



UMBC OFFICE OF ENVIRONMENTAL SAFETY AND HEALTH (ESH) PROCEDURE	TITLE: SHOP AND MAKER SPACE SAFETY PROGRAM
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I. PURPOSE

The purpose of this procedure is to establish minimum requirements for the prevention of injury and illness during the operation of equipment, machinery, or tools in University shop environments, including teaching shops designed for use by students under the supervision of faculty or designated instructors.

II. SCOPE

This procedure applies to all UMBC personnel that utilize shops and makerspaces in the performance of work or academic activities.

III. PROCEDURE

General Requirements for Safe Conduct in Shops and Makerspaces

- Only trained, authorized personnel may operate equipment, tools, or machinery in the shop. Students using the shop must be supervised by a faculty member or designated instructor.
- All shop users shall have the authority to stop work if an unsafe condition or act occurs.
- Avoid working alone in the shop whenever possible.
- Shops and makerspaces shall be secured when not attended.
- Machinery, tools, or equipment shall not be left running unattended.
- Always wear the appropriate personal protective equipment (PPE) when operating machine shop equipment, tools, or machinery.
- Out of service equipment shall be tagged out of service until repairs have been made.

- Compressed air used for cleaning must be regulated to below 30 psi upon dead-ending (when pressed against an object, such as someone's skin) and have appropriate chip guarding in place to prevent flying debris from causing injury.
- Compressed air shall not be used to clean someone's body or clothing. The eyes and other body parts, such as the respiratory system, can be damaged as the result of inadequate personal protective equipment, lack of chip guards, and/or uncontrolled release of compressed air.
- Shop machinery and equipment designed for stationary use shall be secured to prevent movement or walking.
- Long hair shall be secured/tied back when working in the shop area.
- Loose clothing such as long sleeves or shirt-tails shall be tucked in, rolled up, or otherwise secured while in the shop area. Neckties, hood strings, and jewelry such as rings, necklaces, bracelets, and dangling earrings shall not be worn.
- Gloves are prohibited when operating machinery with rotating parts where they could potentially get snagged or caught.
- Wear footwear that is appropriate for the work environment and protects against slipping and dropped objects as needed. Open-toed shoes and sandals/flip-flops are prohibited in all shops.
- Shop areas shall be kept in a clean and orderly manner.
 - Debris such as sawdust, chips, shavings, and other debris shall be cleaned from floors, machinery, bench tops, and other common surfaces at a frequency necessary to maintain a safe and sanitary environment and to prevent hazardous/combustible accumulation of dirt, debris, and dust.
 - Wet or slippery surfaces shall be cleaned in a timely manner to prevent slips and falls.
 - Food and drinks are prohibited in the shop except in designated break areas.
- Shops shall be sufficiently illuminated to allow for safe operation of equipment, machinery and tools.
- Materials, including chemicals and other hazardous material, shall be stored in a safe manner to prevent fire, combustion, leaks, spilling, or falling.
- Know the locations of emergency exits, fire extinguishers, eyewash stations, and first aid kits.

Shop Safety Plan

Each shop shall be responsible for developing and maintaining a Shop and Makerspace Safety Plan. Safety Plans should contain the following information:

- General Shop or Makerspace Information

- Emergency Information
- Rules of Conduct
- Machine/Equipment/Tool-Specific Safety Guidelines
- Inventory of Shop Equipment
- Current list of Authorized Shop Users

Shop supervisors or their designee shall prepare and maintain Shop Safety Plans in collaboration with Department Management, shop employees, and students if applicable. Plans shall be reviewed on an at least an annual basis, and updated or revised when necessary, such as when new equipment is introduced into the shop. Employees and students shall review the Shop Safety Plan prior to performing work in any shop.

A template is available from ESH to assist shops with preparing a Shop Safety Plan.

Shop Inspections

Daily/Pre-Shift Inspections

At the beginning of each shift, prior to the start of work, shops shall be inspected to ensure safe and sanitary conditions. Any hazardous items identified shall be reported and corrected prior to work being performed.

Shop employees shall inspect their assigned work areas, to include assigned tools, equipment, and machinery, to identify any defects, damage, or other issues related to safe operation or proper function. Any identified issues shall be reported and corrected.

- Machine shop tools, equipment, or machinery that are damaged, broken, defective, or otherwise functioning improperly, shall be reported to supervision and removed from service. The equipment shall be marked or tagged as Out of Service/Do Not Use or similar language.
- Out of service tools, equipment, or machinery shall not be used until necessary repairs have been made.

Periodic Inspections

On at least an annual basis, all shops shall undergo a comprehensive inspection. Shop supervisors may perform this inspection or designate a shop employee or student user to perform this inspection. Periodic inspections shall be documented utilizing the accompanying Shop Inspection Form. Any deficiencies or hazards identified during the inspection shall be documented along with steps for corrective actions to be taken.

Machine Guarding

Moving parts of machinery, tools, and equipment have the potential to cause severe injuries, such as lacerations, blunt force trauma, crushed fingers or hands, abrasions, even amputations.

Because of these hazards, many types of machines, tools, and equipment that are operated on job sites and in shop environments must have safeguards in place to protect the operator and others in the area from potentially devastating injuries. Examples of hazards

that guards protect from include nip points, rotating or reciprocating parts, or flying sparks, chips, and debris.

There are three (3) main areas of machinery, tools, and equipment that are required to be guarded to protect against hazards:

1. **Point of Operation** - this is the part where the work is performed on the material, such as cutting, shaping, pressing, or forming.
2. **Power Transmission Apparatus** - The components of the machine, tool, or equipment that transmit energy to the part of the machine that performs the work. Components include pulleys, belts, flywheels, rods, couplings, cams, spindles, gears, cranks, and chains.
3. **Other moving parts** - Other parts of the machine that move while it is in operation.

Types of Machine Guarding:

- **Guards** – these can be fixed, interlocking, adjustable or self-adjusting. They are a physical barrier to contact with the hazard.
- **Devices** – these can be presence sensing, pullback, restraint, operational controls or gates. They limit or prevent access to the hazardous area.
- **Location or distance** – hazards are reduced by locating the machine so that its hazardous areas are not normally accessible.
- **Automated feeding and ejection methods** – these eliminate some of the operator's exposure to the hazards.
- **Miscellaneous aids** – shields, feeding tools (such as push sticks), holding devices or awareness barriers also protect operators and people in the area.

The following are general requirements for machine guarding:

- Physical guards shall prevent operator contact through physical prevention, either through a physical enclosure or by impeding one's ability to reach around or through a guard.
- Points of operation on a machine, tool, or equipment are required to be guarded. The guards shall prevent contact of any body part in the "danger zone" during operation.
- Guards must be of a rigid, durable material that can withstand normal operating use.
- Guards must not introduce any new hazards or create additional interference with operation.
- Guards must not interfere with safe lubrication of shop machinery, tools, or equipment.

- Guards must protect against objects falling into the moving parts of a machine or equipment.
- Special material handling tools may be used as a supplementation to a guard to protect against point of operation hazards.
- Guards are required for any blades of a fan less than seven (7) feet above the working level.
- Foot switches shall be guarded to prevent accidental activation either from a person or a falling object.
- Guards may not be removed, tampered, or defeated during operation. Guards may only be removed during service or repair activities.
- Appropriate lockout tagout practices shall be utilized during any servicing or repair on a machine, tool, or piece of equipment where a guard must be removed (refer to UMBC Lockout Tagout Program).
- If a guard cannot be feasibly installed on a machine, tool, or piece of equipment, or if a guard is not capable of protecting the operator from a hazard, then appropriate alternative controls (such as other engineering or administrative controls) shall be implemented. Contact Environmental Safety and Health if consultation is needed for appropriate alternative measures.

Electronic Safety Devices

- If a machine or piece of equipment is equipped with an e-stop (emergency stop), the e-stop must be located in close proximity to the operator (within arm's reach).
- E-stop buttons/switches shall be red in color with a yellow background.
- All drill presses and lathes shall have spring-loaded chuck keys. Never leave keys in chucks of drill presses or lathes.
- Presses with full revolution clutches shall utilize two-hand trip devices that require two-handed continued pressure away from the point of operation in order to perform an operation.

Hand and Power Tools

The following requirements apply to all hand and power tools and activities associated with their use:

- All tools shall be maintained in good operating condition, free of any defects that would render the tool unusable or not safe to use.
- Any tool that is not usable or safe to operate shall be reported to supervision and tagged out of service to prevent unauthorized use until repairs or replacement can be made. This includes any tools that have dull or chipped edges.
- All employees shall be familiar with the tools they are using and read the operator's manual prior to first time use.

- Electric power tools must be grounded or double insulated.
- Power tools shall be disconnected from their power source (i.e., unplugged or battery removed) prior to performing service, such as blade or wheel replacement.
- Manufacturer's operating guidelines shall be followed at all times.
- Tools shall not be used for a purpose other than which it was designed.
- If a required tool for a task is not available, report the issue to supervision. Departments shall not permit work to take place until all necessary tools are available.
- Departments shall provide the appropriate personal protective equipment (PPE) for use as needed for the tools and equipment being used. Employees shall be expected to wear the appropriate PPE when operating tools.
- Departments shall establish uniform and/or work attire requirements that are appropriate for the tools, machinery, and equipment being operated and do not create an additional hazard for employees.
- Work areas shall be free of hazards and obstructions when operating tools, such as spills, trip hazards, excessive clutter, or obstructions.
- Work areas shall be sufficiently lit to see the task being performed.
- Safely store and secure tools when not in use. Do not store tools near the edges of benches or work platforms.

Bench, Pedestal, and Portable Grinders:

- Bench and pedestal grinders shall have a work rest adjusted no greater than 1/8 inch away from the grinding wheel.
- Tongue guards shall be no greater than 1/4 inch from the grinding wheel.
- Abrasive wheels shall be inspected prior to use. A ring test shall be performed to inspect for cracks on all bench and pedestal grinder wheels.
- Ensure that the grinder speed does not exceed the maximum speed indicated on the grinding wheel.

Hot Work and Fire Prevention

Hot work is considered to be any work that has the potential to create ignition sources or produce excess heat (such as welding, cutting, soldering, brazing, and grinding).

Fire Safety Considerations

- Know the location of fire safety equipment in the shop (fire exits, fire extinguishers, alarm pull stations). Ensure fire safety equipment is visible and unobstructed.
- Do not smoke in shops or maker spaces.

- Wear appropriate hot work personal protective equipment and clothing when performing hot work tasks.
 - Use the appropriately shaded helmet lens for the type of work being performed.
 - Practice good housekeeping to minimize the accumulation of combustible dust, dirt, and debris.
 - Oxygen and acetylene tanks must be appropriately secured in an upright position.
 - Keep combustible and flammable materials a safe distance from hot work activity. If the materials cannot be kept at least 35 inches away from the hot work, then the items must be shielded or otherwise protected from any sparks, flame, or heat.
 - Flammable or combustible-soaked rags (oily rags) shall be stored in an appropriate metal safety container with a self-closing lid.
 - Do not use oily rags to clean up spills.
 - Welding leads must be in good condition and properly insulated.
 - Welding and cutting shall only be performed in the appropriate designated areas of the shop.
 - Ensure adequate ventilation is in place to prevent the accumulation of hazardous or combustible fumes or vapors.
 - Use appropriate compressed gas cylinder handling, storage, and use methods (Refer to Compressed Gas Safety procedure).
 - Use an approved flint or lighter to light a welding torch. Do not use a match or unapproved lighting device.
 - Keep combustible and flammable chemicals and materials appropriately stored in approved storage cabinets when not in use.
 - Utilize appropriate shielding or other protective means (such as an attendant) to protect nearby materials, equipment, and persons from flying sparks when performing hot work in the shop.
 - Do not use tape to repair cylinder fittings or hoses and keep them free from oil, grease, and protect hoses being flattened, pinched, or cut.
- *Gases and Fumes:*
 - o Welding creates “smoke” that is a mixture of very fine particles and gases. Many of the substances contained in welding smoke are highly toxic (i.e., chromium, lead, cobalt, carbon monoxide, asbestos, silica, cadmium, copper, and many more).
 - *Heat*

- o Welding creates intense heat, creating a risk of burns from heat and sparks. Hot slag, metal chips, sparks and hot electrodes can injure the eyes, face, or body if not properly protected.
- o Heat and hot materials pose a serious fire risk if not handled or staged appropriately. Only conduct welding activities in appropriately designated areas that are free of combustible materials.

UV, Visible Light, Infrared Radiation

- o The intense light associated with arc welding can damage the retina of the eyes. Infrared radiation can damage the cornea and result in formation of cataracts.
- o UV light from arc welding can cause “arc eye” which can cause severe eye irritation, including pain, tearing, burning, and blurred vision.
- o Light from welding can reflect off of surrounding materials and injure others nearby.
- o Improper protection while welding can cause permanent eye damage as well as skin burns like sunburn, increasing risk of skin cancer for the welder

· Metal Cutting

- o Use the appropriate tools and blades for the type of metal you will be cutting.
- o Nonferrous metals like aluminum or copper require carbide-tipped blades
- o Do not cut ferrous metals like steel or iron with woodworking or nonferrous cutting tools.
- o Apply lubrication to blades before cutting to reduce blade teeth gumming, extend blade life, and improve surface finish.
- o Only cut metal in areas that are clean and free of debris and dust, particularly if wood cutting also takes place in the area.

· Soldering

- o Review the manufacturer’s SDS for the materials you are using before beginning work.
- o Ensure you are wearing the necessary PPE (goggles, gloves)
- o Do not eat or drink in the soldering area.
- o Use local exhaust ventilation (benchtop fume extractor, snorkel, etc.). If this is not achievable, solder in a fume hood.
- o The tip and element of soldering irons get very hot, do not touch.

- o Allow soldered work pieces to cool off before touching.
- o Do not use lead-based solders without first consulting ESH.
- o Do not solder any energized circuits or equipment.
- o Perform good housekeeping, clean as you go
- o Do not solder on top of any combustible or flammable surface.
- o Do not lay soldering iron flat on benchtop or other surface. Place the iron in its holder.
- o Wash hands and arms thoroughly after soldering activity.
- o Turn off and unplug/de-energize soldering iron when not in use.

3D Printers

While desktop 3D printers have made rapid prototyping and small-scale manufacturing easier and more accessible, they are not without their hazards. In some 3D printing processes, thermoplastics are heated, nozzle-extruded and then deposited onto a surface to build the object.

Countertop 3D printers that use Fused Deposition Modeling/Filament Fabrication are the more commonly used and accessible 3D printers available. 3D printers utilizing ABS and PLA filaments are less hazardous but can still emit low levels of ultrafine particles as well as volatile organic compounds (VOC).

3D printers requiring any materials other than PLA filament must be assessed by ESH prior to use.

General Guidelines for 3D Printing:

- 3D printers with enclosures are highly preferred as they will capture a significant number of particles or fumes emitted during the printing process, thereby reducing employee and student exposure. Preference should be given to enclosures with HEPA/VOC filtration capabilities.
- Use in a well-ventilated area with limited occupancy. A designated area exclusively for 3D printing is highly encouraged.
- Follow all 3D Printer manufacturer guidelines, operating manual instructions, and safety data sheets (SDS) prior to operating the printer or handling the printing materials.
- When 3D printers are running, users should not congregate around the printer for extended periods. This will reduce employee exposure as well as improve ventilation effectiveness.
- Do not eat, drink, or apply cosmetics in 3D printer areas.
- Do not leave the printer unattended, check on the printer periodically.

- Use of any filament or material other than PLA requires ESH consultation and authorization (including SLA/Resin, Nylon, Metal, or Powder).

CNC Machines

CNC (computer-numerical-controlled) milling machinery uses moving cutters and/or move stock materials to cut shapes. Materials typically include metal, wood, or plastic. Hazards associated with CNCs include

- o Flying chips or debris – eye injury hazard
- o Fine dust – respiratory hazard
- o Operating machinery – potentially very loud or excessively noisy

Moving parts such as rotating or reciprocating blades that can catch gloves, loose clothing, jewelry, or loose hair. Body parts can be drawn into machinery because of clothing or items worn on someone's person being caught or snagged.

All users of CNC machinery must receive training from an experienced user prior to operating the equipment. Wear appropriate PPE and attire when operating such equipment and ensure all guards and safety features are in place and functioning properly.

Laser Cutters

Laser-cutting devices are versatile tools used to cut or drill wood, plastics, and metals. These devices are economical, efficient, and easily automated; however, several physical hazards are associated with these design tools. American National Standards Institute (ANSI) generally classifies laser-cutters as nonhazardous, Class 1 LASERs when operated according to manufacturer's instructions. Yet the enclosed lasers are generally Class 3B or 4 LASERs, which emit high levels of energy and are hazardous to the eyes and skin. Therefore, only trained personnel should perform maintenance and other procedures that involve breaching the enclosure.

Cutting or drilling certain materials, such as treated wood, plastics, or epoxy resins, may produce Laser-Generated Air Contaminants (LGACs). These LGACs may be gaseous or particulates and may pose health risks to those exposed to them. Examples of LGAC's include benzene, toluene, HCl, and other airborne hazards. To control the production of LGAC's, proper ventilation must be used to reduce or eliminate personnel exposure and to safely exhaust these by-products.

Consult with ESH and reference your User's Manual when determining the proper ventilation and routine maintenance schedule.

Laser-cutters also use high intensity beams of light, which can pose a fire hazard depending upon the flammability of the materials being cut. Some materials easily ignite and the flame has the potential to destroy not only the machine, but the building in which it is housed.

Painting and Finishing Operations

Applying paint, lacquer, varnish, adhesives, solvents, other similar coatings can present hazards from fumes and from misting particles generated from spraying. Accumulation of fumes can

potentially lead to fires or explosions. Appropriate ventilation is critical when applying any of the above coatings particularly in large amounts or if it is being sprayed.

Important Safety Considerations:

- Heat sources combined with paint can increase the likelihood of fumes and vapors.
- Do not paint in enclosed, confined, or unventilated spaces.
- It is highly recommended that all applications utilize ventilation or similar engineering controls, such as a spray booth, snorkel, or fume hood.
- If spraying outside, ensure the ground and surrounding structures are protected from paint spills or sprays. Maintain sufficient distance from building entry/exit ways and ventilation intakes.
- Do not operate spark or static-inducing equipment or devices near painting or finishing operations. Ensure any corded equipment is grounded and appropriately insulated. Do not use extension cords.
- Wear appropriate protective clothing and PPE.
- All paints, solvents, thinners, and other flammables must be stored in a fire-rated cabinet or container.

Training

Personnel utilizing shops or makerspaces shall receive appropriate training to include demonstration of safe and satisfactory operation of assigned equipment under the supervision of a supervisor, faculty, or experienced designee.

Training shall cover the following subjects:

- A review of the equipment operator's manual(s).
- Appropriate selection and use of PPE.
- How to identify existing and foreseeable hazards in the shop and correct or report as appropriate.
- How to inspect assigned tools, machinery and equipment assigned to them.
- Care and operator-level maintenance of tools and equipment.

Training shall be re-administered in the following circumstances:

- Following any incident or near-miss.
- When the employee is assigned to a new type of machinery, tool, or equipment.
- Processes or conditions in the workplace change that render current training ineffective or no longer relevant to job assignment.

Recordkeeping

Departments shall be responsible for maintaining current records of the following:

- Records of employee or shop/makerspace user training and authorization.
- Records of inspections, repairs, or preventative maintenance for shop or makerspace tools, equipment, and machinery.

Records shall be retained by the department with authority over the Shop for a period of at least three (3) years.

V. ROLES AND RESPONSIBILITIES

Deans, Administrators, Department/Area Managers

- Ensure employees under their responsibility have the resources and equipment necessary to perform work safely and in accordance with this procedure.
- Ensure employees complete all required training.
- Ensure inspections of equipment, tools, and machinery are completed as required.
- Ensure services and repairs to equipment, tools, and machinery are completed in a timely manner.

Shop and Makerspace Supervisors, Coordinators, Stewards or Designees

- Ensure the shop and all machines, tools, and equipment are kept in a safe and sanitary condition.
- Monitor work areas and activities for unsafe conditions. Stop and correct any unsafe conditions or activity as needed.
- Ensure employees are familiar with the safe operation of all machines, equipment, and tools and ensure all employees have completed necessary training.
- Enforce the requirements of this procedure and any applicable department procedures within their areas of responsibility.
- Ensure only authorized and trained personnel perform work on shop equipment, tools, and machinery.
- Facilitate service and repairs for shop machinery, tools, and equipment in a timely manner.

Office of Environmental Safety and Health

- Provide technical consultation and subject matter guidance to departments to facilitate safe completion of work using shop tools, machinery and equipment, in accordance with regulatory requirements, standards, and best practices.
- Periodically review this procedure to ensure continued effectiveness and revise as necessary. Communicate any revisions that are made.

- Perform periodic inspections and audits of shop conditions, activities, and records of training, inspections, and servicing as needed.
- Assist departments with identification of training and other resources to facilitate safe completion of work.

Employees

- Follow all safe work practices in accordance with this procedure.
- Utilize the appropriate PPE, tools, and resources to facilitate safe completion of assigned work, and notify supervision if items required to safely and effectively complete the task are not available.
- Ensure necessary training is completed prior to performing assigned work.
- Perform inspections as needed on tools, machinery, and equipment.
- Promptly report any unsafe or unsanitary shop conditions, or broken, damaged, or defective tools, equipment, or machinery in the shop to supervision.

VI. REFERENCES

- UMBC Policy VI-13.00.01 - Environmental Safety and Health Management and Enforcement
- UMBC Shop and Makerspace Safety Plan
- UMBC ESH Procedure - General Safety Rules for UMBC Employees
- UMBC Lockout Tagout Program