorporation of Consensus Standards and Best Practices into the Federal Regulations. Subpart O contains specific regulatory information pertaining to machine guarding. The machine guarding regulations established by OSHA are the bare minimum requirements for compliance. OSHA incorporates by reference or through the "General Duty Clause" many industry Consensus Standards. Consensus Standards frequently cited by OSHA include those created by ANSI, NFPA, and ISO. Consensus Standards go beyond the requirements set forth by OSHA and include many machine specific safety requirements that have been adopted by industry. Because they are often more stringent and provide more protection for machine operators, OSHA will frequently utilize Consensus Standards in writing citations during facility inspections and incident investigations.

2.7 Types of Machine Guards

There are several different forms of machine guards commonly utilized to protect operators from hazards. Each type of guard is designed and installed on a machine to allow normal operation while affording hazard protection to the operator.

1. **Fixed Guards:** Fixed guards are the most common form of guarding and involve a guard that is directly attached to a machine so that the operator is shielded from the hazard. Fixed guards must be fastened in place and require tools for removal. Fixed guards are normally utilized to protect against areas of a machine that do not require frequent access. These areas can include drive shafts, belts, gears, rollers, and other mechanical power transmission components.
2. **Adjustable Guards:** Adjustable guards are devices which must be positioned by the operator of a machine to properly protect against hazards. Adjustable guards are most frequently installed at the point of operation where an operator frequently needs direct access to a machine component for normal operation. Adjustable guards may also be interlocked with a machine's controls so that they must be in the proper position for a machine to operate. If at any time during operation an interlocked guard is moved, the machine must come to an emergency stop until the guard is repositioned. If an adjustable guard is not interlocked, strong administrative controls and training must be in place so that a machine operator understands the function of the guard and the need for it to be in position during machine operation.
3. **Self-Adjusting Guards:** Self-adjusting guards are a form of guard which automatically adapts to the size of the stock being fed into a machine. They are generally designed to protect the operator from the point of operation. When the machine is not in use, these guards rest all the way down covering the blade or other hazard. When in use, they open just enough to allow the operator to feed stock into the machine.
4. **Presence Sensing Devices:** Presence sensing devices such as light curtains and beams are another form of guarding that is utilized on machinery where direct access to potentially hazardous components is necessary during the operating cycle, or when fixed or moveable guards are not practical to install. These safety systems are wired directly into the machine

controls much like an interlock device. When the path of an optical beam is disrupted by an object, the machine will not be permitted to start or if already operating will trigger an emergency stop.

Considerations must be made for machinery in the event of a loss of power while in operation. Per 29 CFR 1910.213(b)(3), where injury might result if a machine were to unexpectedly restart after a loss of power, provisions shall be made to prevent automatic machine restart after power is restored. An anti-restart device prevents a machine from restarting automatically after a loss of power. To re-start a machine after a power loss, the controls must physically be cycled off before a start cycle can be initiated. This measure ensures that the operation of a machine is under the control of an operator regardless of whether power is supplied.

2.8 Lockout/Tagout of Machinery (LOTO)

All personnel who service, repair, maintain, adjust, clean, or un-jam components of machinery or equipment must follow the Rowan University Academic & Research Laboratory Lockout/Tagout Policy. LOTO procedures must always be used to ensure that machinery, equipment, or processes are isolated from hazardous energy sources prior to any work that could potentially expose an individual to harm. LOTO procedures apply to all forms of hazardous energy, including (but not limited to) electrical, pneumatic, hydraulic, mechanical, spring-actuated, gravity-fed, and electromagnetic energy, including light, radiofrequency, microwave, x-ray, and ionizing radiation.
The LOTO policy does not apply to machinery or equipment meeting the following condition:
Work performed on plug-connected equipment where:

a. Exposure to the hazardous energy or start-up of the equipment is controlled by unplugging the equipment from the energy source, **and**;
b. The plug is under the exclusive control of the individual performing the service or maintenance.

OSHA and ANSI state that LOTO should be the default method for controlling hazardous energy unless it can be demonstrated that a well-established alternative method will provide effective protection for personnel. Certain machines and machine tasks may require frequent access to operating areas possessing potential hazardous energy. These tasks can include making tool changes/adjustments, adjusting work pieces, clearing debris, etc. Alternative methods to standard LOTO measures may be utilized provided that they demonstrate an equal to or greater level of protection as LOTO. If alternative methods are to be used, they must be well documented and included in the Standard Operating Procedure for the machine or equipment. Additionally, Laboratory Safety must approve of all alternative LOTO methods prior to their implementation. Alternative methods to LOTO will not be authorized where convenience is determined to be the reason for their implementation.

2.9 Personal Protective Equipment

Personal protective equipment (PPE) is always the last line of defense against machine hazards. PPE must never be utilized as a substitute for proper machine guarding. PPE must always compliment properly engineered and implemented guarding systems. Eye and hearing protection are the most common forms required PPE when operating most types of machinery. Care must always be taken when selecting PPE to be worn while operating a machine. Certain forms of PPE may create additional hazards such as the risk of becoming caught in a machine. PPE use will be evaluated as part of a hazard assessment performed by the PI, or Staff member that owns the machine. Factors must be considered which will ensure that the machine operator is able to maintain safe control over a machine at all times. Refer to the Rowan University Personal Protective Equipment Policy for additional information on performing PPE Hazard Assessments and general PPE requirements.

2.10 Laboratory Machine Hazard Categories

Appendix A is a table of laboratory machine hazard categories ranked on a scale of 1 to 5. Level 1 represents machines with the lowest operator risk, while level 5 represents machines posing the greatest operator risk. The classification system identifies common machine types within each hazard category, and identifies general training requirements, access limitations, and operator supervision requirements. The hazard level of any laboratory is set by the highest risk piece of machinery contained within that laboratory. The table in Appendix A is not intended to be an all-encompassing representation of hazardous machines found in the laboratory. Therefore, it is up to individual laboratory PI's and Staff to impose more stringent safety requirements as dictated by the hazards within a particular laboratory.

2.11 Access to Machinery in Academic & Research Laboratories

Each academic and research space where student operated machinery is located must develop an access control policy. This policy will identify the measures that will be in place to ensure that only authorized students have access to the machinery. Access to academic and research laboratories containing machinery must be controlled based on the requirements of the Machine Hazard Class (**Appendix A**). Access control methods for individual rooms can include using a keyed door lock, pin code lock, card reader, or other secure means. Access to classrooms or laboratories containing machinery should be restricted so that only personnel authorized to utilize the machinery can enter those spaces. If this is not feasible (such as with mixed use/shared spaces), measures must be implemented to prevent unauthorized machine operation. Access control measures for mixed use/shared spaces can include but are not limited to:

- Storing power tools in locked storage cabinets when not in use.
- Placing locking electrical plug covers on stationary machinery.
- Installing lockable electrical disconnect switches on circuits feeding stationary machinery.

Doors to areas containing machinery must not be propped open or otherwise left unsecured for any reason. Certain high hazard potential machines (such as those in Hazard Class 4), may require that access control devices be installed on each individual machine if access to the space in which they are located cannot be restricted per the requirements of this policy.

All students intending to operate machinery in academic and research spaces must do so under the supervision requirements based on the Machine Hazard Class of the equipment in each space. The Buddy System as defined in **Appendix B** must be utilized by all students working in a machine shop or laboratory space where faculty or staff are not actively present to provide supervision. Buddies must be equally knowledgeable about the safe operation of the equipment in use and authorized to operate that machinery. The buddy system must be followed to ensure that someone is present in the event of an emergency in the work area. Hazard Class 4 machinery require a faculty or staff member from the responsible department be present in the building to assist with machine operations if needed. PI's, Faculty, and Staff owning the machinery are accountable for all work activities performed at all times of day.

Academic and Research spaces containing Hazard Class 1 tools/machinery may be open for work by approved students at any time if they follow the supervision requirements, and that access is approved by the responsible department. It is recommended that Hazard Class 2 or above tools/machinery not be accessible to authorized students outside of normal campus operating hours. However, individual departments can choose to allow work outside of normal campus hours if they can ensure that the supervision requirements for the equipment in use can be met. Workspaces containing mixed Hazard Class tools/machinery that are open 24 hours must have a system in place which disables Hazard Class 4 tools/equipment unless the individual department grants permission for operation to authorized students and appropriate supervision requirements can be met after hours.

2.12 Inspection and Maintenance of Machine Guarding

Machinery and the guarding systems installed on them require regular inspection and maintenance to ensure continued safe operation. Regular inspections fulfill two key objectives in maintaining machine safety. First, inspections performed at regular intervals can identify excessive wear and out of adjustment components before they have a chance to fail during use. Second, inspections can identify issues with functionality and guarding compliance by operators. By proactively addressing inspection findings, machines will be maintained in proper working order and issues with guarding can be resolved.

PI's, Technicians, and Staff * are responsible for ensuring that all components of the machinery within their department are always maintained in proper working order. Laboratories and machine shops must develop a machinery inspection program. Inspections must be performed on a regular basis at a frequency that is determined by the level of machine use. At a minimum, PI's, Technicians, or Staff are to perform an inspection of each machine in a laboratory or machine shop once per month. A basic machine safety inspection checklist is found in **Appendix F**. If a problem

with a machine is identified during an inspection or reported by an operator, that machine must be immediately removed from service until repairs can be made.

* Departments may hire student workers provided they have the training and experience required to competently perform these tasks.

Section 3: Machine Risk Assessments and Guarding

3.1 Machine Risk Assessments

Machinery owned by Rowan University in academic and research departments must undergo machine guarding risk assessments to evaluate the hazards posed by the operation of the machine. These assessments will evaluate the level of unmitigated risk to the operator and make recommendations on corrective actions to take to decrease risk. Risk assessments must be performed initially for all machines, at the time a new machine is purchased, and when significant changes are made to the way a machine is operated. Risk assessments must be documented, with records retained until that machine is disposed of, sold, or otherwise permanently removed from service. Corrective actions will include the implementation or selection of engineering controls, awareness devices, administrative controls, and personal protective equipment.

Because of the amount of technical knowledge and resources necessary for conducting risk assessments, it is strongly recommended that machine owners seek the expertise of a company specializing in the field of machine safety. Such companies can provide complete safeguarding solutions that include conducting the risk assessments, developing guarding systems, installation of guarding systems, and documenting all methodology utilized. Conducting risk assessments is a process requiring multiple steps to properly complete. It can be both time and labor intensive to properly complete machine risk assessments.

In the United States, the preferred method for conducting machine guarding risk assessments is detailed in ANSI B11.0 *Safety of Machinery*. The objective of this standard is to eliminate injuries from machinery by establishing requirements for the design, construction, modification, installation, operation, and maintenance of machinery. **Appendix C** contains a flowchart from ANSI B11.0 outlining the following steps of the assessment process:

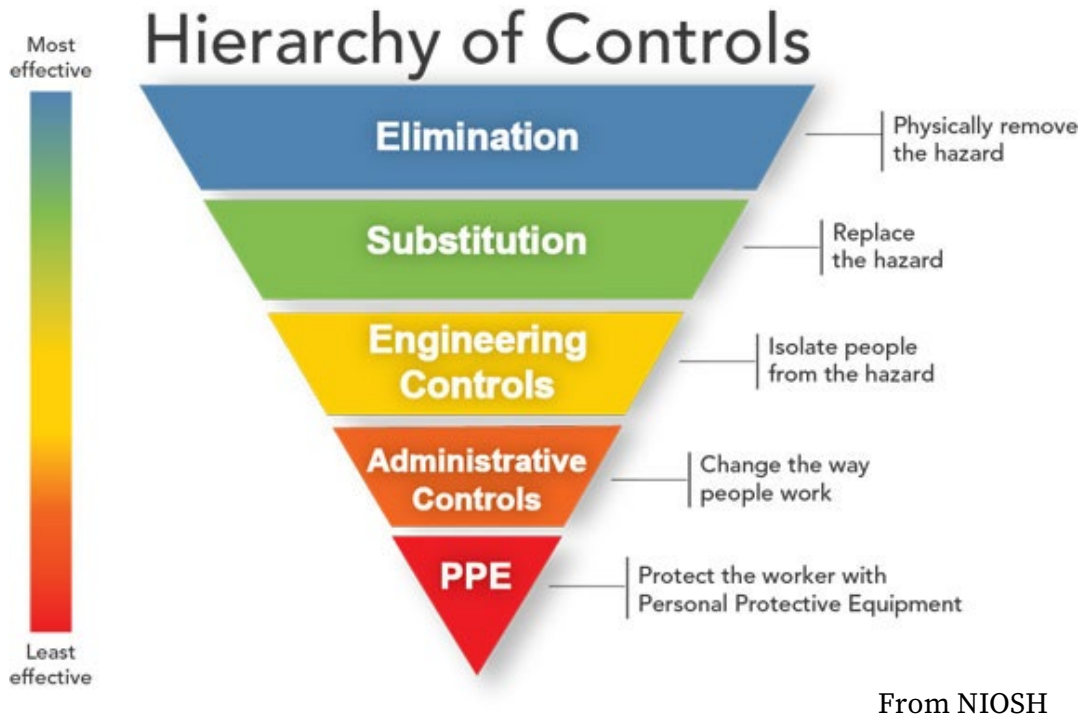
1. The first step in conducting a risk assessment is to prepare for and establish the scope of the assessment. A team of affected personnel including machine operators, maintenance personnel, and EHS professionals should be identified and assembled for the assessment.

2. Information gathering is the next step in the risk assessment process. Relevant information pertaining to the machine type, how it is utilized, the frequency of use, previous near-misses or incidents, etc. needs to be collected. All foreseeable tasks and their associated hazards for a given machine need to be identified and recorded. Affected personnel who operate or interact with the machine need to be identified. It is highly important to get the involvement of personnel who are routinely involved in the operation of a machine. Without their input and

approval, the implementation of effective guarding solutions is likely to be very difficult to accomplish. This is because guarding solutions need to be developed with the specific operation of the machine in mind. A guard that gets in the way of operation or decreases productivity is very likely to eventually be bypassed, disabled, or removed.

3. The third step in the process is to determine the initial level of risk involved in the operation of a machine. The level of risk involved is determined based on an evaluation of the task(s) and the associated hazards identified during machine operation. The actual level of risk is then calculated, and takes into account the existing safeguarding measures in place (if any). If it is determined that the risk is already at a reasonable level, no further action is required to address that particular hazard.

4. In the fourth step of the risk assessment process, safeguarding measures are evaluated and implemented which will decrease the level of risk posed by machine operation. The hierarchy of controls applies directly to the practice of machine guarding. See **Appendix D** for a detailed overview of the Hierarchy of Controls.



From NIOSH

All guards must be installed to the specifications called for by the applicable regulations and/or standards. It is important to have guarding devices installed by qualified individuals who are familiar with machine guarding requirements. This ensures that not only are the correct safeguards selected, they are installed on the machine in a manner which is conducive to their proper use.

5. After control measures have been installed or implemented, the next step in the process is to conduct a follow-up risk assessment in order to determine residual risk. The machine is re-evaluated with the newly implemented safeguards in operation. The new level of risk is then compared to the initial level of risk. The risk level of the machine in this step should be significantly lower than the previously calculated risk level that was determined before the new safeguarding was implemented.

6. The sixth step in the risk assessment process is to make a decision to accept the existing amount of residual risk or to take further steps to reduce it. While achieving zero risk is typically not possible in all situations, the goal is to reduce the level of risk as much as is feasible. If the level of risk is determined to be acceptable at this point, no further guarding measures need to be installed on the machine. The decision to accept a risk is influenced by multiple factors including the culture, technological and economic feasibility of installing additional risk reduction features, the degree of protection achieved through the use of additional risk reduction measures, and the regulatory requirements or industry best practices.

7. After all risk reduction measures have been implemented, their effectiveness needs to be evaluated. This step ensures that the guarding installed on the machine actually is functioning to mitigate the machine hazards. The validation process should include testing the operation of safety devices and electronics, reviewing training, checking for the presence of warning labels, and a review of overall machine operation.

8. The final step in the risk assessment process involves completing or updating all documentation associated with the guarding process. The safeguarding device(s) installed on the machine need to be evaluated for compliance with the applicable regulations and standards. Standard operating procedures (SOPs) and training materials need to be updated to reflect the addition of the safeguarding device(s) installed on the machine. After affected employees complete the required training reflecting the new safeguarding measures, an equipment sign-off should be completed to verify the changes and document the training. Records of the risk assessment need to be maintained until that machine is disposed of, sold, or otherwise permanently removed from operation by the University.

3.2 Selection and Installation of Guarding

Owners of machinery identified in a risk assessment as requiring safeguarding measures will receive advisory assistance from Laboratory Safety on potential solutions. The machine manufacturer should be consulted for assistance where feasible on how to properly select and install guards on their equipment. Laboratory Safety can help to identify the types of guarding that will be required for a machine. A competent person must install all safeguarding equipment on a machine. Care must be taken to ensure that the device being installed works as intended and does not create any unintentional hazards or operational issues. All guidance and instruction provided by the

manufacturer of a machine, or independent company used for the selection and installation of machine guarding must be documented. This information must be kept with the risk assessment documentation for that machine.

If a machine manufacturer cannot supply guarding devices or is no longer in business, machine owners must seek the expertise of a machine safeguarding company for compliant solutions. A listing of potential companies to work with for supplies and services can be found in **Appendix G**. Machine owners or departments who have multiple pieces of equipment, or highly specialized machinery in need of safeguarding should seek the services of a machine guarding professional for assistance. Machine safeguarding can quickly become a complex task, particularly when changes need to be made to machine controls and electronics. By going through a company specializing in machine guarding, the guarding solutions that are selected will be fully integrated with and compatible with the machinery. This also ensures that the machinery will be in full compliance with the applicable Regulations and Industry Standards. Owners of machinery are prohibited from selecting and installing safeguarding equipment on their own without consulting with Laboratory Safety or an outside machine guarding professional.

Appendices

Appendix A – Student Laboratory Machine Hazard Classification Table

Machine Hazard Class:	1	2	3	4
Machine/Tool Category:	Unpowered/Low Power Hand Tools	Corded/Cordless Power Tools	Light Duty Industrial Tools	High Power Industrial Tools
Common Machine Examples*:	• Palm Sander • $^{3}/_{8}$" Chuck Power Drill • Electric Screwdriver • Multitool • Soldering Iron • Heat Gun • Hot Glue Gun • 3D Printer	• $^{1}/_{2}$" Chuck Power Drill • Circular Saw • Handheld Belt Sander • Router • Miter Saw • Angle Grinder • Reciprocating Saw • Jig Saw	• Benchtop Band Saw • Benchtop Drill Press • Benchtop Milling Machine • Radial Arm Saw • ≥6" Bench Grinder • Belt/Disc Sander • Table Saw	• Milling Machine • Metal Lathe • Hydraulic Power Press • Band Saw • Power Shear • Welding equipment
User Training Requirements:	• Basic machine safety training. • Department specific training on lab policies/procedures.	• Basic machine safety training. • Department specific training on lab policies/procedures. • General power tool safety training.	• Basic machine safety training. • Department specific training on lab policies/procedures. • Individual equipment specific training.	• Basic machine safety training. • Department specific training on lab policies/procedures. • Individual equipment specific training.
Space Access Controls:	• Space access is restricted by key, PIN, or card reader.	• Space access is restricted by key, PIN, or card reader. • Tools in mixed use/shared spaces must be stored secured against unauthorized use.	• Space access is restricted by key, PIN, or card reader. • Tools in mixed use/shared spaces must be stored secured against unauthorized use.	• Space access is restricted by key, PIN, or card reader. • Individual machines require an access control system to prevent unauthorized users (unless space access can be fully controlled/restricted).
Machine Use Supervision:	• Solo work permissible for authorized students.	• At least one Buddy, Faculty, OR Staff must be present in the area for work to be performed.	• At least one Buddy, Faculty, OR Staff must be present in the area for work to be performed.	• At least one Buddy, Faculty, OR Staff must be present in the area for work to be performed. • Faculty/Staff must be physically present in building during use.

* This table is not all-inclusive. Contact Laboratory Safety at LabSafety@Rowan.edu or 856.256.5105 for information on any equipment, devices, or tools that are not found on this list, but are in use in your shop space.

Appendix B – Supervision of Operations & Access Control Summary

Supervision and Access Control requirements for tool and machine use are based on the Machine Hazard Class. The highest Hazard Class machine sets the supervision requirement of the work area in which it is located.

Definitions:

Buddy System	A Buddy is another individual who can respond and aid in an emergency. Buddies are two people working in the same area, provided that both are authorized to work in the space and have completed the required training for the machinery. A Buddy is expected to be within sight and hearing of the person performing work. A Buddy should be in the same room or space as the person performing the work. Note: A Buddy is typically another student, but a faculty or staff member may also serve in this role.
Faculty/Staff	Faculty/Staff hold positions which provide oversight and instruction to students in the operation of machinery. Faculty and Staff may include professors, technicians, and principal investigators who use the equipment to teach or perform research.

Supervision of Operations:

The following information provides guidance for determining the level of supervision required based on the Machine Hazard Class:

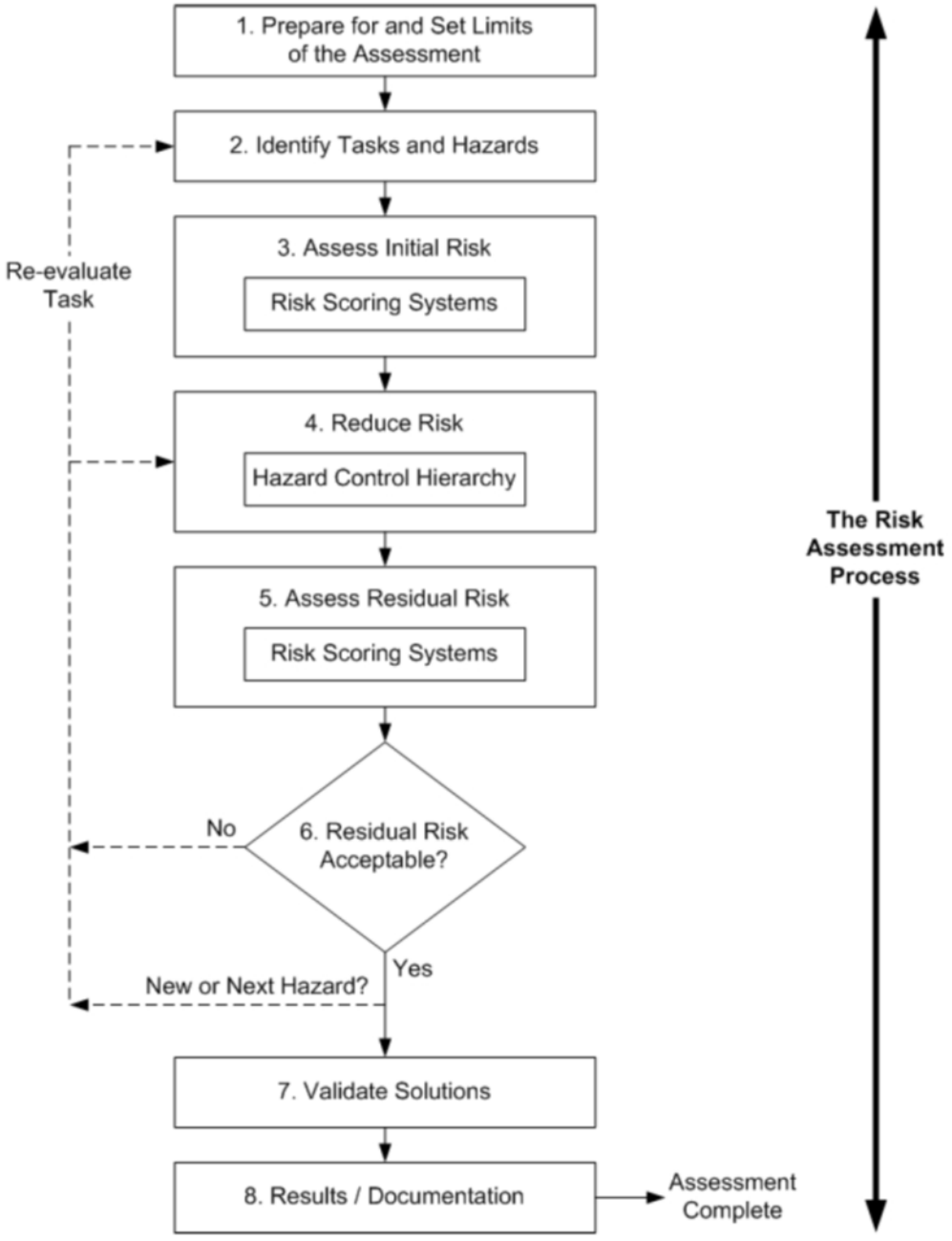
- **Hazard Class 1**: Supervision is not required, but students are encouraged not to work alone or outside of normal university operating hours.
- **Hazard Class 2**: The Buddy System is required to perform work. At least one person must be present in the work area to serve as a Buddy.
- **Hazard Class 3**: The Buddy System is required to perform work. At least one person must be present in the work area to serve as a Buddy. Both individuals must have received equipment specific training required for the applicable Hazard Class 3 machinery.
- **Hazard Class 4**: The Buddy System is required to perform work. At least one person must be present in the work area to serve as a Buddy. Both individuals must have received equipment specific training required for the applicable Hazard Class 4 machinery. At least one Faculty or Staff member from the department must be available in the building to aid students performing work if necessary.

Access Control Policy:

- Each academic and research space where student operated machinery is located must develop an access control policy. This policy will outline what measures will be in place to ensure that only authorized individuals have access to machinery.
- Academic and Research spaces containing Hazard Class 1 or 2 tools/machinery may be open at any time for work if they follow supervision requirements, and that access is approved by the department.
- It is recommended that Hazard Class 3 or above tools/machinery not be accessible to students outside of normal campus operating hours. However, individual departments can opt to allow work outside of normal hours if they can ensure that the supervision requirements for the equipment in use can be met.
- Workspaces containing mixed Hazard Class tools/machinery that are open 24 hours must have a system in place to disable Hazard Class 4 tools/equipment unless the individual department grants approval for operation and appropriate supervision requirements can be met during all hours.

Appendix C – Risk Assessment Process Flow Chart

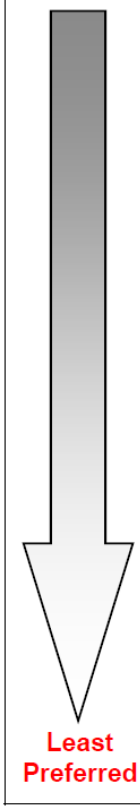
The flow chart on this page outlines the necessary steps for performing a successful machine risk assessment. Risk assessments should only be performed by personnel who are qualified to do so. Ideally, such personnel should be comprised of a team of qualified operators, maintenance, and EHS staff. The goal of the risk assessment is to reduce risk to an acceptable level.



From ANSI B11.0 *Safety of Machinery*

Appendix D – Hierarchy of Controls

The Hierarchy of Controls is the primary means of reducing risk when working with machine hazards. Risk reduction measures are applied following the order of hierarchy as depicted in the following table. Risks can be mitigated by reducing the severity of harm presented by the hazard, improving the possibility of avoiding harm, and/or reducing the need for access to the hazard zone. Identified hazards should ideally be addressed using the most preferred measures on the table.



Risk Reduction Measures	Examples	Influence on Risk Factors	Classification
Elimination or Substitution	• Eliminate pinch points (increase clearance) • Intrinsically safe (energy containment) • Automated material handling (robots, conveyors, etc.) • Redesign the process to eliminate or reduce human interaction • Reduced energy • Substitute less hazardous chemicals	• Impact on overall risk (elimination) by affecting severity and probability of harm • May affect severity of harm, frequency of exposure to the hazard under consideration, and/or the possibility of avoiding or limiting harm depending on which method of substitution is applied.	Design Out
Guards, Safeguarding Devices, and Complementary Measures	• Barriers • Interlocks • Presence sensing devices (light curtains, safety mats, area scanners, etc.) • Two hand control and two-hand trip devices	• Greatest impact on the probability of harm (Occurrence of hazardous events under certain circumstance) • Minimal if any impact on severity of harm	Engineering Controls
Awareness Devices	• Lights, beacons, and strobes • Computer warnings • Signs and labels • Beepers, horns, and sirens	• Potential impact on the probability of harm (avoidance) • No impact on severity of harm	Administrative Controls
Training and Procedures	• Safe work procedures • Safety equipment inspections • Training • Lockout / Tagout / Verify	• Potential impact on the probability of harm (avoidance and/or exposure) • No impact on severity of harm	
Personal Protective Equipment (PPE)	• Safety glasses and face shields • Ear plugs • Gloves • Protective footwear • Respirators	• Potential impact on the probability of harm (avoidance) • No impact on severity of harm	

From ANSI B11.0 *Safety of Machinery*

Appendix E - Hazardous Mechanical Motions and Actions

The following illustrations portray common hazardous machine mechanical motions and actions. This list is not intended to be all inclusive. Other machine hazards exist under specific circumstances. All illustrations are curtesy of OSHA.

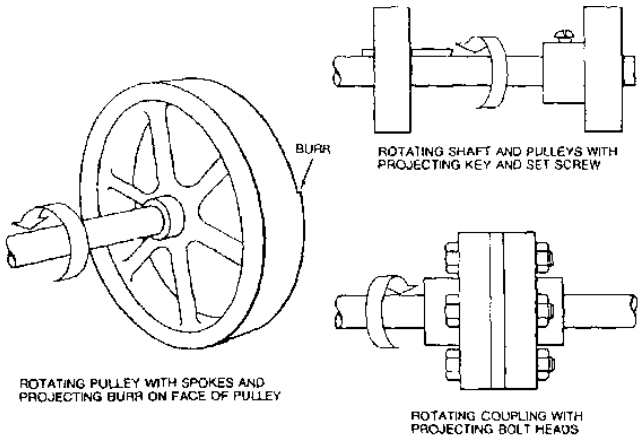


Figure 1: Rotating motion hazards.
Rotating motion can be very dangerous. Even smooth, slowly rotating shafts can grab hair and clothing, pulling a worker into a machine hazard. Common rotating mechanisms are: collars, couplings, cams, clutches, flywheels, shaft ends, spindles, meshing gears, and horizontal or vertical shafting. Projections (such as set screws and bolts) or nicks and abrasions exposed on rotating parts increase this hazard.

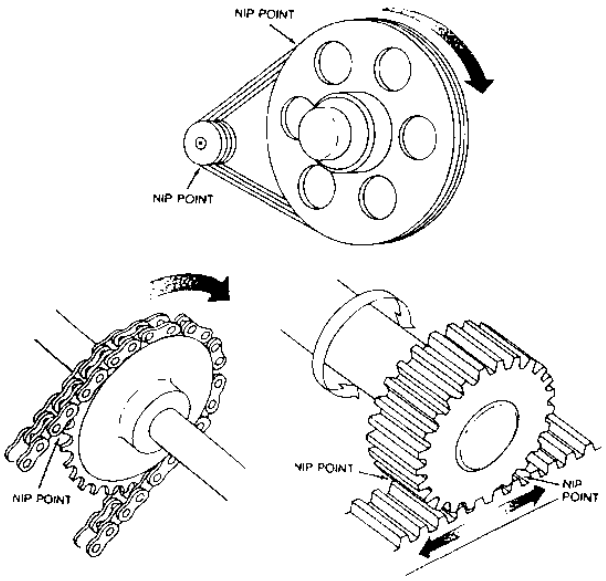


Figure 2: Examples of in-running nip points.
In-running nip point hazards are caused by the rotating parts on machinery. Parts can rotate in opposite directions while their axes are parallel to each other. These parts may be in contact or in close proximity. For example, stock fed between two rolls produces a nip point. Nip points are also created between rotating and tangentially moving parts. Some examples would be: the point of contact between two gears, a power transmission belt and its pulley, a chain and a sprocket, and a rack and pinion gear set.

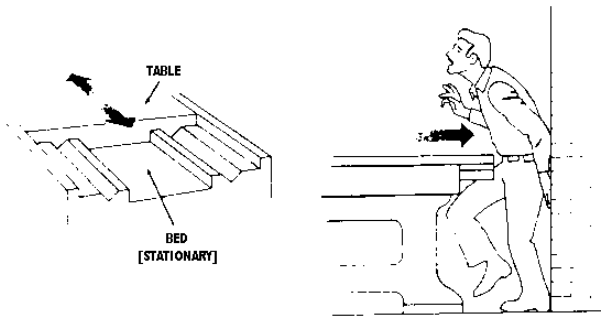
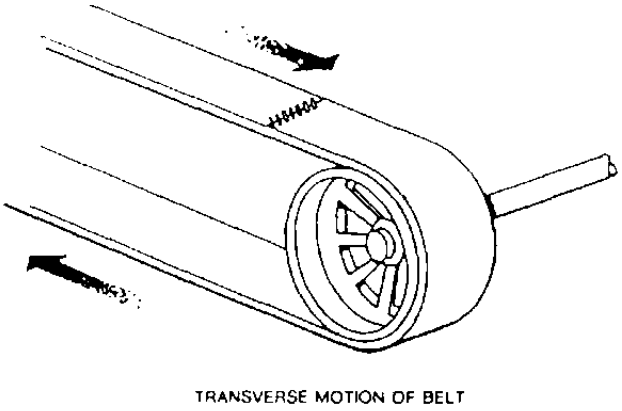


Figure 3: Hazardous reciprocating motion.
Reciprocating motions may be hazardous because, during the back-and-forth or up-and-down motion, a worker may be struck by or caught between a moving and a stationary part.

Figure 4: Hazardous transverse motion.
Transverse motion creates a hazard because a worker may be struck or caught in a pinch or shear point by the moving part in relation to a nearby fixed object.



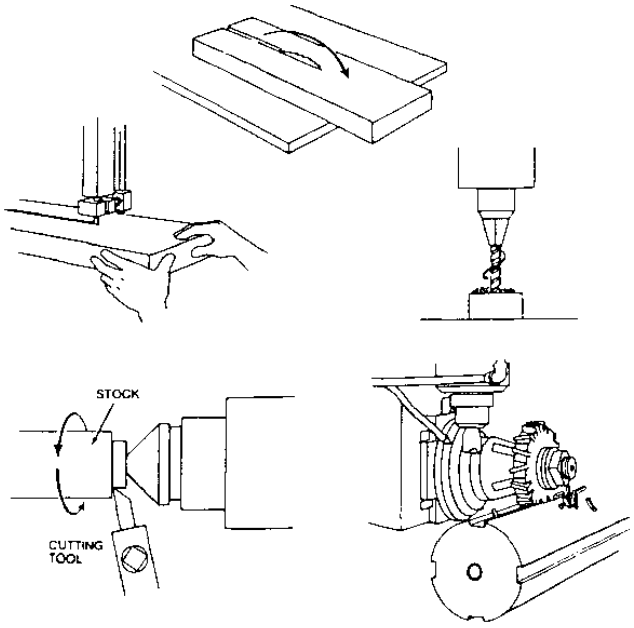
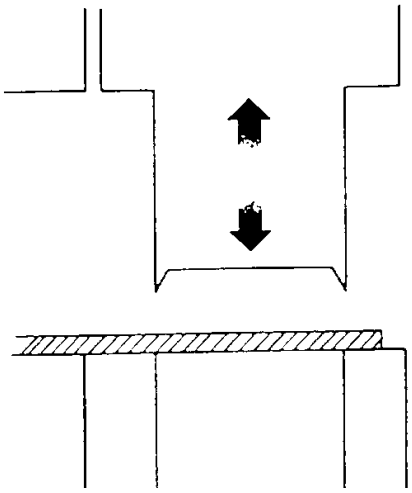


Figure 5: Dangerous cutting actions.
Cutting actions may involve rotating, reciprocating, or transverse motion. The danger of cutting action exists at the point of operation where finger, arm and body injuries can occur, and where flying chips or scrap material can strike the head, particularly in the area of the eyes or face. Examples of mechanisms involving cutting hazards include band saws, circular saws, boring and drilling machines, turning machines, lathes, or milling machines.

Figure 6: Punching action.
Punching action results when power is applied to a ram for the purpose of blanking, drawing, or stamping metal or other materials. The danger of this type of action occurs at the point of operation where stock is physically inserted, held, and removed by hand. Typical machines used for punching operations are mechanical power presses.



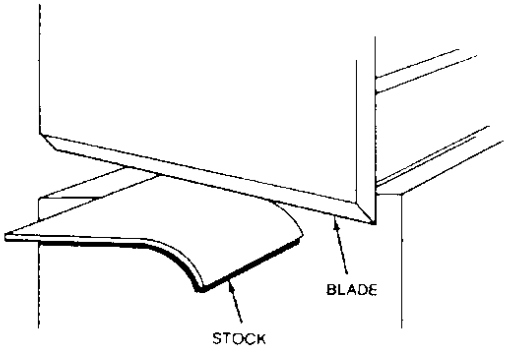


Figure 7: Shearing action.
Shearing action involves applying power to a slide or knife in order to trim or shear metal or other materials. A hazard occurs at the point of operation where stock is physically inserted, held, and removed by hand. Examples of machines used for shearing operations are mechanically, hydraulically, or pneumatically powered shears.

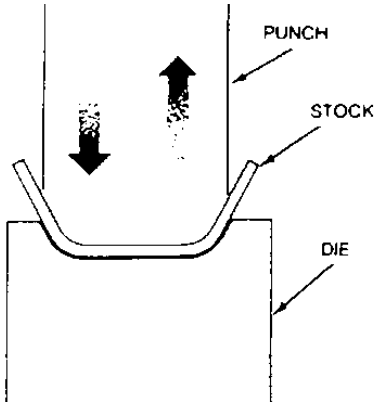


Figure 8: Bending action.
Bending action results when power is applied to a slide in order to draw or stamp metal or other materials. A hazard occurs at the point of operation where stock is physically inserted, held, and removed by hand. Equipment that uses bending action includes power presses, press brakes, and tubing benders.

Appendix F – General Machine Guarding Inspection Checklist

Inspector Name:		Date of Inspection:	
Building:		Room Number:	
Department:			

	Finding	Question	Yes	No	N/A
General Guarding Safety					
1	Effectiveness of Safeguards	Do the safeguards prevent workers hands, arms, and other body parts from making contact with dangerous moving parts?			
2	Safeguard Installation	Are the safeguards firmly secured and not easily removable?			
3	Machine Protection	Do the safeguards prevent objects from falling into or contacting moving parts?			
4	Safe Machine Operation	Do the safeguards permit safe, comfortable, and relatively easy operation of the machine?			
5	Machine Lubrication	Can machinery be lubricated without removing the safeguards?			
6	General Machine Controls	Are starting and stopping controls within easy reach of the operator?			
7	Posting of Safety Signage	Are safety signs (danger, warning, or caution, etc.) posted where necessary?			
8	Fixed Machine Anchoring	Are all machines designed for a fixed location securely anchored to prevent movement?			
9	Standard Operating Procedures (SOP)	Are SOPs for each machine available and is the information up to date?			
10	Area and Machine Access	Is the shop or room where machinery is located secured against unauthorized users and access?			
Point of Operation Safety					
11	Point of Operation Guarding	Is point of operation guarding installed on the machine?			
12	Guarding Effectiveness	Does the guarding keep the operator's hands, fingers, and/or body out of the danger area?			
13	Evidence of Tampering	Is there evidence that the safeguards have been tampered with or removed?			
14	Cutting Tool Condition	Are blades, bits, and other cutting tools sharp and free of damage?			
Mechanical Power Transmission Safety					
15	Unguarded Gears, Pulleys, or Flywheels	Are there any unguarded gears, sprockets, pulleys, or flywheels on the machine?			
16	Exposed Belts/Chains	Are there any exposed belts or chain drives?			
17	Exposed Set Screws	Are there any exposed set screws, keyways, collars, etc.?			

18	Overall Mechanical Power Transmission Guarding	Are safeguards provided for all hazardous moving parts of the machine, including auxiliary parts?			
Electrical Safety					
19	Machine Grounding	Is the machine properly grounded?			
20	GFCI Protection	Is GFCI protection installed for machinery where required?			
21	Area Free of Electrical Hazards	Is the area free of recognized electrical hazards that are likely to cause death or serious physical harm? (Ex. missing knockouts, missing circuit breakers, missing/broken/damaged covers, exposed live electrical components, open/unlocked electrical panels, etc.)			
Housekeeping					
22	Walking Surface Hazards	Is the shop floor free from slip, trip, and fall hazards (water, oil, debris, etc.)?			
23	Machine Cleanliness	Are all machines free of debris?			
24	Safe Material Storage	Are shop materials, including scrap, stored in a safe manner?			
25	Shop Tool Storage	Are shop tools safely stored away and not left on machines?			
Training					
26	Guard Training	Do operators have the training for how to properly use safeguards?			
27	Guard Function	Have operators been trained in where the safeguards are located, how they provide protection, and what hazards they protect against?			
28	PPE Training	Has personal protective equipment training been provided where needed?			
Findings, Comments, & Corrective Actions					
The Machine Guarding Inspection in BioRAFT should be used to document inspections. This form may be utilized in the laboratory with results transferred to the BioRAFT inspection afterwards. The BioRAFT inspection may also be accessed directly from a tablet or other mobile device.					

Appendix G – Machine Guarding Product & Service Resources

All machinery in Rowan University academic and research laboratories must be equipped with proper guarding and other safety features as required by OSHA and applicable industry consensus standards. For complete machine safeguarding information, please read and understand the Rowan University Machine Guarding Policy for Research & Academic Operations. Machine safeguarding requirements apply to all machinery regardless of age. Contact Laboratory Safety for machine safeguarding assistance at LabSafety@Rowan.edu or 856-256-5105.

The following subjects are fundamental machine safety requirements, and all machinery in operation in Rowan academic and research operations are required to be in full compliance:

Point of Operation Guarding

The point of operation is the area or areas of a machine where work is performed on a material, such as drilling, cutting, shaping, or forming of stock. All machines that expose Students, Faculty, or Staff to injury must be guarded. One of the most common types of point of operation guards is a transparent chip shield.

Mechanical Power Transmission System Guarding

The mechanical power transmission system includes all components of the machine system which transmit energy to the part of the machine performing the work. These components include, but are not limited to: flywheels, pulleys, belts, connecting rods, couplings, cams, spindles, chains, cranks, and gears. Components must be properly guarded to prevent accidental contact. Guarding of these hazards is normally in the form of fixed metal guards that are bolted in place.

Machine Anchoring

Machines intended by the equipment manufacturer to be used in a fixed location must be anchored in place. This applies to **both** benchtop and floor mounted machinery. Information on proper anchoring methods is often found in the owner's manual for a machine. Machinery are generally anchored in place with bolts driven into a secure surface.

Machine Operating Controls

A mechanical or electrical power control shall be provided on each machine to make it possible for the operator to cut off the power from each machine without leaving his/her position at the point of operation.

Lockout/Tagout (LOTO)

Individual machine owners must establish machine specific LOTO programs consisting of energy control procedures, operator training, and periodic inspections to ensure that before any individual performs any servicing or maintenance on a machine or equipment, the machine or equipment is isolated from the energy source and rendered inoperative.

Anti-Restart Controls

On machinery where injury to the operator might result if motors were to restart after a power failure, provisions shall be made to prevent machines from automatically restarting upon restoration of power. Anti-restart protection can be added to many machines through a simple device that plugs into the existing power cord.

Resources for Obtaining Guards and Safety Systems

Table 1 of this guide contains several companies and websites where machine guards, safety devices, and services can be purchased. All machine guards and safety systems must be installed and maintained by a competent person. Students are not permitted to install guards or safety systems on machinery. In certain cases, it will be necessary for machine owners to obtain services through a professional machine safeguarding company. Supplemental resources to learn more about machine safeguarding are listed in **Table 2** of this guide. Always consult with Laboratory Safety before purchasing or installing any guards or safety devices to ensure that they will provide proper protection and can be installed correctly.

Table 1: Machine Safeguarding Supply and Service Companies	
Company Name:	**Description:**
Advent Design Corporation	Specialty machine safeguarding company capable of designing, fabricating, and installation of custom guarding solutions
ATS Machine Safety Solutions	Machine safety company offering various safeguarding products and custom fabrication.
Ferndale Safety	Offers a wide variety of safeguarding products, safeguarding assessments, and installation services.
Flexbar	Machine equipment supplier offering a wide variety of guarding and machine safety products.
Grainger	Industrial supply company offering select guarding products.
JDS Products Inc.	Manufacturer of machine anti-restart modules.
Machine Guard & Cover Co.	Offers a wide variety of fixed guards for mechanical power transmission systems.
Machine & Process Safety Assessment Group	Specialty machine safeguarding company capable of designing, fabricating, and installation of custom guarding solutions
MSC	Industrial supply company offering select guarding products.
Protech Systems	Machine equipment supplier offering a wide variety of guarding and machine safety products.
Rockford Systems, LLC	Offers turnkey machine safeguarding services, resources, and guarding supplies.
NOTE: The companies and websites in this table are provided as a courtesy. Guarding and services may be obtained from companies not listed in this table.	

Table 2: Machine Guarding Information and Resources	
Resource:	**Description:**
29 CFR 1910.147 The control of hazardous energy (lockout/tagout)	Direct link to the Federal Regulations pertaining to lockout/tagout.
** 29 CFR Part 1910 Subpart O Machinery and Machine Guarding	Direct link to the Federal Regulations pertaining to machine guarding.
ANSI B11 Machine Safety Standards	Website providing an overview of the applicable ANSI industry standards for machine safety.
Machine Safeguarding at the Point of Operation	Produced by Oregon OSHA, this guide provides machine guarding information for a wide variety of equipment. The information provided reflects how OSHA incorporates ANSI and NFPA Standards in machine safety enforcement.
**OSHA Machine Guarding eTool	Basic introductory machine safety information provided by OSHA.
**OSHA Machine Guarding Website	OSHA's main website for machine safety information. This page contains links to the Federal Regulations, as well as to a variety of tools and resources on machine safety.
NIOSH Machine Safety Website	NIOSH's website for machine safety information. Contains a variety of information, publications, and links to resources.
** The information provided by Federal OSHA does not represent all requirements for proper machine safeguarding. Through what is known as the General Duty Clause, OSHA requires that a workplace be "*free from recognized hazards that are causing or are likely to cause death or serious physical harm*". As a result, OSHA will cite industry safety standards established by organizations such as ANSI and NFPA. At the very minimum, all machinery/equipment must comply with OSHA regulations. To ensure full regulatory compliance and operator safety, any applicable industry standards must also be utilized.	

Contact Laboratory Safety for machine safeguarding questions or assistance at:

LabSafety@Rowan.edu or 856-256-5105

Appendix H – Machine Standard Operating Procedure (SOP) Outline

The following template outlines basic topics and information necessary on SOPs for machinery.

SOP Title		
Machine Identification Information:		
Department:	Room Number:	SOP Revision #:
Written By:	Signature:	Date:
Reviewed By:	Signature:	Date:

1. Purpose
Provide a brief description of the purpose of the SOP.

2. Definitions
Provide any important definitions or acronyms that are relevant to the machine.

3. Responsibilities
Briefly summarize the roles and responsibilities associated with machine operation. Identify key tasks and who is responsible.

4. Safety/PPE
Identify any specific safety precautions and any PPE required for machine operation.

5. Procedure
Include in this section all relevant information necessary to operate the machine. Write in sufficient detail so that a trained person would be able to perform the procedure without supervision. This section can include supplemental aids such as pictures, diagrams, and flow charts.
Note: The procedure does not generally need to include details pertaining to work that will be performed on the stock/workpiece. For example: Details about how specific dimensions will be achieved when turning metal on a lathe.

6. References
Use this section to list any applicable reference materials. Examples include other SOPs, operating manuals, etc.

7. Change History
Document any significant changes made to each version of the SOP.

8. SOP Acknowledgment

Reader Acknowledgment:		
Name:	**Signature:**	**Date:**

Appendix I – General Machine Shop Safety Rules

Rowan University General Machine Shop Safety Rules

- Safety glasses with side shields are to be worn at all times while you are in the designated shop area. Safety glasses must be worn regardless of whether you are the individual operating the machine. Some operations and equipment may require the use of additional PPE.

- No loose clothing may be worn in the shop work area. This includes including clothing with drawstrings, ties, scarves, loose sleeves, etc. Open-toed shoes, short pants, or skirts are also prohibited. Any jewelry that could potentially become entangled must be removed before working with a machine.

- Long hair must be tied up and secured, or tucked into a hat or hairnet. Long beards must also be tied back securely.

- Cell phones and other electronic devices are a distraction and are prohibited from use while operating any machine.

- Always obtain the appropriate training and approval to operate equipment prior to use. Never attempt to operate a machine that you have not been trained and approved to use or that you do not feel completely comfortable with.

- All machine guards and shields must be fully functional, secured, and in place prior to operating equipment.

- Never use damaged equipment, equipment that has been tagged out of service, or equipment that does not appear to be operating normally. Immediately report defective machinery so that repairs can be made.

- Aisles, exits, and access to emergency equipment must be kept clear at all times.

- Food and beverages are permitted in designated areas only.

- Never attempt to operate machinery when you are impaired, tired, sick, rushed, or distracted. Always maintain your full focus and attention to the operation of the machine.

- PI's, Technicians, and Laboratory Safety have full authority over the shop and its safe use, including the responsibility and obligation to prohibit shop or tool access for the safety of an individual, others in the shop, or equipment.

- Always familiarize yourself with and understand the rules and procedures specific to the shop and the machinery that you will be working with.