LONGWOOD
UNIVERSITY

Theater, Art, Graphic and Animation Design Safety Guide

Environmental Health and Safety

IMPORTANT PHONE NUMBERS

Fire and Medical Emergencies……911

Blue Ridge Poison Control……(800)451-1428

LU Campus Police…….. (434)395-2091

LU Environmental Health and Safety…….. (434)395-2940

LU Emergency Management……..(434)395-2457

201 High Street

Farmville, VA 23909

434.395.2940

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Art and Theater Safety Guide

PURPOSE

When you think of art in classrooms and studios you most likely think of students' busy drawing, painting, working with clay or other types of media. It is in these areas where creativity and learning take place. However, it can also be a room where safety hazards exist and student's health can be compromised. There are classrooms and studios that contain materials or substances that are toxic or carcinogenic. Dangerous conditions exist and unsafe practices take place, often without anyone realizing the possible outcome. This guide will aid in minimizing those dangerous conditions and unsafe practices.

SCOPE

This guide has been written to minimize the risk of injury or illness to the students, faculty and staff in the Department of Theatre, Art, and Graphic & Animation Design. This will be done by ensuring that they have information, support, equipment and training needed to work safely in classrooms, studios and workshops and stages. This guide has been prepared as a companion document to Longwood University's *"Hazard Communication Plan"* and the *"Hazardous Waste Plan"*, which provide detailed procedures regarding chemical handling and hazardous waste management. If discrepancies are noted between these documents, the companion documents will take precedent over this document.

GENERAL SAFETY

The following safety procedures should be followed by a person's working in the classrooms, studios and workshops:

1. Know the materials you are working with: Refer to written procedures and review the Safety Data Sheet (SDS) for chemicals. Consider the toxicity of materials, the health and safety hazards of each procedure, the knowledge and experience of personnel, and the safety equipment that is available.
2. Know the location of s emergency procedures and safety equipment for your area.
3. Always wear appropriate clothing (e.g. pants, shirts, close toed shoes) and personal protective equipment (e.g. safety glasses, lab coats, gloves) whenever hazardous chemicals and equipment are used. Remove personal protective equipment before leaving the studio or workshop.
4. Do not engage in hazardous operations by yourself. Arrangements should be made to have another person present in the studio or workshop.
5. Use a properly operating exhaust when working with hazardous chemicals.
6. Do not eat, drink, chew gum, prepare food, or apply cosmetics in rooms where hazardous chemicals are being used or stored.
7. Keep work areas clean and uncluttered at all times.

Safety Training

At the beginning of each semester, every instructor must review the applicable safety protocols with their classes before students are permitted to work with hazardous materials or equipment. This can be accomplished through instruction, viewing a safety video or the combination of the two. Appendix X provides the basic safety instruction that should be included in the training.

Instructors should have their students sign a safety contract. It is the responsibility of the Department Chair to maintain the safety contracts. A safety contract is included in Appendix X.

Security

Security is an integral part of an effective safety program. Follow these steps to ensure a secure working environment in your studio or workshop:

- Keep doors locked when rooms are unoccupied.
- Keep an accurate record of chemicals, project materials, and other valuable items that support activities.
- Notify Longwood University's Police Department at (434)295-2091 if materials are missing from your studio or workshop.
- Inspect all packages arriving at the work area.
- When work is complete for the day, ensure that chemicals and potentially hazardous equipment have been stored properly and securely.
- Ask strangers (someone you do not recognize as a co-worker or student) to exit the room if they are not authorized to be there.
- Discuss other security-specific requirements with your Department Chair and colleagues.

Safety Equipment

In areas where chemicals are used, drench showers, eyewashes, and fire extinguishers are located in the classroom, studio, or workshop for occupant safety.

Drench Showers

Drench showers and other emergency wash systems are used in an emergency to flush chemicals that have accidentally come in contact with skin and clothing. In order to wash the body properly, clothing should be removed as water is applied. The drench shower can be used to extinguish a clothing fire, but this not recommended if the shower is more than a couple of feet away. The best method of extinguishing a clothing fire is to "Stop, Drop & Roll", and then remove clothing.

At least three feet of space in each direction is required beneath the shower and this area must be kept free of all obstacles (i.e. no wastebaskets, etc.)

Eye Washes

The best treatment for chemical splashes of the eye and face is immediate flushing with copious amounts of water for 15 minutes. Eyewashes are equipped with a stay-open valve. All plumbed eyewashes should be flushed monthly by allowing water to flow for approximately three minutes to remove stagnant water from the pipes. Plastic eyewash bottles are not a suitable replacement for an eyewash.

In general, the emergency eyewash equipment should be installed within 10 seconds walking time from the location of a hazard. The equipment must be installed on the same level as the hazard (accessing the equipment should not require going up or down stairs or ramps). In addition, the path of travel from the hazard to the equipment should be free of obstructions and as straight as possible.

Fire Extinguishers

Fire extinguishers are placed in the room or in the hallway outside of classrooms, studios and workshops. While not required, a fire extinguisher can be used in the event of an emergency.

Environmental Health and Safety conducts fire extinguisher training. If you are interested in being trained email safety@longwood.edu and request training.

First Aid Kits

A First Aid Kit is available in the main office of Bedford. This kit is stocked by EHS. If the kit needs resupplied please email safety@longwood.ed and request supplies.

Spill Kits

The Department should make spill kits available in each room where hazardous chemicals are used and stored. They should only be used by qualified staff or faculty with knowledge of the properties and hazards posed by the chemical, and any potential dangers posed by the location of the spill.

Detailed information on chemical spills can be found in the *"Chemical Hygiene Plan"*.

Sharps Containers and Glass Only Boxes

"Glass Only" boxes are used for the disposal of glass only. When the box is about ¾ full, the box should be properly sealed, and set outside the door of the studio or workshop. Label the box as broken glass/trash and our housekeeping contractor will dispose of it.

Sharp containers are used for the disposal of syringes, disposable blades such as X-Acto knives, razor blades and other sharp items. Containers for sharps must be puncture resistant. The sides and bottom must be leak-proof and be appropriately labeled. Containers for sharps must be closable (that is, have a lid, flap, door, or other means of closing the container), and they must be kept upright to keep the sharps

and any liquids from spilling out of the container. Use the following procedures when disposing of non-medical and non-hazardous sharps:

- Collect in a puncture resistant container (e.g. coffee can or used laundry detergent bottle). Make sure that there are NO biohazard symbols or label on the container
- Close and seal when it is ¾ full
- Label the container **"Sharp Objects Inside-Use Caution when Handling"**
- Dispose of container in trash

Sharps containers are not supplied by EHS. However, EHS will assist with recommendation for purchasing sharp containers.

PERSONAL PROTECTIVE EQUIPMENT (PPE)

Studios and workshops must provide personal protective equipment (i.e. safety glasses, aprons, gloves, etc.) for students and visitors. For more information on PPE see Longwood University's *"Personal Protective Equipment Program"*.

Personal protective equipment is not supplied by EHS. However, EHS will assist with recommendation on specific types and uses of protective equipment.

SAFETY INFORMATION

Safety Data Sheets (SDS's) are available in the CEMS Data Base https://SDS.longwood.edu/CEMS/Dashboard. EHS recommends that hard copies of SDS's for chemicals used in studios and workshops be in and SDS binder in the room.

Emergency procedures, safety manuals and other reference materials should be readily available to faculty and staff. Currently these are in a Canvas Course "Longwood Chemical Safety Course". If you need access to the course please email EHS at safety@longwood.edu.

Safety Door Signs

Studios, Shops and Mechanical Rooms often contain hazardous materials, equipment or processes that could endanger first responders. All rooms and laboratories that contain hazardous materials, hazardous equipment, or other hazards shall be posted with a sign facilitated by Environmental Health and Safety.

Safety Room Surveys

Professors and the Cole Cook College of Arts and Sciences Academic Safety Specialist shall conduct formal housekeeping and chemical hygiene self-inspections during the fall and spring semesters. The

results are to be recorded, signed by the Department Chairs and submitted to the CHO. Work orders should be submitted to correct any facilities issues identified. The Inspection Checklist can be found in Appendix A Studio and Shop Safety Checklist. EH&S will conduct formal housekeeping and chemical hygiene inspections with Cole Cook College of Arts and Sciences Academic Safety Specialist on a yearly basis or as needed.

VENTILATION

All work with hazardous materials must be conducted with the appropriate exhaust ventilation

General room ventilation does not provide protection against hazardous gases, vapors and aerosols. All work with corrosives, flammable, odoriferous, toxic or other dangerous materials shall be conducted in a properly ventilated space. When it is not possible to meet the above requirements, EHS and the Department Chair must evaluate hazards together with the faculty member to determine if work can be conducted safely.

Fume Hoods, Down Draft Tables, Snorkels and Wall Vents

Ventilations systems are checked annually by a contractor of Facilities Management. Ventilation systems that do not meet the minimum requirements during the inspection should be posted "DO NOT USE" and Facilities Management is notified to arrange repairs. Once the repairs are made the system will be returned to service and the "DO NOT USE" sign taken off.

Before using a ventilation system make sure the exhaust is turned on and functioning properly (i.e. pulling air). Report any problems to Facilities Management. Do not block baffle openings or place bulky items in front of the ventilation system that will prevent air from entering the baffle opening.

Ventilation system alarms indicate substandard operations of the system. If an alarm goes off notify Facilities Management and posted "DO NOT USE".

Spray Paint Booth

Spray Paint Booths should be used when spraying paints, fixatives, and glazes. Be sure the filters are clean, the vents are clear, and fans are operating when using the spray booths. Report any problems to Facilities Management.

HOT WORK SAFETY

Anytime cutting, welding, brazing, grinding, soldering, thawing pipes, Torch applied roofing, any operation involving open flames or one that is capable of producing heat and/or sparks, a safety hazard can exist unless proper care is observed.

EHS issues the hot work permits. If a permit is needed contact EHS as soon as possible at safety@longwood.edu to request a permit.

- A Hot Work Permit may be issued each semester for small projects that are performed in an Art Studio or Shop.
- The professor using the studio must request a Hot Work Permit from EHS prior to the start of each semester.

The exemption to this is the acetylene torch brazing in the metals studio that is designed for this specific use only.

The studio will be inspected for compliance with Hot Work Permit Required Precautions Checklist and this policy before the permit will be issued, and may be inspected throughout the semester.

For more information on hot work see Longwood University's *"Hot Work Policy"*.

COMPRESSED GAS CYLINDER SAFETY

Compressed gases can be toxic, flammable, oxidizing, corrosive, inert, or some combination of these hazards. In addition to the chemical hazards, the amount of stored energy resulting from the compression of the gas makes a compressed gas cylinder a potential rocket. Appropriate care in the handling and storage of compressed gas cylinders is essential. Following are general recommendations.

Know and Understand Gas Properties: Know and understand the properties, uses and safety precautions before using any gas or gas mixture. Consult Safety Data Sheets (SDS's) for safety information on the gases that you will be using.

Check Equipment: Leak test lines and equipment before they are used. Lines and equipment should be designed and maintained to handle full cylinder pressure. Materials of construction should be compatible with the gases being used.

When in Doubt, Contact Longwood University's Environmental Health & Safety: If you are unfamiliar with the hazards associated with a particular gas or unsure of the correct handling and storage procedures. Primary Hazards The following is an overview of the primary hazards to be avoided when handling and storing compressed gases

Primary Hazards

The following is an overview of the primary hazards to be avoided when handling and storing compressed gases.

Fire and Explosion: Fire and explosion are the primary hazards associated with flammable gases, oxygen, and other oxidizing gases. Flammable gases can be ignited by static electricity or by a heat source, such as a flame or a hot object. Oxygen and other oxidizing gases do not burn, but will support combustion of flammable materials. Increasing the concentration of an oxidizer accelerates the rate of

combustion. Materials that are nonflammable under normal conditions may burn in an oxygen-enriched atmosphere.

High Pressure: All compressed gases are potentially hazardous because of the high pressure stored inside the cylinder. A sudden release of pressure can cause injuries by propelling a cylinder or whipping a line.

Improper Handling of Cylinders: Compressed gas cylinders are heavy and awkward to handle. Improper handling of cylinders could result in sprains, strains, falls, bruises, and broken bones. Other hazards such as fire, explosion, chemical burns, poisoning, and cold burns could occur if gases accidentally escape from the cylinder due to mishandling.

Handling, Storage, and Use of Gases

Only persons familiar with the hazards should handle compressed gas cylinders. All cylinder movement should be done with a cylinder cart. The cylinders should always be secured by a strap or chain to a stationery object. When in storage, cylinders must be capped. In addition, safety glasses, work gloves and appropriate work shoes should be worn when using or moving compressed gas cylinders.

If gas cylinders are stored in a cabinet, the area must be ventilated to prevent gas build up in case of a release. Compressed gas cylinders should not be subjected to any mechanical shock that could cause damage to their valves or pressure relief devices. Cylinders should not be dropped, dragged, slid or used a rollers for moving material or other equipment.

Cylinder caps perform two functions. First, they protect the valve on the top of the cylinder from damage if it is knocked over. Second, if gas is accidentally released through the valve, the cap will vent the gas out of both sides, minimizing the likelihood that the cylinder will topple. Cylinder caps should not be removed until the cylinder is secured in place and ready for use.

Cylinder Storage Precautions

Several precautions should be taken to prevent the release of high-pressure gases, fire and explosion. Compressed gas cylinders should not be exposed to sparks, flames, or temperatures above 125 degrees F. Cylinders should not be placed where they could come into contact with any electrical apparatus or circuits.

Smoking and open flames should not be permitted in areas used for storage of oxygen or flammable gas cylinders. Never permit oil, grease, or other combustible substances to come into contact with oxygen or other oxidizing gas cylinders, valves and systems.

Special Notes on storage:

- **Acetylene tanks are not to be stored horizontally (on its side)**
- **Liquid Propane (LP) tanks cannot be stored inside**

Returning Cylinders

When returning an empty cylinder, close the valve before shipment, leaving 25 psig of residual pressure in the cylinder. Replace the cylinder cap and any valve outlet caps or plugs originally shipped with the cylinder. If repair is needed on a cylinder or its valve, be sure to mark it and return it to the supplier.

Leaking Cylinders

Most leaks occur at the valve in the top of the cylinder and may involve the valve threads, valve stem, valve outlet, or pressure relief devices. Personnel should not attempt to repair leaking cylinders. Where action can be taken without serious exposure to workers, move the cylinder to an isolated, well-ventilated area (away from combustible materials if the cylinder contains a flammable or oxidizing gas) and contact EHS. Otherwise, evacuate the area and immediately contact LUPD.

FLAMMABLE LIQUIDS

Flammable and combustible liquids should be stored in only certain types of approved containers. Containers used by the manufactures of flammable and combustible liquids generally meet these specifications.

The type of container needed depends on the quantity and class of flammable or combustible liquid.

Safety Can

A safety can is an approved container of not more than 5 gallon capacity that has a spring closing lid and spout cover. Safety cans are designed to safely relieve internal pressure when exposed to fire conditions.

Flammable Liquid Storage Cabinet

A flammable liquid storage cabinet is an approved cabinet that has been designed and constructed to protect contents from external fires.

Storage Considerations

- Quantities should be limited to the amount necessary for the work in progress
- No more than 10 gallons per room combined or flammable and combustible liquids, may be stored outside of a flammable cabinet unless safety cans are used
- Storage of flammable liquids must not obstruct any exit
- Flammable liquids should be stored separately from strong oxidizers, shielded from direct sunlight, and away from heat sources.
- Containers must be sealed when not in use

Handling Precautions

Control all ignition sources in areas where flammable liquids are used. Smoking, open flames and sparks producing equipment should not be used.

Flammable Aerosols

Flammable aerosols are in pressurized containers that may rupture when exposed to fire. As with flammable liquids, these should be stored in flammable storage cabinet.

GENERAL SAFETY

The most important thing you can do to work safely is to think through your project and ask yourself the following questions:

- What type of materials and equipment will I be working with?
- What are the possible hazards will I be using chemicals (including paints), sharp tools, or mechanical equipment that could cause injury or fires?
- Do I understand these hazards and do I know how to use the equipment?
- Have I read all the instructions?
- Do I have permission to use the equipment?
- Do I have the proper PPE (safety glasses, goggles, clothing, shoes, etc.)?
- If something goes wrong, do I know where the emergency equipment is and how to use it (fire extinguisher, eyewash, emergency shower, fire alarm pull station)?

If you have trouble answering any of these questions be sure to ask for help before you begin

Working with Chemicals

Here are some basic general rules that apply to all studios and shops where chemicals are used.

- No eating or drinking. Wash your hands thoroughly when you finish working or leave the studio to remove contaminates from your hands. Good personal hygiene is one of the most important ways you can reduce your exposure
- Avoid eye and skin contact. Never wash your hands in solvent and wear gloves if your hands have cuts or are chaffed. Chemicals can pass through these breaks in your skin and enter directly into your blood stream. Apply skin moisturizers regularly to keep your skin from drying out
- Wear older non-synthetic clothes or a full length smock or coveralls while working in a studio. Wash them frequently and separate them from other clothing

- Wear chemical protective gloves, aprons, and eye protection as necessary when handling solvents and corrosive chemicals, or when cleaning brushes, screens, and other equipment
- Use solvents sparingly, use water-based products instead of solvent-based ones whenever possible
- Label all chemical containers and keep them closed when not in use.
- Wear comfortable shoes. No high heels, sandals, flip flops, open toed shoes or bare feet are allowed
- Long hair should be tied back
- Apply aerosol paints, fixatives, and adhesives in a spray booth or a well ventilated area

Hazardous Waste

Hazardous waste management is ruled by increasingly stringent and complex regulations. The proper management of chemical and hazardous wastes is the responsibility of the generator of the waste. Indiscriminate disposal by pouring waste chemicals down the drain or adding them to mixed refuse for landfill burial is not allowed. Hoods shall not be used as a means of disposal for volatile chemicals. All wastes shall be collected and stored according to the Hazardous Waste Plan. Hazardous waste shall be stored in a safe and secure area with the proper labels attached. For further information see Longwood University's Hazardous Waste Plan.

CERAMICS

Ceramic art and pottery has a wide variety of hazards. The predominate hazard is from silica dust exposure. Specific hazards and precautions can be divided into four areas:

- Working with clay
- Glazing and coloring
- Firing in a kiln
- Potential leaching of finished ware

Clay

Clays are minerals composed of hydrated aluminum silicates, often containing large amounts of crystalline silica. Other impurities may include organic matter or sulfur compounds. Sometimes, grog (ground firebrick), sand, talc, vermiculite, perlite, and small amounts of minerals such as barium carbonate and metal oxides, are added to modify clay properties. Clays can be worked by hand or on the potter's wheel, or cast in a clay slurry into molds.

Clay is made by mixing dry clay with water in clay mixer. Clay slip is made by adding talcs which themselves can be contaminated with fibrous asbestos or asbestos-like materials. Geographical sources of talc's are relevant, for example, New York State talcs are notoriously asbestos-contaminated, while Vermont talc's are not. Pfizer has some fiber-free talcs.

Hazards

- There have been known cases of silicosis, or "potter's rot, from chronic inhalation of large amounts of free silica during clay mixing. Symptoms of silicosis include: shortness of breath, dry cough, emphysema, and high susceptibility to lung infections such as tuberculosis. The disease may take years to develop. Silica dust exposure is not hazardous by skin contact or ingestion.
- Chronic inhalation of kaolin is moderately hazardous, and can result in kaolinosis, a disease in which the lungs become mechanically clogged.
- Asbestos is extremely toxic by inhalation and possibly by ingestion. Asbestos inhalation may cause asbestosis, lung cancer, mesothelioma, stomach cancer, and intestinal cancer.
- Sand, perlite, grog, and vermiculite contain free silica and are, therefore, highly toxic by inhalation. Vermiculite is also frequently contaminated with asbestos.
- There is a danger of accidents if clay or water can be added while the mixer is in operation.
- Bags of clay and glaze materials can be very heavy, and lifting can cause back problems.
- Hypersensitivity pneumonia, asthma, or other respiratory problems may occur with exposure to molds growing in wet clay that is being soured or aged in a damp place, in slips that stand for months, or with inhalation of dry aged clay. Molds can cause or exacerbate skin problems and change the workability of clay.
- Throwing on a potter's wheel for long periods of time can result in carpel tunnel syndrome because of the awkward position of the wrists. Pain, numbness and/or pins and needles in the thumb and first three fingers, are common symptoms. Back problems can occur from bending over the potter’s wheel for long periods of time.
- Hand contact with wet clay can result in abrasion and dryness of fingertips and hands. Moving parts of kick wheels can cause cuts and abrasions.
- Clay scraps on the floor, bench and other surfaces can dry and pulverize, producing an inhalation hazard due to the presence of free silica. Similarly, reconditioning clay by pulverization and sanding finished green ware, can create very high concentrations of hazardous silica dust.

Precautions

- Use premixed clay to avoid exposure to large quantities of clay dust.
- Clay storage and mixing should take place in a separate room. Bags of clay (and other pottery materials) should be stacked on palettes or grids off the floor for easier clean-up.
- All clay mixers should be equipped with local exhaust ventilation to remove fine silica dust particles from the air.
- Clay mixers should be equipped with proper machine guards so that they cannot be opened to add clay or water while the mixer blades are turning.
- Wear separate work clothes while in the studio. Choose clothes of material and design that don't trap dust. Wash these clothes weekly, and separately from other laundry.
- Avoid contact of clay with broken skin. Use a skin moisturizer.

- To prevent back problems, always lift with knees bent. Also, use a standup wheel (Cranbrook style treadle wheel), or elevate electric wheels to a height that doesn't require bending over. Exercise and massage may relieve minor muscular pain.
- Keep wrists in un-flexed position as much as possible to prevent carpel tunnel syndrome. Take frequent work breaks.
- Be careful of the moving parts on kick wheels.
- Recondition clay by cutting still-wet clay into small pieces, letting them air-dry, and soak in water.
- Finish green ware while still wet or damp with a fine sponge instead of sanding when dry. Do not sand green ware containing fibrous talc.
- **Wet mop floors and work surfaces daily to minimize dust levels and prevent dry scraps from becoming pulverized.**

Glazes

Glazes used to color or finish clay pieces are a mixture of silica, fluxes and colorants. Common fluxes include lead, barium, lithium, calcium and sodium, and are used to lower the melting point of silica. The actual colorants, which are an assortment of metal oxides usually account for less than 5% of the glaze by weight.

Originally, soluble raw lead compounds including red lead, white lead, galena, and litharge were used as fluxes in low-fire glazes. In fact, over 400 cases of lead poisoning were reported in British potters in 1897. Lead frits and good housekeeping greatly lowered the number of potters that had been poisoned by these highly toxic lead compounds. Frits are made of melted minerals and metal compounds that are sintered and ground into powder form. While lead frits are sometimes assumed to be insoluble and nontoxic, leaching tests with acids have shown that many frits are as soluble as raw lead compounds and, in fact, there have been cases of lead poisoning from both inhalation or ingestion of these.

High fire porcelain and stoneware techniques eliminate the need for lead as a flux. Also, alkali earth or alkaline earth fluxes can be used for low-fire conditions instead of lead. Silica may also be removed from leadless type glazes. The substitution can be based on boric oxide as the glass-former, instead of silica. Alkali earth fluxes include sodium, potassium, and lithium oxides; alkaline earth fluxes include calcium, magnesium, barium, and strontium oxides. Minerals containing these fluxes include certain feldspars, nepheline syenite, pearlite, bone and plant ashes, whiting, and dolomite.

An assortment of metal oxides or other metal compounds produce particular colors when fired. These are added in such small amounts to the glaze, that they aren't usually a great hazard. Luster or metallic glazes are fired in a reduction atmosphere. These glazes can contain mercury, arsenic, highly toxic solvents such

as aromatic and chlorinated hydrocarbons, and oils such as lavender oil. The common metals are often resonates of gold, platinum, silver, and copper. Some underglazes and over glazes use mineral spirits as the vehicle instead of water.

Glaze components are weighed, sorted and mixed with water. These materials are often in fine powdered form, and result in high dust exposures. Glazes can be dipped, brushed, poured, or sprayed on the ceramic piece.

Hazards

- Lead compounds are highly toxic by inhalation or ingestion. Symptoms of lead poisoning include: damage to the peripheral nervous system, brain, kidney, or gastrointestinal system, as well as anemia, chromosomal damage, birth defects and miscarriages.
- Lead-glazed food ware can leach lead if not fired properly, or if the glaze composition is not correctly adjusted. For example, the addition of copper to lead frits renders a higher solubility of lead in the final fired ware. Acidic drinks and foods such as tomato juice, citric juices, sodas, tea, or coffee, can increase this hazard.
- A glaze label marked "lead-safe" means that the finished ware, if fired properly, will not release lead into food or drink. The actual glaze is still hazardous to handle and fire and may contain lead. Adequate control over firing conditions is very difficult in the craft studio.
- Other fluxes such as barium and lithium are also highly toxic by inhalation, but less so than lead.
- Certain colorant compounds of particular metals are known or probable human carcinogens, including: arsenic, beryllium, cadmium, chromium (VI), nickel, and uranium.
- Antimony, barium, cobalt, lead, lithium, manganese, and vanadium colorant compounds are highly toxic by inhalation.
- Antimony, arsenic, chromium, vanadium, and nickel compounds are moderately toxic by skin contact.
- Free silica occur in many of the clays, plant ash, flint, quartz feldspars, talcs, etc. used in glazes. See the discussion above for the hazards of silica and the disease silicosis. Weighing and mixing glazes can result in the inhalation of these toxic materials.
- Soda ash, potassium carbonate, alkaline feldspars, and fluorspar used in glazes are skin irritants.
- Spray application of glazes is very hazardous because of the potential inhalation of glaze mists.
- Dipping, pouring, and brushing certain glazes may cause skin irritation and accidental ingestion due to careless personal hygiene habits.
- Glazes containing solvents are both flammable and hazardous**.**

Precautions

- Use lead-free glazes. If the glaze does not state "lead-free" or "leadless" on the label, assume it contains lead until proven otherwise.
- Lead glazes should only be used on non-food ware items. Design lead-glazed pieces so that they won't be used for food or drink. Lead-glazed pottery should be labeled as lead-containing.

- If possible, don't use colorants that are known human carcinogens and avoid probable human carcinogens. There is no known safe level of exposure to carcinogens.
- Consider wearing a respirator when weighing and mixing powders. Wet glazes are not an inhalation hazard. Good housekeeping procedures and cleanup of spills reduce the risk of inhalation or ingestion of toxic dusts. Wet mop spilled powders.
- Gloves should be worn while handling wet or dry glazes.
- Good dilution ventilation or local exhaust ventilation should be available when applying solvent-containing glazes.
- Basic personal hygiene rules should be followed including restricting eating, drinking, or smoking in the studio, and wearing personal protective equipment such as gloves, and separate work clothes or coveralls. Wash hands after work. Leftover glazes and glaze scrapings can be homogenized, combined, tested, and used as a glaze.

Kilns

Electric kilns and fuel-fired kilns are used to heat the pottery to the desired firing temperature. The most common type are the electric kilns. Heating elements heat the kiln as electric current passes through the coils. The temperature rises until the kiln is shut off.

Fuel-fired kilns are heated by burning gas (natural or propane), oil, wood, coke, charcoal or other materials. Propane gas or natural gas is used most often. These kilns can be either located indoors or outdoors. The fuels produce carbon monoxide and other combustion gases. Fuel-fired kilns are usually vented from the top through a chimney.

Firing temperatures can vary from as low as 1382°F for raku and bisque wares, to as high as 2372 °F for stoneware, and 2642 °F for certain porcelains.

The early stages of bisque firing involves the oxidization of organic clay matter to carbon monoxide and other combustion gases. Sulfur breaks down later producing highly irritating sulfur oxides. Also, nitrates and nitrogen-containing organic matter break down to nitrogen oxides.

Galena, Cornish stone, crude feldspars, low grade fire clays, fluorspar, gypsum, lepidolite and cryolite can release toxic gases and fumes during glaze firings. Carbonates, chlorides, and fluorides are broken down to releasing carbon dioxide, chlorine, and fluorine gases.

At or above stoneware firing temperature, lead, antimony, cadmium, selenium and precious metals vaporize and the metal fumes can either escape from the kiln, or settle inside the kiln or on ceramic ware in the kiln. Nitrogen oxides and ozone can be generated from oxygen and nitrogen in air.

Hazards

- Chlorine, fluorine, sulfur dioxide, nitrogen dioxide, and ozone are highly toxic by inhalation. Bisque firings of high-sulfur clay have caused the production of great amounts of choking sulfur dioxide. Other large acute exposures to gases are not common. Inhalation of large amounts of these gases can result in severe acute or chronic lung problems. Long-term inhalation of low levels of these gases can cause chronic bronchitis and emphysema. Fluorine gas can also cause bone and teeth problems.
- Many metal fumes generated at high temperatures are highly toxic by inhalation. Since lead vaporizes at a relatively low temperature, it is especially hazardous.
- Carbon monoxide from fuel-fired kilns or the combustion of organic matter in clays is highly toxic by inhalation and can cause oxygen starvation. One symptom of carbon monoxide poisoning is an intense frontal headache, unrelievable by analgesics.
- Hot kilns produce infrared radiation, which is hazardous to the eyes. There have been reports of cataracts, from years of looking inside the hot kilns.
- Heat generated by the kiln can cause thermal burns. The Edward Orton Jr. Ceramic Foundation reported that when a kiln was operated at 2370 °F, the surface temperature, was at and above 595 °F, and the temperature one foot away from the peephole was 156 °F.
- Heat produced by even small electric kilns can cause fires in the presence of combustible materials or flammable liquids.
- If an electric kiln fails to shut off, the heating elements melt which can cause fires. Gas kilns also generate a lot of heat, and room temperatures often exceed 100 °F.

Precautions

- Infrared goggles approved by the American National Standards Institute (ANSI) or hand-held welding shields should be worn when looking into the operating kiln. Shade number from 1.7 to 3.0 is recommended, but a darker shade may be required if spots appear in front of one's eyes after looking away from the kiln.
- Do not use lead compounds at stoneware temperatures since the lead will vaporize.
- Lumber, paper, solvents, or other combustible and flammable materials should not be stored in kiln areas.
- Always check that the kiln has shut off.
- If gas leaks are suspected (e.g. gas odor): shut off gas at the source; shut off power to the kiln room at the circuit breaker; and call the gas company. Test for leaks with nonfat, soapy water or use approved leak-detection solutions.

Salt Glazing

This process involves throwing wet salt (sodium chloride) into the heated kiln while the bisque ware is being fired. Wet salt at high temperatures decomposed to sodium and chlorine. The sodium reacts with the bisque ware to form a glaze. Large amounts of hydrogen chloride gas and possibly chlorine are also formed.

Sodium carbonate (washing soda) can also be used. Carbon dioxide is generated instead of hydrogen chloride.

Hazards

- Hydrogen chloride gas is highly toxic by inhalation. Health effects are both similar and more irritating compared with most other kiln gases. Often, local environmental protection laws ban salt kilns.
- Hydrogen chloride and water vapor form hydrochloric acid, which can corrode metal fittings in the area.

Precautions

- Substitute safer sodium carbonate for sodium chloride.
- Sodium chloride salt glazing should only be done outdoors. Kilns should be equipped with canopy hoods and chimney stacks that are tall enough to disperse the hydrogen chloride safely.
- All gas piping, and metal fixtures should be routinely checked for corrosion.

Raku Firing

Raku involves first firing ware at a low temperature in a regular gas kiln, and then removing the still hot pieces and placing in them in sawdust, leaves or other organic materials for a reduction phase.

Hazards

- See above for the hazards and safety precautions used with gas kilns.
- The reduction step produces large amounts of smoke and carbon monoxide.
- Treated wood or other materials can yield an exposure to highly toxic preservatives or pesticides, such as arsenic and chromium compounds.

Precautions

- Raku should only be done outdoors because of smoke. Be careful to not locate raku near air intakes or open windows of buildings.
- Do not use materials that have been treated with preservatives or pesticides for the reduction phase.

Leaching of Finished Ceramic Ware

Lead Leaching

There is a real concern about lead leaching into food and drink from pottery fired with lead glazes. Both the U.S. Food and Drug Administration (FDA) and the Canadian Consumer and Corporate Affairs have regulated how much lead can leach from food ware into food and drink. Acidic liquids are of particular concern. Similarly, continual microwave reheating, (e.g. a coffee mug at work) can yield greater leaching of lead glazes. Many cases of lead poisoning, and even some fatalities, have occurred from the leaching of lead from lead-glazed pottery.

While commercial ceramics companies routinely test their ware for lead leaching, craft potters do not have the same quality control as does the ceramics industry, and lead leaching is more of a problem.

According to United States regulation, ceramic ware that does not pass the lead leaching tests must have a permanent fired decal stating:

**"NOT FOR FOOD USE - MAY POISON FOOD.
FOR DECORATIVE PURPOSES ONLY."**

As mentioned earlier, you can also drill a hole in the pottery so it cannot be used for liquids or food.

Preferably, do not use lead glazes, especially for food and drink vessels. Any food ware finished with lead glazes should be tested regularly by certified laboratories.

Other Leachable Metals

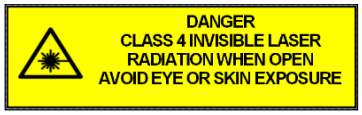
Other metals can leach into food and drink. Cadmium is the single metal besides lead presently regulated in the United States and Canada. However, other possible toxic metals in glazes can leach. Barium has been seen in some tests to leach in hazardous amounts from certain glaze formulations. If a barium glaze, or other glaze, changes color from contact with food, do not use the vessel for food. Try and use only glazes with calcium, magnesium, potassium, and sodium fluxes and minimize the amounts of toxic metal colorants. Routine testing for other metal leaching should be done. More research needs to be done in this area.

LASER SAFETY FOR THE LASER CUTTER

A laser cutter is a cutting device which focuses a high energy laser beam onto a material resulting in a high quality and dimensionally accurate cut. These devices can be used to cut, etch, engrave, or drill a variety of materials. They are often easily affordable and easy to use causing the use of laser cutters by schools, hobbyists, small businesses, makerspaces and universities to expand significantly. Laser cutters are normally fully enclosed systems that prevent laser operation unless the safety interlocked doors are fully closed. They typically contain a carbon dioxide (CO_2) laser that produces invisible laser radiation at a wavelength of 10600 nm in the infrared spectrum.

Classification

Since they are a fully enclosed and interlocked systems, laser cutters are normally a low-risk, Class 1 lasers in accordance with ANSI Z136.1 Safe Use of Lasers. These devices are safe when used as designed, without manipulating the safety features, and are exempt from LU laser registration and other control measures.



HOWEVER, the lasers embedded inside the enclosed system are often Class 3B or Class 4 lasers, which emit high energy laser beams capable of causing serious eye and skin injury if the beam is not contained within the device. Therefore, safety interlocks should never be bypassed without permission from EHS. Laser cutters must be obtained from a reputable suppliers and must be in full compliance with the FDA regulations

Training and PPE

All users must be properly trained on the potential hazards, control measures, manufacturer's operating procedures, use of personal protective equipment (PPE), emergency procedures, and safety precautions for operating the laser cutter.

Required PPE includes safety glasses to protect eyes from particles, debris, etc., proper skin protection to reduce burns, and hearing protection (if necessary).

Hazards

- The invisible high energy laser beam can cause severe eye damage, including blindness and serious skin burns. The doors are interlocked such that the laser beam will be disabled when the doors are opened. This will completely contain the laser beam under normal operations. The invisible high energy laser beam can cause severe eye damage, including blindness and serious skin burns. The doors are interlocked such that the use.
- Improper use of the controls and modification of the safety features may cause serious eye injury and burns.

Precaution

- **DO NOT** modify or disable any safety features of the laser system.
- **DO NOT** operate the laser unless all covers are in place and interlocks are working properly.
- **DO NOT** look directly into the laser beam.

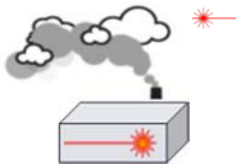
Fire

- The high intensity laser beam can produce extremely high temperatures and significant amounts of heat as the substrate material is burned away while cutting.
- Some materials can catch fire during cutting operations creating fumes and smoke inside the device.
- Dirt and debris may cause fire and a poor quality cut or mechanical component failure
- It is important that users remain with the laser during operation to ensure that any flare-ups/ flame are properly contained and extinguished.

- Obtain the Safety Data Sheet (SDS) from the material's manufacturer when handling or processing the materials.

- **DO NOT** use materials that are highly flammable, explosive or produce toxic byproducts.
- **DO NOT** remove material from the cutting bed before it has cooled.
- **DO NOT** leave a laser cutter operating unattended.
- **ALWAYS** clean up clutter, debris and flammable materials in the laser cutter after use.
- **ALWAYS** keep a properly maintained fire extinguisher nearby.

Air Contaminates



- Laser cutters will generate fumes, vapors, particulates, and metal fumes from substrate that can be highly toxic (plastics and other combustible materials).
- All laser cutter systems must be equipped with a fume exhaust system and filtration system that meets manufacturer specifications.
- These fumes or air contaminants can damage the machine and harm your health. If the air filter or exhaust system is malfunctioning, immediately stop operating the laser cutter and notify your supervisor.
- Filters must be changed regularly according to the frequency of use or as specified by the manufacturer.
- **DO NOT** cut a material that has not been approved by the manufacturer.
- **DO NOT** use a laser cutter with a malfunctioning exhaust system or clogged air filter.

JEWLERY MAKING AND METALWORKING

The hazards associated with metalworking depend on the type of work performed and methods used. Artists may weld, braze, or solder metals as well as cast or forge them. Carefully review the Safety Data Sheet (SDS) for the products your students will use and identify the hazardous materials involved in their projects.

Hazards

Metal Casting: The sand used in molds has high silica content, which can become airborne when being mixed with binders and resins. Some resins (phenol-formaldehyde, hexamethylenetetramine, polyurethane) are moderately toxic by skin contact and inhalation. Some mold releases may contain asbestos as a contaminant. Melting metal can liberate metal fume (a small, deeply inhaled particle). The lead and zinc commonly found in bronze, as well as other metals, are highly toxic in this form. Furnaces may generate combustion products, such as

carbon monoxide, that are highly toxic. Furnaces also generate high heat and infrared radiation that can lead to heat stress, skin burns, and possible cataracts. Pouring metal liberates metal fume, and the hot metal will burn the organic resins and binders in the sand mold, releasing potentially toxic decomposition products. Molten metal can cause severe burns. Breaking up sand molds can release high levels of silica dust.

Metal Forging: Metal forging involves shaping hot or cold metal with hammers and generates high noise levels and potential for crushing injuries. The furnaces used to heat metal may generate combustion products, such as carbon monoxide, that are highly toxic. Furnaces also generate high heat and infrared radiation. Hot metal can cause severe burns.

Welding, Brazing, Soldering: The welding process generates a number of toxic air contaminants, including metal fume. If high energies are involved, such as in arc welding, oxides of nitrogen, ozone, and highly irritating acidic gases can also be created. If the metals being welded are coated with metals such as lead paint, zinc, chrome, cadmium, or other toxic materials, these metals will become vaporized and could be highly toxic if inhaled. Cobalt, chromium, cadmium, nickel, and beryllium are carcinogenic and cause brain damage. The ultraviolet radiation emitted from arc welding can transform chlorinated hydrocarbons into extremely toxic phosgene gas. Oxyacetylene torches produce carbon monoxide. The physical hazards associated with welding include electric shock (arc welding), burns, fires, and exposure to infrared and ultraviolet radiation. Lead and zinc are sometimes found in brazing rods, and fluoride and lead are common hazards associated with soldering.

Precautions

- Use silica-free sand. Mix molding sand under local exhaust ventilation if possible. Otherwise, wear appropriate respiratory protection.
- If possible, avoid using formaldehyde and polyurethane resins in molding sand and all asbestos-containing mold releases. Avoid using metals that contain lead, zinc, nickel and other toxic metals.
- The furnace should be locally exhausted to remove combustion gases and fume generated from molten metal (casting).
- Wear appropriately shielded goggles, a helmet and/or a face shield (depending on the work you are doing), coveralls, apron, insulated gloves, and shoe coverings when working around hot metal and furnaces. Wear earplugs or muffs while forging.
- Work in pairs to pour metals into molds or use mechanical lifting aids. The pouring area should be equipped with local exhaust ventilation and contain a sand pit to catch overflow metal. Never pour directly over cement. Never let molten metal come in contact with water, grease, oil, or other organic materials.
- Keep a fire extinguisher close by and know how to use it.

- Before using welding equipment, carefully review the manufacturer's operational and safety procedures for all electrical equipment, compressed gas cylinders, regulators, and torches. After reviewing this information, obtain additional instruction and assistance in using the equipment from a qualified instructor. Follow all operational and safety instructions for your equipment.
- Report any damaged welding equipment to your instructor immediately.
- Use local exhaust ventilation to collect air contaminants generated while welding.
- Never store or use chlorinated hydrocarbons or flammable or combustible materials in the same area in which you are welding, particularly arc welding.
- Use a welding curtain to shield your work from others.
- When finished working or leaving the studio wash your hands thoroughly. Good personal hygiene is one of the most important ways you can reduce your exposure.
- Wear a full-length smock or coveralls in the studio and do not wear them outside the studio. Wash them frequently and separately from other clothing.

Metal Cutting: Metal shears are typically used to make straight cuts in flat sheet metal stock. Metal shears may be bench mounted or have integral stands and can be manually powered or electrically, hydraulically, and/or pneumatically powered. For the purpose of this Procedure, the term "shear" will be used to refer to manual and powered metal shears unless specifically stated.

Hazards

- Amputation – The shear blade can easily amputate body parts if proper safe guards and procedures are not used.
- Flying Objects – Cutting activities can generate sharp flying chips. Work pieces can become disengaged and be flung across the room. This is especially true for cutoffs on the exit side of the shear.
- Cuts, Laceration, and Puncture – Sharp edges on tooling, sharp edges and potential burrs on the work piece are created when using this tool.
- Pinch Points – Potential pinch points exist with hold down clamps, moving shear parts, and between the work piece and the tool. Familiarity of all potential pinch points, appropriate guarding, and proper tool use will prevent accidental contact with pinch points.

Precautions

- Understand and follow manufacturer operating procedures.
- Inspect the tool for damage prior to use.
- Verify all guards are in place and adjusted properly.
- Do not bypass any safety devices.
- Always stay at the machine while it is running.
- Clean the tool after use.
- Report any malfunction or damage to the Shop Supervisor after tagging the tool "Out of Service, do not use".
- Always keep fingers clear of the blade.

- For foot operated manual shears, keep the foot that is not being used out from under the treadle. Never exceed the capacity of the tool. For hand operated manual shears, never attempt to exceed the capacity by using an extension bar on the handle to increase leverage. Similarly, for foot operated manual shears, never attempt to exceed the capacity by jumping on or placing both feet on the treadle.
- Never attempt to shear multiple work pieces at a time.
- If a two-person operation is required, communication and responsibilities must be clear and defined. The helper must give the signal to the operator to cycle the shear. The operator must know the helper's position at all times and give a "clear" signal before bringing the blade down.
- Never feed material from the backside of the shear.
- Never feed material from the backside of the shear.
- Only wear protective gloves when handling sheet metal with manual shears with no powered feed.
- Place scraps and trimmings in metal waste containers

LITHOGRAPHY AND RELIEF PRINTING

Inks

Intaglio, lithography and relief inks consist of pigments suspended in either linseed oil or water as a vehicle. There can be additional hazardous binders or preservatives, etc.

Hazards

Oil-based inks contain treated linseed oils. While linseed oil is not considered a hazard by skin contact or inhalation, ingestion of large amounts of some treated linseed oils might be hazardous due to presence of small amounts of toxic heavy metals. Oil vehicles are flammable when heated, and rags soaked in these may ignite by spontaneous combustion.

Precautions

- Know what materials are used.
- Obtain the Safety Data Sheets (SDSs) on all products used. Use the least toxic inks possible.
- Do not use an open flame to heat linseed oil, linseed oil, varnishes, or burnt plate oil. Take normal fire prevention measures (e.g. no smoking or open flames in work area).
- Place oil-soaked rags in self-closing disposal cans and remove from the studio each day. An alternative is to place the oil-soaked rags on a drying rack, but do not pile them up.

Pigments

Pigments are the colorants used in lithography, intaglio, and relief printing inks. There are two types of pigments: inorganic pigments, and organic pigments.

Hazards

- Pigment poisoning can occur if pigments are inhaled or ingested. For normal printing with prepared inks, the main hazard is accidental ingestion of pigments due to eating, drinking or smoking while working, or inadvertent hand to mouth contact.
- The classic example of a toxic inorganic pigment in printmaking is lead chromate (chrome yellow). Lead pigments can cause anemia, gastrointestinal problems, peripheral nerve damage (and brain damage in children), kidney damage and reproductive system damage. Other inorganic pigments may be hazardous also, including pigments based on cobalt, cadmium, and manganese.
- Some of the inorganic pigments, in particular cadmium pigments, chrome yellow and zinc yellow (zinc chromate) may cause lung cancer if inhaled. In addition, lamp black and carbon black may contain impurities that can cause skin cancer.
- Chromate pigments (chrome yellow and zinc yellow) may cause skin ulceration and allergic skin reactions.
- The long-term hazards of the modern synthetic organic pigments have not been well studied.

Precautions

- Obtain SDSs on all pigments. This is especially important because the name that appears on label of the color may or may not truly represent the pigments present.
- Use the safest pigments possible. Avoid lead pigments.
- Avoid mixing dry pigments whenever possible. If dry pigments are mixed, wear a NIOSH-approved toxic dust respirator.

Solvents

In general, organic solvents are one of the most underrated hazards in art materials. Organic solvents are used in printmaking to dissolve and mix with oils, resins, varnishes, and inks, and to clean plates, rollers, tools, and even hands.

Hazards

- Repeated or prolonged skin contact with solvents can cause defatting of the skin and resultant dermatitis. Many solvents can also be harmful through skin absorption.
- Inhalation of solvent vapors is the major way in which solvents are harmful. High concentrations of most solvents can cause dizziness, nausea, fatigue, loss of coordination, or coma. This can also increase the chances for mistakes and accidents.

- Many solvents are toxic if ingested. Swallowing an ounce of turpentine can be fatal.
- Most solvents, except chlorinated hydrocarbons, are also either flammable or combustible.

Precautions

- Obtain the SDS on all solvent products used. Use the least toxic solvent possible. For example, replace the more toxic methyl alcohol with denatured alcohol or isopropyl alcohol.
- Use adequate ventilation.
- Keep minimum amounts of solvents on hand and purchase in smallest practical container size. Large amounts of solvents or solvent-containing materials should be stored in a flammable storage cabinet.
- Never store solvents or solvent-containing materials in food or drink containers. Always label containers.
- Do not allow smoking, open flames or other sources of ignition near solvents.
- Have a class B fire extinguisher in the area. If ordinary combustible materials are present, you may need a Class ABC fire extinguisher.
- Wear gloves when handling solvents to avoid skin contact In particular do not use solvents to clean ink off hands. Baby oil is a good substitute.

Acids

Acids are used in intaglio (acid etching) and in lithography. Strong acids commonly used include nitric acid, hydrochloric acid, ferric chloride, and phosphoric acid, and less commonly carbolic acid (phenol), chromic acid, hydrofluoric and sulfuric acids.

Hazards

- Concentrated acids are corrosive to the skin, eyes, respiratory system and gastrointestinal system. Dilute acids can cause skin irritation on repeated or prolonged contact.
- Chromic acid is a skin sensitizer, suspect carcinogen, and oxidizer.
- Phenol is highly toxic by skin absorption and ingestion. It may cause severe kidney damage, central nervous system effects and even death if absorbed in large amounts.
- Hydrofluoric acid is highly toxic and can cause severe, deep burns which require medical attention. There is no immediate pain warning from contact with hydrofluoric acid.
- Concentrated nitric acid is a strong oxidizing agent and can react explosively with other concentrated acids, solvents, etc. Nitric acid gives off various nitrogen oxide gases, including nitrogen dioxide which is a strong lung irritant and can cause emphysema.

Precautions

- Know what is used. Obtain the SDS for all acids.

- Whenever possible avoid concentrated acids.
- Doing acid etching requires working in an enclosed hood, or in front of a slot exhaust hood or window exhaust fan at work level.
- Store concentrated nitric and chromic acids away from organic materials. Concentrated nitric acid should always be stored separately even from other acids.
- An important safety rule when diluting concentrated acids is to add the acid to the water, never the reverse.
- Wear appropriate gloves, goggles and protective apron or lab coat when handling acids.
- If adequate ventilation is not available, wear a NIOSH-approved respirator with acid gas cartridges. Contact EHS for a respirator.
- If acid is spilled on your skin, wash with lots of water. In case of eye contact, rinse the eyes with water for at least 15 minutes and seek medical attention.

Lithography

Lithography uses either zinc and aluminum metal plates or stones for printing. It involves use of a variety of chemicals to make the image ink-receptive and non-image areas receptive to water and ink-repellent.

Plate and Stone Preparation

A variety of drawing materials with high wax and fatty acid content are used to make the image, including tusche and lithographic crayons. Airbrushing liquid drawing materials or using spray enamel or lacquer is also common. Other materials used in stone or plate processing include etch solution containing acids and gum arabic, counter etch solutions containing acids and sometimes dichromate salts, and fountain solutions containing dichromate salts. Phenol (carbolic acid) has been used for removing grease from stones, and a variety of solvents including lithotine, gasoline, kerosene, and mineral spirits, which are used for diluting drawing materials, washing out images and correction of images. Talc and rosin mixtures are also used. Metal plates are prepared with solvent-based vinyl lacquers.

Hazards

- Acids used include phosphoric, nitric, acetic, hydrochloric, hydrofluoric and tannic acids. The concentrated acids are corrosive, and even dilute acid solutions can cause skin irritation from prolonged or repeated contact. Hydrofluoric acid and phenol are the most dangerous to use.
- Lithotine, kerosene, and mineral spirits are skin and eye irritants and inhalation can cause intoxication and respiratory irritation.
- The solvents contained in vinyl lacquers can include highly toxic Isophorone and cyclohexanone. Methyl ethyl ketone (MEK), which is moderately toxic, is often used as a thinner.
- Dichromate salts may cause skin and nasal ulceration and allergic reactions, and are suspect cancer-causing agents.
- Rosin dust may cause asthma and allergic dermatitis. There is the hazard of explosion from the buildup of rosin dust, in enclosed rosin boxes, around an ignition source.
- Talc's may be contaminated with asbestos and silica.
- Airbrushing drawing materials or using spray enamel paints is more hazardous than drawing with a brush because the inhalation hazard is higher.

Precautions

- Obtain the SDS for all materials used.
- See Acids and Solvents sections for the precautions with acids and solvents.
- Use the least toxic solvents. Gasoline should never be used. Lithotine and mineral spirits are less toxic than the more irritating kerosene.
- Use asbestos-free talc's such as baby powders.
- Avoid dichromate-containing counter etches and fountain solutions if possible. Do not use hydrofluoric acid or phenol.
- Appropriate gloves, goggles and a protective apron should be worn when mixing or using concentrated acids.

Printing and Cleanup

For all types of lithographic inks, solvents are used to make image corrections on the press, to remove images, and to clean the press bed and rollers.

Hazards

Some roller cleaners and glaze cleaners can contain chlorinated hydrocarbons such as perchloroethylene and methylene chloride. Most chlorinated solvents (except 1,1,1-trichloroethane) have been shown to cause liver cancer in animals and are therefore suspect human carcinogens. In addition perchloroethylene can cause liver damage, and methylene chloride heart attacks.

Precautions

- Know materials used. Obtain the SDS for all solvents. See Solvents section for the precautions with solvents.
- Choose products that do not contain chlorinated solvents whenever possible.
- For small scale solvent use in correcting images or cleaning the press bed using lithotine or mineral spirits, dilution ventilation (e.g. window exhaust fan) is sufficient.

Intaglio

Intaglio is a printmaking process in which ink is pressed into depressed areas of the plate and then transferred to paper. These depressed areas can be produced by a variety of techniques, including acid etching, dry point, engraving and mezzotint.

Etching

Etching involves use of dilute nitric acid, Dutch mordant (hydrochloric acid plus potassium chlorate) or ferric chloride to etch the zinc or copper (respectively) metal plate. Unetched parts the plate are protected with resists such as stop out varnishes containing ethyl alcohol, grounds containing asphaltum or gilsonite and mineral spirits, rubber cement, and rosin or spray paints for aquatinting. Sometimes, soft grounds contain more toxic solvents.

Hazards

- See Solvents section for the hazards of solvents. 1,1,1- trichloroethane found in some soft grounds is moderately toxic by inhalation under normal conditions but may cause fatalities at very high concentrations.
- See Acids section for the hazards of acids. In particular nitric acid etching releases the respiratory irritant nitrogen dioxide which has poor odor warning properties. During the etching process, flammable hydrogen gas is also produced.
- Concentrated nitric acid is a strong oxidizing agent and can react with many other chemicals, especially solvents or other organic compounds, to cause a fire.
- Mixing hydrochloric acid with potassium chlorate to make Dutch mordant produces highly toxic chlorine gas. Potassium chlorate is a key ingredient in many pyrotechnics, and is a potent oxidizing agent. It can react explosively with organic compounds, sulfur compounds, sulfuric acid or even dirt or clothing. On heating it can violently decompose to oxygen and potassium chloride. Storage and use are very dangerous require special precautions especially when mixing.
- Rosin dust (and asphaltum dust which is also sometimes used) is combustible. Sparks or static electricity have caused explosions in enclosed rosin and aquatint boxes. Rosin dust may also cause asthma and dermatitis in some individuals.
- Inhalation of solvents and pigments can result from use of aerosol spray paints.

Precautions

- Obtain the SDS for all materials used.
- See Solvents and Acids sections for specific precautions.
- Use Dutch mordant with extreme caution. A safer substitute for etching copper plates is ferric chloride (iron perchloride). This forms acidic solutions so should be handled accordingly, but does not have the dangers of handling concentrated acids. Ferric chloride solution might cause minor skin irritation from prolonged contact.
- Application of grounds or stop outs should be done with local exhaust ventilation, (e.g. slot or enclosed hood).
- Acid etching should be done with local exhaust ventilation. See section on precautions for Acids for more information. Rosin (or asphaltum) boxes should be explosion-proof. Use spark proof metal cranks, explosion-proof motors, or compressed air. Don't use hair dryers to stir up rosin dust.

Other Techniques

Dry point, mezzotint and **engraving** use sharp tools to incise lines in metal plates.

Hazards

- One major hazard associated with these types of processes involves accidents with sharp tools.
- Long-term use of these tools can cause carpel tunnel syndrome, which can cause numbness and pain in the first three fingers. Severe cases can be incapacitating.

Precautions

- Keep tools sharp, store them safely and always cut away from yourself.
- When possible, clamp down plates to avoid slippage.
- Minimize the chance of carpel tunnel syndrome by choosing tools with wide handles, avoiding tight grips, and doing hand flexing exercises during regular rest periods. Set work table height so wrist flexing motions are minimal.

Printing and Cleanup

Intaglio inks contain pigments, treated linseed oil and modifiers. Printing involves placing the ink on the inking slab, inking the plate by hand, and then printing. Cleanup of inking slab, press bed, and cleaning the plate is done with a variety of solvents including mineral spirits, alcohol, lithotine, turpentine, etc.

Hazards

- Preparing your own inks from dry pigments can involve inhalation of toxic pigments. See Pigments section for the hazards of pigments.
- See Solvents section for the hazards of solvents. Plate cleaning is more hazardous than cleaning inking slabs or press beds because larger amounts of solvents are used.
- Lithotine, turpentine, or oil-soaked rags can be a spontaneous combustion hazard if improperly stored.

Precautions

- See Pigments and Solvents sections for the specific precautions for pigments and solvents.
- NIOSH-approved respirators with organic vapor cartridges can be used if ventilation is not adequate.

Relief Printing

Relief printing techniques include woodcuts, linoleum cuts and acrylic plates for plaster relief. These techniques involve the cutting away of plate areas that are not to be printed. Relief inks can be oil-based or water-based.

Hazards

- Some woods used for woodcuts can cause skin irritation and/or allergies. This is particularly true of tropical hardwoods.
- Accidents involving sharp tools can result in cuts.
- Wood carving and cutting tools can cause carpel tunnel syndrome. This was discussed earlier in the section that included dry point and mezzotint.

- Caustic soda (sodium hydroxide) is sometimes used for etching linoleum. It can cause skin burns and severe eye damage if splashed in the eyes.
- Eating, drinking or smoking while printing can result in accidental ingestion of pigments.
- Hazardous solvents are used in stop outs and resists in linoleum etching, and for cleaning up after printing with oil-based inks. See Solvents section for more information on the hazards of solvents.

Precautions

- Obtain the SDS for all materials used.
- See Acids and Solvents sections for precautions with acids and solvents.
- Water-based inks are preferable to oil-based inks since solvents are not needed.
- Wear appropriate gloves, goggles and protective apron when handling caustic soda.
- If the chemical is spilled on your skin, wash with lots of water. In case of eye contact, rinse the eyes with water for at least l5-20 minutes and contact a physician.
- Always cut in a direction away from you, with your free hand on the side or behind the hand with the tool.
- Carpel tunnel syndrome can be minimized or avoided by using tools with wide handles, avoiding tight grips, and rest periods with hand flexing exercises. Linoleum cutting is softer to work, and thus can reduce musculoskeletal injury.

Collagraphs

Collagraphs are prints produced by using a collage of different materials glued onto a rigid support. A wide variety of materials and adhesives can be used in making collagraphs.

Hazards

- Rubber cement, a common adhesive used with collagraphs, is extremely flammable and most rubber cements and their thinners contain the solvent n-hexane which can cause damage to the peripheral nervous system (hands, arms, legs, and feet) from chronic inhalation.
- Epoxy glues can cause skin and eye irritation and allergies.
- Spraying fixatives on the back of collagraph plates to seal them can involve risk of inhalation of the solvent-containing spray mist.
- Sanding collagraph plates which have been treated with acrylic modeling compounds or similar materials can involve inhalation of irritating dusts.

Precautions

- Know the hazards of materials used. Obtain the SDSs from the manufacturer.
- Use the least toxic materials available. In particular use water-based glues and mediums (e.g. acrylic medium) whenever possible. Some rubber cements are made with the solvent heptane, which is less toxic than n-hexane, primarily because peripheral neuropathy is not associated with its use.
- Wear gloves when using epoxy glues.
- Wear a NIOSH-approved toxic dust respirator when sanding collagraph plates. Contact EHS for respirator.

Plastic Prints

Plastic prints can involve making prints from a wide variety of plastic materials and resins.

Hazards

Plastic prints can involve hazards from inhalation of plastic resin vapors (e.g. epoxy resins) and also from inhalation of decomposition fumes from drilling, machining, sawing, etc. of finished plastics.

Precautions

- Obtain the SDS for all materials used.
- See Solvent section for the precautions with solvents.
- Use the least toxic material available.
- Have adequate ventilation.

Monoprints

Monoprints involve standard intaglio, lithographic and other printmaking techniques, but only one print is made. Monoprints have the same hazards involved in plate preparation and printing as the parent techniques.

Photoprintmaking

Photoprintmaking involves exposing a light-sensitive emulsion or film to ultraviolet light through a transparent support containing an opaque image to transfer the image to a plate. The transparency through which the photoemulsions are developed can include drawings on a transparent support such as Mylar or acetate, or photographic images processed on graphic arts film to yield a positive image. Several photoprintmaking methods will be discussed.

Photolithography

Photolithography involves transferring graphic images to stones or metal plates that are coated with a light-sensitive emulsion. One can coat the stone or metal plate, or use presensitized metal plates. Light-sensitive emulsions used on stone consist of a mixture of powdered albumin, ammonium dichromate, water, and ammonia; commercial emulsions are usually based on diazo compounds. Developing solutions for these mixtures often contain highly toxic solvents. Diazo-sensitizing solutions, developers with highly toxic solvents, plate conditioners containing strong alkali, and other brand name mixtures are used for metal plates.

Hazards

- Diazo photoemulsions are the least hazardous although they can cause eye irritation.
- Ammonium dichromate used for stone is a probable human carcinogen, is moderately toxic by skin contact, and may cause allergies, irritation, and external ulcers; it is highly flammable and a strong oxidizer.
- Ammonia is a skin irritant and highly toxic by inhalation. Ammonia is highly corrosive to the eyes. It has good odor-warning properties.
- Light exposure sources include photoflood lamps, vacuum Poly- Lite units, and carbon arcs. Carbon arcs produce large amounts of ultraviolet radiation which can cause skin and eye damage and possible skin cancer. Carbon arcs also produce hazardous metal fumes, and ozone and nitrogen dioxide (which can cause emphysema), and toxic carbon monoxide.
- Screen cleaning solutions include strong caustic solutions, enzyme detergents which can cause asthma, and chlorine bleach. These are skin and respiratory irritants.
- Many solvents used in developing solutions are highly toxic both by inhalation and skin absorption.

Precautions

- Obtain a SDS for all materials used.
- See Solvents section for more precautions with solvents.
- Avoid ammonium dichromate and use presensitized plates if possible. If you cannot substitute, wear gloves and goggles. Store it away from heat, solvents and other organic materials.
- Use ammonia solutions or solvent-containing photolithographic solutions inside a laboratory hood, or in front of a slot exhaust hood. Wear gloves, goggles, and if ventilation is inadequate, a respirator. Contact EHS for respirator.
- Do not use carbon arcs unless they are equipped with local exhaust ventilation exhausted to the outside. Quartz mercury or metal halide lamps are safer.
- Wear gloves, goggles and plastic apron or laboratory coat when mixing hazardous chemicals.

Photoetching

Photoetching is usually done using the Kodak Photo Resistant (KPR) products. Photoresist dyes often contain a variety of highly toxic solvents, including ethylene glycol monomethyl ether acetate (2-

ethoxyethyl acetate, cellosolve acetate), ethylene glycol monomethyl ether, and xylene, and benzaldehyde. The developers contain xylene and ethylene glycol monomethyl ether acetate (2-methoxyethyl acetate or methyl cellosolve acetate). Developers used for safer presensitized plates also contain solvents. Exposure of the plate is done with ultraviolet sources such as carbon arcs, mercury lamps, or metal halide lamps.

Hazards

- See the Solvents section for the hazards of various solvents. In particular, methyl and ethyl ether acetates of ethylene glycol are highly toxic by skin absorption and inhalation and can cause anemia, kidney damage, testicular atrophy and sterility in men, and miscarriages and birth defects in pregnant women.
- Xylene is moderately toxic by skin absorption, and highly toxic by inhalation and ingestion. It is a strong narcotic.
- The Photolithography section discusses carbon arc hazards.

Precautions

- See Solvents section for precautions with solvents.
- Pregnant or nursing women, children, and men trying to conceive should not work with these materials.
- Use photofloods or other light sources instead of carbon arcs. Precautions with carbon arcs is discussed in the Photolithography section.
- Use presensitized plates if possible.
- Use photoresist solutions with local exhaust ventilation, or wear an organic vapor respirator. Contact EHS for a respirator.
- Wear butyl rubber gloves when handling KPR solutions.

PAINTING AND DRAWING

The health hazards associated with painting and drawing have been known since Ramazzini described such illnesses in 1713. Working safely can involve changes in how you select your art materials and how you handle them.

Chemical Safety Basics

- Read the label. Be sure you understand what you are working with and the associated hazards.
- When transferring thinners and other chemicals from the original stock container to a new container:
    - Do not use food containers including mason jars with lids and labels.
    - Cover or place a lid on the container when not in use to avoid evaporation and unneeded vapors.
    - Label the new container with the contents and associated hazards.

- Ensure you have a safety data sheet.

Pigments

Painters use pigments in oil paints, acrylics, watercolor paints, gouache, encaustic, poster paints, casein paints and tempera. Sometimes commercial paints such as oil, enamel, epoxy paints and automobile paints are used.

Paints are pigments mixed with a vehicle or binder. Both inorganic and organic pigments are used as colorants. Dry pigments are especially hazardous because they are easily inhaled and ingested. They are used in encaustic, paper-marbleizing and in the fabrication of paint products, and will be discussed more thoroughly in the section below on pastels.

Pigments vs. Hues

Most paints used in Visual Arts do not contain metal pigments and are considered non-toxic. These are most easily identified by the product name. If the paint is described as *hue*, such as "chromium yellow hue", there is no (or too little to be concerned about) toxic metal contained in the product.

Hazards

- Poisoning can occur if toxic pigments are inhaled or ingested. The main hazard in standard painting techniques is accidental ingestion of pigments due to eating, drinking or smoking while working, inadvertent hand to mouth contact, or pointing the paint brush with the lips. If methods such as spraying, heating, or sanding are employed then there is an opportunity for inhalation of toxic pigments.
- The classic example of a toxic inorganic pigment in painting is white lead, or flake white (basic lead carbonate). Lead pigments can cause anemia, gastrointestinal problems, peripheral nerve damage (and brain damage in children), kidney damage and reproductive system damage. Other inorganic pigments may be hazardous, including pigments based on cobalt, cadmium, and manganese.
- Some of the inorganic pigments, in particular cadmium pigments, chrome yellow and zinc yellow may cause lung cancer. In addition lamp black and carbon black may contain impurities that can cause skin cancer.
- Chromate pigments (chrome yellow and zinc yellow) may cause skin ulceration and allergic skin reactions (such as rashes).
- The long-term hazards of the modern synthetic organic pigments have not been well studied.

Precautions

- Obtain SDSs on your paints to find out what pigments you are using. This is especially important because the name that appears on the tube of color may or may not truly represent the pigments present. Manufacturers may keep the name of a color while reformulating the ingredients.
- Use the least toxic pigments possible. Do not use lead or carcinogenic pigments.

- Avoid mixing dry pigments whenever possible. If dry pigments are mixed, do it inside a glove box (a box with a glass or Plexiglas top and holes in the sides for arms) or inside a laboratory-type fume hood.
- Wet mop and wipe all surfaces when using dry pigments.
- Do not use dishes, containers or utensils from the kitchen to mix and store paints and pigments.

Water-Based Paints

Water-based paints include water color, acrylic, gouache, tempera and casein. Water is used for thinning and cleanup.

Hazards

- See section above for pigment hazards.
- Acrylic paints contain a small amount of ammonia. Some sensitive people may experience eye, nose and throat irritation from the ammonia. Acrylics and some gouaches contain a very small amount of formaldehyde as a preservative. Only people already sensitized to formaldehyde would experience allergic reactions from the trace amount of formaldehyde found in acrylics. The amounts can vary from manufacturer to manufacturer.
- Casein paints use the protein casein as a binder. While soluble forms are available, casein can be dissolved in ammonium hydroxide which is moderately irritating by skin contact and highly irritating by eye contact, ingestion, and inhalation.
- All water-based paints contain a preservative to prevent mold or bacterial growth. Sometimes artists add preservatives when they make their own paints. Although present in small amounts, certain preservatives may cause allergic reactions in some people.

Precautions

- See section above for precautions when mixing dry pigments.
- If you add your own preservative, avoid using sodium fluoride, phenol or mercury compounds. For tempera, a small amount of pine oil works for short periods of time.
- If you mix casein paints using ammonium hydroxide, mix in an area where there is adequate ventilation.
- Wear gloves, goggles and protective apron when handling ammonia.
- An eyewash station should be available when handling ammonia.

Non Water-Based Paints

Oil paints, encaustic, and egg tempera use linseed oil, wax and egg respectively as vehicles, although solvents are often used as a thinner and for cleanup. Turpentine and mineral spirits (paint thinner), for example, are used in oil painting mediums, for thinning, and for cleaning brushes. Alkyd paints use solvents as their vehicle. In addition many commercial paints used by artists also contain solvents.

Hazards

- See section above for pigment hazards.

- All solvents can cause defatting of the skin and dermatitis from prolonged or repeated exposure. Turpentine can also cause skin allergies and be absorbed through the skin.
- Acute inhalation of high concentrations of mineral spirits, turpentine vapors, and other solvents can cause narcosis, which can include symptoms of dizziness, headaches, drowsiness, nausea, fatigue, loss of coordination, coma, as well as respiratory irritation.
- Chronic inhalation of large amounts of solvents could result in decreased coordination, behavioral changes and brain damage. Chronic inhalation of turpentine can cause kidney damage and respiratory irritation and allergies. Odorless mineral spirits and turpenoid, in which the aromatic hydrocarbons have been removed, are less hazardous.
- Ingestion of either turpentine or mineral spirits can be fatal. In the case of mineral spirits, this is usually due to chemical pneumonia caused by aspiration (breathing in) of the mineral spirits into the lungs after vomiting.
- Natural resins (copal, damar, rosin, Japanese Lacquer) may cause skin irritation or allergies. Rosin dust can cause asthma.
- Encaustic involves suspending pigments in molten wax. If the wax is overheated, flammable wax vapors and wax decomposition fumes are produced, which are strong respiratory irritants.
- Epoxy paints consist of an epoxy resin component containing the pigment, and a hardener component. The epoxy resin may contain diglycidyl ethers which are irritants, may cause bone marrow damage, and are suspect carcinogens. Epoxy hardeners may cause skin and respiratory allergies and irritation.

Precautions

- Whenever possible replace turpentine or ordinary mineral spirits with the less toxic odorless mineral spirits. Mineral spirits is also less flammable than turpentine, since its flashpoint is over 100 F (38 C), while turpentine has a flashpoint of 95 F, (35 C).
- Apply the same health and safety considerations for the use of "citrus" or "pine" solvents. These have been found to be quite irritating to the skin and eyes.
- Techniques such as turpentine washes will require a lot of ventilation because they result in the evaporation of large amounts of solvents in a short period of time. Acrylic paint can be substituted for underpainting.
- Ventilation only needs to be provided while the solvent is evaporating from the canvas, not during the time while the oil paint film is drying (oxidizing).
- Wear nitrile gloves while cleaning brushes with mineral spirits or turpentine.
- Used solvent can be reclaimed by allowing the paint solids to settle and then pouring off the clear solvent.
- Paint can be removed from your hands with baby oil, and then soap and water.
- Wax should be only heated to the minimum temperature needed for proper flow of the paint. Do not heat with open flame or hot plate with exposed element. During pregnancy and nursing, switch to water-based paints to avoid exposure to solvents.

Airbrush, Spray Cans, and Spray Guns

Artists use many products in spray form, including fixatives, retouching sprays, paint sprays, varnishes, and adhesive sprays. Airbrush, aerosol spray can and spray guns are used.

Hazards

- Spray mists are particularly hazardous because they are easily inhaled. If the paint being sprayed contains solvents, then you can be inhaling liquid droplets of the solvents. In addition the pigments are also easily inhaled, creating a much more dangerous situation than applying paint by brush.

- Aerosol spray paints have an additional hazard besides pigments and solvents. They contain propellants, usually isobutanes and propane, which are extremely flammable and have been the cause of many fires. Other aerosol spray products such as retouching sprays, spray varnishes, etc. also contain solvents, propellants and particulates being sprayed.
- Airbrushing produces a fine mist which is a serious inhalation hazard because artists work so close to their art work. Airbrushing solvent-containing paints is especially dangerous.
- Spray guns are less common in art painting but usually involve spraying much larger quantities of paint than either spray cans or airbrush. Spraying solvent-based paints is a serious fire hazard.

Precautions

- See section above for precautions with pigments.
- Try to brush items rather than spraying if possible.
- Use water-based airbrushing paints and inks rather than solvent-based paints.
- Use spray cans or an airbrush in a spray booth if possible.
- If ventilation is not adequate, then respiratory protection is necessary while air brushing or spraying. Contact EHS for selection and fit-testing.
- Never try to spray paint by blowing air from your mouth through a tube. This can lead to accidental ingestion of the paint.

Dry Drawing Media

This includes dust-creating media such as charcoal and pastels which are often fixed with aerosol spray fixatives, and media such as crayons and oil pastels which do not create dust.

Hazards

- Pencils are made with graphite, rather than lead and are not considered a hazard. Colored pencils have pigments added to the graphite, but the amounts are small so that there is no significant risk of exposure. Charcoal is usually made from willow or vine sticks, where wood cellulose has been

heated without moisture to create the black color. Compressed charcoal sticks use various resins in a binder to create the color. Although charcoal is just considered a nuisance dust, inhalation of large amounts of charcoal dust can create chronic lung problems through a mechanical irritation and clogging effect. A major source of charcoal inhalation is from the habit of blowing excess charcoal dust off the drawing.

- Colored chalks are also considered nuisance dusts. Some chalks are dustier than others. Individuals who have asthma sometimes have problems with dusty chalks, but this is a nonspecific dust reaction, not a toxic reaction.
- Pastel sticks and pencils consist of pigments bound into solid form by a resin. Inhalation of pastel dusts is the major hazard. Some pastels are dustier than others. Pastels can contain toxic pigments such as chrome yellow (lead chromate) which can cause lung cancer, and cadmium pigments (which can cause kidney and lung damage and are suspect human carcinogens). Blowing excess pastel dust off the drawing is one major source of inhalation of pastel pigments. Pastel artists have often complained of blowing their nose different colors for days after using pastels, a clear indication of inhalation.
- Crayons and oil pastels do not present an inhalation hazard, and thus are much safer than pastels. Some oil pastels can contain toxic pigments, but this is only a hazard by accidental ingestion.
- Both permanent and workable spray fixatives used to fix drawings contain toxic solvents. There is high exposure by inhalation to these solvents because the products are sprayed in the air, often right on a desk or easel. In addition you can be inhaling the plastic particulates that comprise the fixative itself.
- Never try to spray fixative by blowing air from your mouth through a tube. This can lead to accidental ingestion of the fixative.

Precautions

- Use the least dusty types of pastels, chalks, etc. Asthmatics in particular might want to switch to oil pastels or similar non-dusty media.
- Spray fixatives should be used with a spray booth that exhausts to the outside. If use of spray fixatives is occasional, you can use them outdoors with a NIOSH-approved respirator equipped with organic vapor cartridges and dust and mists filter for protection against inhalation of solvent vapors and particulates. Contact EHS for selection and fit-testing. An exhaust fan is also needed to remove organic vapors and particulates.
- Don't blow off excess pastel or charcoal dust with your mouth. Instead tap off the built up dust so it falls to the floor (or paper on floor).
- Wet-mop and wet-wipe all surfaces clean of dusts.
- If inhalation of dusts is a problem, a respirator may be appropriate. Contact EHS for selection and fit-testing.

Liquid Drawing Media

This includes both water-based and solvent-based pen and ink and felt tip markers. Hazards of dry erase or white board markers can be considered here, although they are more used in teaching or commercial art.

Hazards

- Drawing inks are usually water-based, but there are some solvent-based drawing inks. These usually contain toxic solvents like xylene.
- Permanent felt tip markers used in design or graphic arts contain solvents. Xylene, which is a highly toxic aromatic hydrocarbon, is the most common ingredient; newer brands often contain the less toxic propyl alcohol (although it is an eye, nose and throat irritant). The major hazard is from solvent inhalation by using multiple permanent markers results at the same time at close range.

Precautions

- Use water-based markers and drawing inks if possible.
- Alcohol-based markers are less toxic than aromatic solvent-based markers.
- Solvent-based drawing inks and permanent markers should be used with good dilution ventilation (e.g. window exhaust fan).
- Never paint on the body with markers or drawing inks. Body painting should be done with cosmetic colors.

PHOTOGRAPHY

Photographers are exposed to chemical, physical, and psychological hazards during the course of their work. Photojournalists are at physical risk from motor vehicle crashes and work in war zones. Ergonomic risk comes from handling heavy equipment as well as work in awkward postures in dangerous positions.

Black-and-White Photographic Processing

A wide variety of chemicals are used in black and white photographic processing. Film developing is usually done in closed canisters. Print processing uses tray processing, with successive developing baths, stop baths, fixing baths, and rinse steps. Other treatments include use of hardeners, intensifiers, reducers, toners, and hypo eliminators.

Mixing Photochemicals

Hazards

- Developer solutions and powders are often highly alkaline, and glacial acetic acid, used in making the stop bath, is also corrosive by skin contact, inhalation and ingestion.

- Developer powders are highly toxic by inhalation, and moderately toxic by skin contact, due to the alkali and developers themselves (see Developing Baths below).

Precautions

- Use liquid chemistry whenever possible, rather than mixing developing powders. Pregnant women, in particular, should not be exposed to powdered developer.
- When mixing powdered developers, use a glove box (a box with glass or Plexiglas top, and two holes in the sides for hands and arms), local exhaust ventilation, or wear a NIOSH-approved toxic dust respirator. Contact EHS for selection and fit-testing.
- Wear gloves, goggles and protective apron when mixing concentrated photochemicals. Always add any acid to water, never the reverse.
- In case of skin contact, rinse with lots of water. In case of eye contact, rinse for at least 15 minutes, preferably using an eyewash station, seek medical attention.
- Store concentrated acids and other corrosive chemicals on low shelves so as to reduce the chance of face or eye damage in case of breakage and splashing.
- Do not store photographic solutions in glass containers.

Developing Baths

The most commonly used developers are hydroquinone, monomethyl para-amino phenol sulfate, and phenidone. Several other developers are used for special purposes. Other common components of developing baths include an accelerator, often sodium carbonate or borax, sodium sulfite as a preservative, and potassium bromide as a restrainer or antifogging agent.

Hazards

- Developers are skin and eye irritants, and in many cases strong sensitizers. Monomethyl-p-aminophenol sulfate creates many skin problems, and allergies to it are frequent (although this is thought to be due to the presence of para-phenylene diamine as a contaminant). Hydroquinone can cause depigmentation and eye injury after five or more years of repeated exposure, and is a mutagen. Some developers also can be absorbed through the skin to cause severe poisoning (e.g., catechol, pyrogallic acid). Phenidone is only slightly toxic by skin contact.
- Most developers are moderately to highly toxic by ingestion, with ingestion of less than one tablespoon of compounds such as monomethyl-p-aminophenol sulfate, hydroquinone, or pyrocatechol being possibly fatal for adults. Symptoms include ringing in the ears (tinnitus), nausea, dizziness, muscular twitching, increased respiration, and headache, cyanosis (turning blue from lack of oxygen) due to methemoglobinemia, delirium, and coma. With some developers, convulsions also can occur.
- Para-phenylene diamine and some of its derivatives are highly toxic by skin contact, inhalation, and ingestion. They cause very severe skin allergies and can be absorbed through the skin.
- Sodium hydroxide, sodium carbonate, and other alkalis used as accelerators are highly corrosive by skin contact or ingestion. This is a particular problem with the pure alkali or with concentrated stock solutions.

- Potassium bromide is moderately toxic by inhalation or ingestion and slightly toxic by skin contact. Symptoms of systemic poisoning include somnolence, depression, and lack of coordination, mental confusion, hallucinations, and skin rashes.
- Sodium sulfite is moderately toxic by ingestion or inhalation, causing gastric upset, colic, diarrhea, circulatory problems, and central nervous system depression. It is not appreciably toxic by skin contact. If heated or allowed to stand for a long time in water or acid, it decomposes to produce sulfur dioxide, which is highly irritating by inhalation.

Precautions

- See the section on Mixing Photochemicals for mixing precautions.
- Do not put your bare hands in developer baths. Use tongs instead. If developer solution splashes on your skin or eyes immediately rinse with lots of water. For eye splashes, continue rinsing for 15 minutes and seek medical attention.
- Do not use para-phenylene diamine or its derivatives if at all possible.

Stop Baths and Fixer

Stop baths are usually weak solutions of acetic acid. Acetic acid is commonly available as pure glacial acetic acid or 28% acetic acid. Some stop baths contain potassium chrome alum as a hardener.

Fixing baths contain sodium thiosulfate ("hypo") as the fixing agent, and sodium sulfite and sodium bisulfite as a preservative. Fixing baths also may also contain alum (potassium aluminum sulfate) as a hardener and boric acid as a buffer.

Hazards

- Acetic acid, in concentrated solutions, is highly toxic by inhalation, skin contact, and ingestion. It can cause dermatitis and ulcers, and can strongly irritate the mucous membranes. The final stop bath is only slightly hazardous by skin contact. Continual inhalation of acetic acid vapors, even from the stop bath, may cause chronic bronchitis.
- Potassium chrome alum or chrome alum (potassium chromium sulfate) is moderately toxic by skin contact and inhalation, causing dermatitis and allergies.
- In powder form, sodium thiosulfate is not significantly toxic by skin contact. By ingestion it has a purging effect on the bowels. Upon heating or long standing in solution, it can decompose to form highly toxic sulfur dioxide, which can cause chronic lung problems. Many asthmatics are particularly sensitive to sulfur dioxide.
- Sodium bisulfite decomposes to form sulfur dioxide if the fixing bath contains boric acid, or if acetic acid is transferred to the fixing bath on the surface of the print.
- Alum (potassium aluminum sulfate) is only slightly toxic. It may cause skin allergies or irritation.
- Boric acid is moderately toxic by ingestion or inhalation and slightly toxic by skin contact (unless the skin is abraded or burned, in which case it can be highly toxic).

Precautions

- All darkrooms require good ventilation to control the level of acetic acid vapors and sulfur dioxide gas produced in photography.
- Wear gloves and goggles.
- Cover all baths when not in use to prevent evaporation or release of toxic vapors and gases.

Intensifiers and Reducers

A common after-treatment of negatives (and occasionally prints) is either intensification or reduction. Common intensifiers include hydrochloric acid and potassium dichromate, or potassium chlorochromate. Mercuric chloride followed by ammonia or sodium sulfite, Monckhoven's intensifier consisting of a mercuric salt bleach followed by a silver nitrate/potassium cyanide solution, mercuric iodide/sodium sulfite, and uranium nitrate are older, now discarded, intensifiers.
Reduction of negatives is usually done with Farmer's reducer, consisting of potassium ferricyanide and hypo. Reduction has also be done historically with iodine/potassium cyanide, ammonium persulfate, and potassium permanganate/sulfuric acid.

Hazards

- Potassium dichromate and potassium chlorochromate are probable human carcinogens, acutely toxic, strong oxidizers, and can cause skin allergies and ulceration. Potassium chlorochromate can release highly toxic chlorine gas if heated or if acid is added.
- Concentrated hydrochloric acid is corrosive; the diluted acid is a skin and eye irritant.
- Mercury compounds are moderately toxic by skin contact and may be absorbed through the skin. They are also highly toxic by inhalation and extremely toxic by ingestion. Uranium intensifiers are radioactive, and are especially hazardous to the kidneys.
- Sodium or potassium cyanide is extremely toxic by inhalation and ingestion, and moderately toxic by skin contact. Adding acid to cyanide forms extremely toxic hydrogen cyanide gas which can be rapidly fatal.
- Potassium ferricyanide, although only slightly toxic by itself, will release hydrogen cyanide gas if heated, if hot acid is added, or if exposed to strong ultraviolet light (e.g., carbon arcs). Cases of cyanide poisoning have occurred through treating Farmer's reducer with acid.
- Potassium permanganate and ammonium persulfate are strong oxidizers and may cause fires or explosions in contact with solvents and other organic materials.

Precautions

- Chromium intensifiers are probably the least toxic intensifiers, even though they are probable human carcinogens. Gloves and goggles should be worn when preparing and using these intensifiers. Mix the powders in a glove box or wear a NIOSH-approved toxic dust respirator. Contact EHS for selection and fit-testing. Do not expose potassium chlorochromate to acid or heat.

- Do not use mercury, cyanide or uranium intensifiers, or cyanide reducers because of their high or extreme toxicity.
- The safest reducer to use is Farmer's reducer. Do not expose Farmer's reducer to acid, ultraviolet light, or heat.

Toners

Toning a print usually involves replacement of silver by another metal, for example, gold, selenium, uranium, platinum, or iron. In some cases, the toning involves replacement of silver metal by brown silver sulfide, for example, in the various types of sulfide toners. A variety of other chemicals are also used in the toning solutions.

Hazards

- Sulfides release highly toxic hydrogen sulfide gas during toning, or when treated with acid.
- Selenium is a skin and eye irritant and can cause kidney damage. Treatment of selenium salts with acid may release highly toxic hydrogen selenide gas. Selenium toners also give off large amounts of sulfur dioxide gas.
- Gold and platinum salts are strong sensitizers and can produce allergic skin reactions and asthma, particularly in fair-haired people.
- Thiourea is a probable human carcinogen since it causes cancer in animals.

Precautions

- Carry out normal precautions for handling toxic chemicals as described in previous sections. In particular, wear gloves and goggles. See also the section on mixing photochemicals.
- Toning solutions must be used with local exhaust ventilation.
- Take precautions to make sure that sulfide or selenium toners are not contaminated with acids. For example, with two bath sulfide toners, make sure you rinse the print well after bleaching in acid solution before dipping it in the sulfide developer.
- Avoid thiourea whenever possible because of its probable cancer status.

Other Hazards to Consider

Many other chemicals are also used in black and white processing, including formaldehyde as a pre-hardener, a variety of oxidizing agents as hypo eliminators (e.g., hydrogen peroxide and ammonia, potassium permanganate, bleaches, and potassium persulfate), sodium sulfide to test for residual silver, silver nitrate to test for residual hypo, solvents such as methyl chloroform and freons for film and print cleaning, and concentrated acids to clean trays.

Electrical outlets and equipment can present electrical hazards in darkrooms due to the risk of splashing water.

Hazards

- Concentrated sulfuric acid, mixed with potassium permanganate or potassium dichromate, produces highly corrosive permanganic and chromic acids.
- Hypochlorite bleaches can release highly toxic chlorine gas when acid is added, or if heated.
- Potassium persulfate and other oxidizing agents used as hypo eliminators may cause fires when in contact with easily oxidizable materials, such as many solvents and other combustible materials. Most are also skin and eye irritants.

Precautions

- See previous sections for precautions in handling photographic chemicals.
- Cleaning acids should be handled with great care. Wear gloves, goggles and acid-proof, protective apron. Always add acid to the water when diluting.
- Do not add acid to, or heat, hypochlorite bleaches.
- Keep potassium persulfate and other strong oxidizing agents separate from flammable and easily oxidizable substances.
- Install ground fault interrupters (GFCIs) whenever electrical outlets or electrical equipment (e.g. enlargers) are within six feet of the risk of water splashes.

Color Processing

Color processing is much more complicated than black and white processing, and there is a wide variation in processes used by different companies. Color processing can be either done in trays or in automatic processors.

Color Developing Baths

The first developer of color transparency processing usually contains monomethyl-p-aminophenol sulfate, hydroquinone, and other normal black and white developer components. Color developers contain a wide variety of chemicals including color coupling agents, penetrating solvents (such as benzyl alcohol, ethylene glycol, and ethoxydiglycol), amines, and others.

Hazards

- See the developing section of black and white processing for the hazards of standard black and white developers.
- In general, color developers are more hazardous than black and white developers. Para-phenylene diamine, and its dimethyl and diethyl derivatives, are known to be highly toxic by skin contact and absorption, inhalation, and ingestion. They can cause very severe skin irritation, allergies and poisoning. Color developers have also been linked to lichen planus, an inflammatory skin disease characterized by reddish pimples which can spread to form rough scaly patches. Recent color developing agents such as 4-amino-N-ethyl-N-[P-methane-sulfonamidoethyl]-m-toluidine sesquisulfate monohydrate and 4-amino-3-methyl-N-ethyl-N-[,3-

hydroxyethyl]-aniline sulfate are supposedly less hazardous, but still can cause skin irritation and allergies.
- Most amines, including ethylene diamine, tertiary-butylamine borane, the various ethanolamines, etc. are strong sensitizers, as well as skin and respiratory irritants.
- Although many of the solvents are not very volatile at room temperature, the elevated temperatures used in color processing can increase the amount of solvent vapors in the air. The solvents are usually skin and eye irritants.

Precautions

- Wear gloves and goggles when handling color developers. Wash gloves with an acid-type hand cleaner (e.g. pHisoderm (R)), and then water before removing them.
- Mix powders in a glove box, or wear a NIOSH-approved toxic dust respirator. Contact EHS for selection and fit-testing.
- Color processing needs more ventilation than black and white processing due to the use of solvents and other toxic components at elevated temperatures.

Color Processing: Bleaching, Fixing, and Other Steps

Many of the chemicals used in other steps of color processing are essentially the same as those used for black and white processing. Examples include the stop bath and fixing bath. Bleaching uses a number of chemicals, including potassium ferricyanide, potassium bromide, ammonium thiocyanate, and acids. Chemicals found in prehardeners and stabilizers include succinaldehyde and formaldehyde; neutralizers can contain hydroxylamine sulfate, acetic acid, and other acids.

Hazards

- Formaldehyde is moderately toxic by skin contact, and highly toxic by inhalation and ingestion. It is a skin, eye and respiratory irritant, and strong sensitizer, and is a probable human carcinogen. Formaldehyde solutions contain some methanol, which is highly toxic by ingestion.
- Succinaldehyde is similar in toxicity to formaldehyde, but is not a strong sensitizer or carcinogen.
- Hydroxylamine sulfate is a suspected teratogen in humans since it is a teratogen (causes birth defects) in animals. It is also a skin and eye irritant.
- Concentrated acids, such as glacial acetic acid, hydro bromic acid, sulfamic acid and p-toluene sulfonic acids are corrosive by skin contact, inhalation and ingestion.
- Acid solutions, if they contain sulfites or bisulfites (e.g., neutralizing solutions), can release sulfur dioxide upon standing. If acid is carried over on the negative or transparency from one step to another step containing sulfites or bisulfites, then sulfur dioxide can be formed.
- Potassium ferricyanide will release hydrogen cyanide gas if heated, if hot acid is added, or if exposed to strong ultraviolet radiation.

Precautions

- Local exhaust ventilation is required for mixing of chemicals and color processing.
- Use premixed solutions whenever possible.

- Avoid color processes using formaldehyde, if possible.
- Wear gloves, goggles and protective apron when mixing and handling color processing chemicals. When diluting solutions containing concentrated acids, always add the acid to the water. An eyewash should be available.
- A water rinse step is recommended between acid bleach steps and fixing steps to reduce the production of sulfur dioxide gas.
- Do not add acid to solutions containing potassium ferricyanide or thiocyanate salts.
- Control the temperature carefully according to manufacturer's recommendations to reduce emissions of toxic gases and vapors.

Disposal of Photochemicals

There is considerable concern about the effect of dumping photographic chemicals and solutions down the drain. The following recommendations are for disposing small volumes of photographic solutions daily.

- Old or unused concentrated photographic chemical solutions, toning solutions, ferricyanide solutions, chromium solutions, color processing solutions containing high concentrations of solvents, and non-silver solutions should be treated as hazardous waste
- Alkaline developer solutions should be neutralized first before being poured down the drain. This can be done with the stop bath or citric acid, using pH paper to tell when the solution has been neutralized (pH 7).

- Stop bath left over from neutralization of developer can be poured down the drain, once mixed with wash water.
- Fixing baths should never be treated with acid (e.g. mixing with stop bath), since they usually contain sulfites and bisulfites which will produce sulfur dioxide gas.
- Fixing baths contain large concentrations of silver thiocyanate, well above the 5 ppm of silver ion allowed by the U.S. Clean Water Act. Collect fixers and either pour into the silver recovery unit or dispose as hazardous waste.

SCULPTURE

Many artists work with traditional sculptural materials including plaster, stone, lapidary, clay, wax, and modeling materials. See Ceramics for information on some other sculpting media.

Plaster and Plaster Molds

Plaster can be carved, modeled, and casted. Varieties of plaster include: Plaster of Paris, casting plaster, white art plaster, molding plaster, and Hydrocal. These are all varieties of calcined gypsum, composed of calcium sulfate. Mold releases used with plaster include Vaseline, tincture of green soap, auto paste wax-benzene, silicone-grease-benzine, and mineral oil-petroleum jelly. In waste molding, the plaster mold is chipped away.

Hazards

- Plaster dust (calcium sulfate) is slightly irritating to the eyes and respiratory system. In situations where there is heavy inhalation of the dust, more severe respiratory problems can result.
- Potassium sulfate and potassium alum are slightly toxic by ingestion; potassium alum is slightly toxic by skin contact, and can cause mild irritation or allergies in some people.
- Borax is moderately toxic by ingestion, by inhalation, and by absorption through burns or other skin injuries. It is also slightly toxic by skin contact, causing alkali burns.
- Concentrated acetic acid is highly corrosive by ingestion, inhalation, and skin contact.
- Burnt lime (calcium oxide) is moderately corrosive by skin contact (especially if the skin is wet), and highly toxic by inhalation or ingestion.
- Careless use and storage of sharp tools can cause accidents. Chipping set plaster can result in eye injuries from flying chips.
- Benzene used with many mold releases is moderately toxic by skin contact and inhalation, and is highly toxic by ingestion. It is also flammable.
- Making plaster casts of hands, legs, and other body parts can be very hazardous due to the heat released during the setting process.

Precautions

- Wear gloves and goggles when mixing acetic acid and burnt lime.
- Always carve or cut in a direction away from you, and keep hands behind the tool. If the tool falls, don't try to catch it.
- Wear safety goggles when chipping plaster.
- Wear gloves and goggles when pouring benzene. Store in safety containers and do not use near open flames.
- Do not use plaster for body part casts. Instead, use a plaster-impregnated bandage (such as Johnson and Johnson's (Paris craft), along with Vaseline or similar mold release as protection.

Stones and Lapidary

Stone carving involves chipping, scraping, fracturing, flaking, crushing, and pulverizing with a wide variety of tools. Soft stones can be worked with manual tools whereas hard stones require crushing and pulverizing with electric and pneumatic tools. Crushed stone can also be used in casting procedures.

Soft stones include soapstone (steatite), serpentine, sandstone, African wonder stone, greenstone, sandstone, limestone, alabaster, and several others. **Hard stones** include granite and marble. Electric

tools include saws, drills, grinders, and sanders, and pneumatic tools include roto hammers, drills, and other tools powered by compressed air. **Stone casts** can be made using Portland cement, sand, and crushed stone. Marble dust is often used with this technique. Cast concrete sculptures can also be made using sand and Portland cement. **Lapidary** involves cutting and carving semiprecious stones and has similar risks as hard stone carving. Stones carved include garnet, jasper, jade, agate, travertine, opal, turquoise and many others.

Stones can be finished by grinding, sanding, and polishing, by either hand or with machines. Polishing can use a variety of materials, depending on the hardness of the stone being polished. Polishing materials include carborundum (silicon carbide), corundum (alumina), diamond dust, pumice, putty powder (tin oxide), rouge (iron oxide), tripoli (silica), and cerium oxide.

Hazards

- Sandstone, soapstone, and granite are highly toxic by inhalation because they contain large amounts of free silica. Limestone, containing small amounts of free silica, is less hazardous.
- Serpentine, soapstone, and greenstone may contain asbestos, which can cause asbestosis, lung cancer, mesothelioma, and stomach and intestinal cancers.
- During chipping and other carving, flying chips and pieces of rock may cause eye injury. Grinding and sanding can release small pieces of stone and dust which are hazardous to the eyes.
- Lifting heavy pieces of stone may cause back injuries.
- Power tools create larger amounts of fine dust than hand tools. Pneumatic tools can create large amounts of fine silica dust.
- Vibration from pneumatic equipment can cause Raynaud's phenomenon, ("white fingers" or "dead fingers") a circulation disease. The hazard is greater with exposure to cold, (e.g. the air blast from pneumatic tools). This temporary condition can spread to the whole hand and cause permanent damage.
- Calcium oxide in Portland cement is highly corrosive to the eyes and respiratory tract, and is moderately corrosive to the skin. Allergic dermatitis can also occur due to chromium contaminants in the cement. The silica in the cement is also highly toxic by inhalation. Lung problems from inhalation of Portland cement include emphysema, bronchitis, and fibrosis. Acrylic resins are skin irritants and sensitizers.
- The dust from quartz gemstones such as agate, amethyst, onyx, and jasper is highly toxic because they are made of silica. Other gemstones such as turquoise and garnet may be contaminated with substantial amounts of free silica. Opal is made of amorphous silica, which is slightly toxic by inhalation.
- Grinding and sanding, especially with machines can create fine dust from the stone which is being worked. There are also inhalation hazards from grinding wheel dust (especially sandstone wheels). Some polishing materials such as tripoli are highly toxic if inhaled in powder form.

Precautions

- Do not use stones which may contain asbestos unless you are certain that your particular pieces are asbestos free. New York soapstones may contain asbestos, whereas Vermont soapstones are usually asbestos free. Alabaster is a substitute.
- Wear chipping goggles to protect against flying particles; wear protective shoes to protect against falling stones. Wear approved safety goggles when grinding, sanding, or polishing. For heavy grinding also wear a face shield.
- When using carving tools, keep your hands behind the tools, and carve or cut in a direction away from you. Don't try to catch falling tools.
- Use proper lifting techniques (bent knees).
- Protect against vibration damage from pneumatic tools by measures such as having comfortable hand grips, directing the air blast away from your hands, keeping hands warm, taking frequent work breaks, and using preventive medical measures such as massage and exercises.
- Tie long hair back, and don't wear ties, jewelry, or loose clothing which can get caught by machinery.

Modeling Materials

See Ceramics for information about clay compounds. Modeling clays of the plasticine type usually contain China clay in an oil and petrolatum base. Additives are often present, including dyes, sulfur dioxide, vegetable oils, aluminum silicate, preservatives, and turpentine. These are modeled and carved with simple tools. There are also a variety of polymer clays that are self- hardening, or oven-hardening (e.g. FIMO, Sculpey), which are not really clays at all. These are often based on polyvinyl chloride.

Hazards

- Some of the additives in plasticine clays such as turpentine and preservatives might cause skin irritation or allergies, and sulfur dioxide might cause some respiratory problems in certain asthmatics. The amounts present are usually small.
- The curing temperatures of different product are not the same, and in some cases, very close to the temperatures at which decomposition can occur.

Precautions

- Use gloves or apply a barrier cream to hands if skin irritation results from using plasticine modeling clays. Wash hands with soap and water after contact.
- Obtain the Safety Data Sheet (SDS) from the manufacturer or supplier, and make sure the temperature of decomposition is not reached.

Wax

Many different types of waxes are used for modeling, carving, and casting. These include beeswax, ceresin, carnauba, tallow, paraffin, and micro-crystalline wax. In addition there are the synthetic chlorinated waxes. Solvents used to dissolve various waxes include alcohol, acetone, benzine, turpentine,

ether, and carbon tetrachloride. Waxes are often softened for carving or modeling by heating in a double boiler or with a light bulb, by sculpting with tools warmed over an alcohol lamp, or by the use of soldering irons, alcohol lamps, and blowpipes. Wax can be melted for casting in a double boiler. Additives used with waxes include rosin, dyes, petroleum jelly, mineral oil, and many solvents.

Hazards

- Overheating wax can result in the release of flammable wax vapors, as well as in the decomposition of the wax to release acrolein fumes and other decomposition products which are highly irritating by inhalation. Explosions have occurred from heating wax that contained water.
- Alcohol and acetone are slightly toxic solvents by skin contact and inhalation; benzine and turpentine are moderately toxic by skin contact, inhalation, and ingestion. Carbon tetrachloride is extremely toxic, possibly causing liver cancer and severe liver damage, even from small exposures. Exposure to carbon tetrachloride can be fatal by skin absorption or inhalation.
- Chlorinated synthetic waxes are highly toxic by skin contact and skin absorption, causing a severe form of acne (chloracne). Some may be contaminated with polychlorinated biphenyls (PCBs), which are highly toxic, causing chloracne, liver problems, and possibly cancer of the pancreas and melanoma (a fatal form of skin cancer).

Precautions

- Do not overheat waxes. Use a double boiler and a temperature-controlled hot plate, or a crock pot. Do not use an open flame to melt waxes.
- Use the least hazardous solvent to dissolve your wax. Do not use carbon tetrachloride under any circumstances. Store solvents safely, do not smoke or have open flames near solvents. Dispose of solvent-soaked rags in an approved waste disposal container which is emptied daily.
- Do not use chlorinated synthetic waxes.

Woodworking

Wood sculpture uses a large number of different types of hard and soft woods, including many exotic tropical woods. Many of these woods are hazardous themselves. Sometimes woods are treated with hazardous preservatives or pesticides.

Hazards

- Saps present in many green woods, and lichens and liverworts present on the surface of freshly cut wood, can cause skin allergies and irritation from direct contact.
- Many **hardwood** dusts, especially those from exotic woods, are common sensitizers and can cause allergic skin reactions. Some hardwoods can cause allergic reactions in individuals working with or using finished hardwoods. **Softwoods** do not cause as high a frequency of skin and respiratory problems as do hardwoods. A few individuals can develop allergic reactions to some softwoods.

- Contact with the dust of many hardwoods can cause conjunctivitis (eye inflammation), hay fever, asthma, coughing, and other respiratory diseases. Canadian and Western Red Cedar are examples.
- Some hardwoods can cause hypersensitivity pneumonia (alveolitis), and frequent attacks can cause permanent lung scarring (fibrosis). Examples of these highly toxic woods include giant sequoia, cork oak, some maple woods and redwood.
- Some hardwoods contain chemicals that are toxic, and can cause a variety of symptoms, including headaches, salivation, thirst, giddiness, nausea, irregular heartbeat, etc. A classic example is hemlock.
- Inhalation of hardwood dust is associated with a particular type of nasal and nasal sinus cancer (adenocarcinoma). This type of cancer has a latency period of 40-45 years, and occurs to the extent of about 7 in 10,000 among woodworkers who are heavily exposed. This rate is many times higher than the rate of nasal adenocarcinoma in the general population. Over half of all known cases of this type of cancer are found in woodworkers.

Precautions

- Whenever possible, use common hardwoods rather than rare tropical hardwoods.
- If you have a history of allergies, you should avoid common sensitizing woods.
- If you are handling woods that can cause skin irritation or allergies, wear gloves.

Plywood and Composition Board

Plywood is made by gluing thin sheets of wood together with either urea-formaldehyde glues (for indoor use) or phenol-formaldehyde glues (for outdoor use). Composition board, for example particle board, is made by gluing wood dust, chips, etc. together with urea-formaldehyde resins. The materials can emit unreacted formaldehyde for some years after manufacture, with composition board emitting more formaldehyde. In addition, heating these materials or machining them can cause decomposition of the glue to release formaldehyde.

Hazards

- Formaldehyde is highly toxic by inhalation, highly toxic by eye contact and ingestion, and moderately toxic by skin contact. It is an irritant and strong sensitizer. Formaldehyde is a probable human carcinogen. Even trace amounts of free formaldehyde may cause allergic reactions in people who are already sensitized to it.
- Machining, sanding, or excessive heating of plywood or composition board can cause decomposition releasing formaldehyde, carbon monoxide, hydrogen cyanide (in the case of amino resins) and phenol (in the case of phenol-formaldehyde resins).

Precautions

- Use low-formaldehyde products whenever possible. There are particle boards that are made without formaldehyde, but these are very expensive.

- Do not store large amounts of plywood or composition board in the shop since it will emit formaldehyde. Instead store in a ventilated area where people do not work.

Wood Preservation and Other Treatments

Pesticides and preservatives are often applied to wood when it is being timbered, processed or shipped. Unfortunately, it is hard to find out what chemicals, if any, have been added. This is especially a problem with imported woods, since pesticides and wood preservatives banned in the United States and Canada are often used in other countries. Pentachlorophenol and its salts, creosote, and chromated copper arsenate (CCA) have been banned for sale in the United Sates as wood preservatives because of their extreme hazards. They can, however, still be found in older woods and chromated copper arsenate is still allowed as a commercial treatment (e.g. "green" lumber, playground equipment, and other outdoor uses). It is supposed to be labeled. A variety of other chemicals can be used in treating wood including fire retardants, bleaches, etc.

Hazards

- Pentachlorophenol is highly toxic by all routes of entry. It can be absorbed through the skin, cause chloracne (a severe form of acne) and liver damage, and is a probable human carcinogen and reproductive toxin.
- Chromated copper arsenate is extremely toxic by inhalation and ingestion, and highly toxic by skin contact. It is a known human carcinogen and teratogen. Skin contact can cause skin irritation and allergies, skin thickening and loss of skin pigmentation, ulceration, and skin cancer. Inhalation can cause respiratory irritation, and skin, lung and liver cancer. Inhalation or ingestion may cause digestive disturbances, liver damage, peripheral nervous system damage, and kidney and blood damage. Acute ingestion may be fatal.
- Creosote has a tarry look, and is also used for outdoor wood. It is a strong skin and respiratory irritant, and is a probable human carcinogen and teratogen.
- Zinc and copper naphthenate are slight skin irritants; copper naphthenate is moderately toxic by ingestion. If suspended in solvents, the solvent would be the main hazard.

Precautions

- Obtain Material Safety Data Sheets on all chemicals being used in wood treatment. Treated wood itself does not have Material Safety Data Sheets, so you have to try and find out about any treatments from the supplier. In the United States, CCA-treated wood is required to have a label and information on safe handling.
- Do not handle woods that have been treated with pentachlorophenol or creosote. Avoid scrap or old woods of unknown origin.
- If you add wood preservatives yourself, use zinc or copper naphthenates, if possible.
- Do not burn wood that has been treated with creosote, pentachlorophenol or chromated copper arsenate.

Carving and Machining Wood

Woods can be hand carved with chisels, rasps, files, hand saws, sandpaper, and the like, or they can be machined with electric saws, sanders, drills, lathes and other woodworking machines.

Hazards

- Woodworking machinery and tools also present physical hazards from accidents. Machinery accidents are often due to missing machine guards, faulty equipment, or using the wrong type of machine for a particular operation. Tool accidents are often caused by dull tools or improper use.
- Vibrating tools, for example chain saws, can cause "white fingers" (Raynaud's phenomenon) involving numbness of the fingers and hands. This can lead to permanent damage.
- Electrical equipment can also present electrical shock and fire hazards from faulty or inadequate wiring.
- Sawdust and wood are fire hazards. In addition, fine sawdust is an explosion hazard if enclosed.

Precautions

- Wear goggles when using machines that create dust. For lathes and similar machines which may produce wood chips, use a face shield and goggles, and make sure the machines are properly shielded.
- Be sure that all woodworking machines are equipped with proper guards to prevent accidents. Use the proper machine for particular operations and repair defective machines immediately. Do not wear ties, long loose hair, loose sleeves, necklaces, long earrings or other items that could catch in the machinery.
- Keep hand tools sharpened, and cut away from your body. Do not place your hands in front of the tool.

STAINED GLASS

A piece of stained glass artwork begins as a pattern on paper. The pieces of the pattern are then constructed by scoring and breaking sheet glass. Once the pattern is cut out of various colors and textures of glass, the glass piece edges are ground to create a rough surface. Copper foil with adhesive backing is then wrapped around each piece of glass, and the pieces are then fluxed and soldered together using a soldering iron and solder. Finishing touches include adding patinas, wires for hanging, lamp bases, or picture frame backings.

Most glass cuts result from not paying enough attention to what you're doing. Razor sharp edges can slice like a scalpel, and thin slivered shards will impale like a spear. It's important to always be aware of the potential for serious damage when you work with glass. Complacency causes more injuries than anything else. Keep yourself sharp – always pay attention to what you're doing.

Lead Poisoning

This is serious, but not near as much as has been publicized or as many people have come to believe. Fear of lead contamination has been fueled with an irrational paranoia that is often unsupported by scientific evidence.

Lead will NOT absorb through the pores of your skin. Soldering lead will NOT produce particles you can inhale. There is a risk when cutting lead with power saws, or when repairing leaded glass. Fine particles of lead produced by the saw, or when you scrape old lead, can easily be inhaled. Always wear a protective mask when doing either of these.

The most common way to get lead poisoning is by ingesting it. Protecting yourself is simple. Don't eat it, always wash your hands after working with it, and don't drop it on your foot. For peace of mind, have regular blood and hair analysis tests done to monitor the amount of lead in your body.

Flux Fumes

If there has been too much fear about lead poisoning, there has been too little about potential harm from flux fumes. Vaporized flux is both poisonous and corrosive. It isn't enough to just have a fan blow the fumes away from you where you're working. This just circulates the fumes around the workplace so you can inhale them later. It's important to remove flux fumes entirely from where you work. Several small "fume traps" are available that vacuum the fumes and send them through a filter. To some varying degrees they all work. An inexpensive and more effective protection is to extract the fumes entirely with a ventilation system. This can be as simple as a cheap kitchen range hood over your work table that vents the fumes to outside. You can help protect the environment with a HEPA filter on the line venting to outside.

To effectively exhaust flux fumes, you want to create a steady air flow that draws the fumes away from you. It's better to draw the fumes away from in front of you then to push them from behind you. A large fan moving slowly works better then small one moving quickly.

Dust

Dust is a serious hazard often ignored or overlooked when working with glass. Dust from whiting compound, or the fine particles of glass from grinding can be inhaled. When you clean up glass dust, or whenever you work with whiting, you should wear a dust mask. It can be as simple and inexpensive as a disposable drywall mask - but you should use one. When wiping up glass dust, do it with a wet sponge or cloth. Don't sweep or vacuum it.

If inhaled, glass dust can cause serious and permanent damage to your lungs. You can't just go to the hospital and have it removed. Once you breathe glass dust in, like asbestos, it's there forever. Protect your lungs – wear a dust mask.

Soldering Irons

A soldering iron hot enough to melt lead is more than hot enough to burn through flesh. Always be careful when handling a hot iron.

WOOD SHOP SAFETY

Woodworking shops can be very dangerous. There are blades, cutting edges, and shapers which have no more respect for flesh than for wood. Improperly or inadequately guarded machines are one of the top OSHA violations. Not only are lacerations and amputations and eye injuries of concern in woodworking shops but also wood dust and finishing chemicals. These guidelines are not all inclusive but rather serve to provide a framework for shop safety. The following applications are reviewed:

- Milling equipment
- Production
- Assembly
- Finishing

Milling Equipment

Milling equipment includes table saws, radial saws, jointers, and planers. Production machines includes table, band and scroll saws, lathes, jointers, shapers, planers, drill presses, sanders, tenon/mortising machines, jig saws, routers, circular saws, drills, and pneumatic guns. The major area of concern related to the assembly of production material is related to ergonomics. Finishing generally involves chemicals and the hazards associated with their use. Issues associated with wood dust, noise, electricity and machine maintenance are addressed separate from each section.

Table Saws

Injuries can occur if the operator's hands slip as the stock is being fed into the saw or the hands are too close to the blade. The operator can also be injured when removing wood from the table.

The portion of the saw above the table should have a self-adjusting guard. The guard must adjust to the thickness of the material being cut and remain in contact with it.

The motor's arbor should have a brake to stop the saw from continuing after it has been shut off. If a brake is not practical the operator should remain at the station until the blade stops turning.

Hands should never be placed in the cut line and both should remain in contact with the stock, table or push stick at all times when blade is turning. A push stick should be used when pushing stock past the blade.

The blade under the table and the power transmission apparatus should be enclosed or situated in such a way to prevent operator contact.

A kickback occurs when the blade catches the stock and throws it back toward the operator. Kickbacks are more likely to occur when ripping rather than crosscutting. These can result if the blade isn't properly maintained or the height isn't correct. Poor quality lumber is a major contributor to kickback.

For ripsaws a spreader should be used to prevent materials from squeezing the blade or kicking back. Anti-kickback fingers should be used to hold the stock down in the event that the saw kicks back the stock.

Precautions

- Use the proper blade
- Operate the saw at the proper speed
- Use a well maintained sharp blade
- Stand to the side of the blade
- Properly support all pieces of the stock
- Guide stock parallel to the rip fence
- Avoid crosscutting long boards on table saws
- Remove damaged blades from service
- Flying particles may be thrown by the saw eye protection must be worn

Radial Saw

Radial saws have circular blades that either rip or crosscut. They are much more versatile than table saws. The saw arm can be raised or lowered and swung to adjust the depth and angle of the cut. The blade can be replaced shaping cutters, sanders, and other accessories.

The most significant hazard is contact with the turning saw blade. The upper half of the saw should have a fixed hood. The lower half should be guarded with a self-adjusting, floating guard that automatically adjust to the thickness of the stock. The cutting head should return to its original position when released by the operator. An adjustable stop should be installed to limit forward travel distance of the blade during repeat cuts.

Stock may be measured against a stop gauge without turning the blade off. The blade must be stopped before moving materials or measuring by ruler.

A kickback may occur if stock is caught in the blade or fed in the wrong direction. When ripping non kickback fingers should be installed on both sides of the blade. A spreader may be used when ripping to prevent binding the blade. The hood should show the direction of blade rotation so stock will be in the correct direction. When crosscutting operator the saw on the side of the table with the handle.

Precautions

- Flying particles may be thrown by the saw eye protection must be worn.
- Use the proper blade
- Remove damaged blades from service
- During crosscutting operate the saw on the side of the table with a handle

Jointers

Jointers are used to join pieces of material. The operator passes stock over a cylindrical multiple knife cutter head while keeping the stock flush against a guide. The depth of the cut is adjustable.

Injuries occur when fingers contact the cutting knives. For hand fed jointers with a horizontal cutting head the head should be enclosed with an automatic guard that exposes the cutter head only when the stock is being fed. The guard must automatically adjust to cover the unused portion of the head and must remain in contact with the material at all times. The cylindrical cutter head knife should be adjusted so that the knife projects no more than 1/8 inch beyond the cylindrical body of the head. The clearance between the path of the knife projection and the saw table should be no more than 1/8 inch. The clearance between the table and the head should be as small as possible. For versatile head jointers the cutter head should be completely enclosed except for the slot to apply the stock for jointing.

Precautions

- Use hold down push blocks foe wood narrower than 3 inches
- Avoid deep cuts. Make several shallow cuts
- Eye protection is required
- Knives should be checked regularly for proper seating and adjustment

Planers

Planers are used to dress and size sawed lumber on one or more sides. The cutter heads are located above or below the stock. The stock passes under or between cylindrical cutter heads with multiple knives. An operator's hands can come into contact with the point of operation while adjusting the blades. They may also be pinched between the stock and rollers if the feed system isn't properly guarded.

Belts and pulleys shall be completely enclosed. Guards shall be used regardless of the location of the line shaft. The cutting heads shall be curved with a metal guard or cage. Barriers shall be at the loading and unloading sides to keep hands out of the point of operation. Guards shall be in place to prevent clothing, hair, and hands from being caught by and pulled into the automatic feed mechanism. Guard feed allows boards to pass but keep the operators fingers out.

Precautions

- Stand to the side after starting boards through the planer
- Do not feed boards of different thickness without adjusting properly
- Wear eye protection
- Make sure planer is anchored to a solid foundation

Band Saws

Band saws use thin, flexible, continuous steel strips with cutting teeth on one edge. The blade runs on a driver and idle pulley and through a work table where stock is manually fed. The two types of band saws are horizontal and vertical. The operator is required to hand feed and manipulate the stock against the blade to saw along the line. The stock must be kept flat on the work table and the operator must exert the correct cutting pressure.
The most common operator injury is caused by contact with the blade. The blade should be guarded entirely except at the point of operation. A self-adjusting guard should be used for the portion of the blade between the sliding guide and the ripper saw so it raises and lowers with the guide. The pulley mechanism

should be fully enclosed. Feed rolls should be guarded. The saw should be equipped with a tension control device to indicate proper blade tension. The blade guide post should be adjusted to fit the thickness of the stock.

Precautions

- Use a blade of the proper size and type
- Set the guard to just clear the stock when it is near the blade
- Use a jig when cutting small pieces of stock
- Use a push stick whenever possible

Scroll Saw

Scroll saws are used for precision cutting of curves and patterns. They have small thin blades that are held in upper and lower chucks that keep the blade tight. The blade moves rapidly up and down through the opening in the saw table.

Scroll saws are not as dangerous as most other saws. However, contact at the point of operation can cause hand and finger injuries. The portion of the blade below the table must be guarded.

Lathes

Lathes are used for shaping parts. Automatic and manual feed lathes are used. In an automatic feed lathe the stock is mounted on a carriage and is moved into contact with multiple knife cutter head that runs the length of the stock. The stock rotates at low speed while the cutter rotates faster.

In a hand feed lathe the stock rotates rapidly while the operator applies a simple point tool to the wood. The operator holds the tool on the tool rest and advances it along the length of the rest to shape the stock.

The hazards associated with lathes are contact with rotating parts at the point of operation. Hands, clothing, or jewelry may be caught on the rotating parts and pulled into the machine. The hazard is greater with hand fed lathes because the operator is in close proximity to the rotating stock and the cutting tool.

For automatic lathes with rotating knives a metal shield or hood that completely covers the knives and stock except at the contact points must be in place when the machine is in operation. For manual lathes cover the cutter heads as completely as possible with the shield or hood. For lathes used for turning long stock; long stock guards should be present which would prevent the stock from being thrown from the machine should the stock come loose. The power transmission should be enclosed.

Precautions

- Set the tool rest close to the stock
- Don not support the tool with your hands use the rest
- Make adjustments to the rest when the lathe isn't running
- Never allow operators to wear loose clothing, long hair, jewelry, or gloves
- Do not use stock that has splits, cracks, or knots
- Allow glue joints to fully dry

- Hold tools firmly

Shapers

Woodworking shapers are machines that are used to shape the edges of stock. Cutting occurs by hand feeding stock against a vertical rotating cutter mounted on a spindle. The cutting edges rotate at 7200 to 10000 rpm.
The spindle should be enclosed with an adjustable guard. Templates and jigs should be used to distance the operator's hands from the point of operation. Feather boards may be used if necessary.

Operators should listen for chatter. This indicates the knives are out of balance. Knives must be balanced, properly fitted, and precision ground to minimize the possibility of being flung from the cutter head.
In order to lessen the potential of kickback double-spindle shapers shall have starting and stopping device for ach spindle. Automatic feed rollers should be guarded.

Precautions

- Operators should not wear loose clothing, long hair, jewelry, or gloves

Drill Press

A drill press uses a rotating tool to produce a hole in stock. Normally drill presses are vertical and have variable speeds. Some may have multiple spindles for gang drilling. The most common machines are single spindle and belt driven.

The most common accident results when the operator attempts to hand hold the stock while drilling. When the drill enters or passes through stock it can catch and twist the stock which could result in an uncontrolled rotating piece of wood. Clamps or some type of hold-down fixture should be utilized.

As with most wood working machines flying wood chips are a hazard. Good housekeeping is essential when using a drill press. The work area must be kept clear of debris.

Power transmission components should be enclosed for machines that have adjustable belt drives. Automatic and high production machines should use barricades or enclosures to separate the operator from the drilling machine.

Sanders

Sanders finish stock by using a coated abrasive surface to remove material. The three general types of sanders are drum, Belt, and disc. Sanders produce a considerable quantity of wood dust. Controls and

hazards of wood dust are addressed in a separate topic. The major safety hazard associated with belt sanders is that operators may catch their hand, clothing, or jewelry in the in running rolls. Contact with the abrasive surface may cause abrasions and lacerations.

On automatic sanders feed rolls should be guarded to prevent operator contact. The guard design must allow for adjustment to any thickness of stock. The unused sum of the sanding belt should be guarded to prevent accidental contact. Drum and disc sanders should be enclosed with guards except for the portion of the drum above the table. The guard can consist of a protective cover at the rear side of the wheel and a hinged cover around the wheel periphery. Power transmission pulleys should be enclosed with a fixed guard.

Precautions

- Keep hands away from abrasive surfaces
- Sand on the downward moving side of the disc or belt
- Replace torn, frayed, worn or damaged belts or drums

Routers – Stationary

Routers are used for cutting and shaping decorative pieces, making frame and panel doors and milling moldings. Routers have spindles that spin variously shaped small diameter cutting tools at high speeds. The cutting tool is held in a collet chuck and protrudes through a flat, smooth bace that slides on the surface of the wood. The spindle is driven by belts and pulleys or by a high speed motor.

Inadvertent conduct with the cutting head when handling stock or removing scrap from the table is the most likely cause of injuries. For stationary routers the tool should be enclosed with an adjustable guard. Feed rolls should also be guarded.

Precautions

- Operators should not wear loose clothing, long hair, jewelry, or gloves.
- Use cutting tools at the proper spindle speed.
- Feed stock in the proper direction.
- Use good quality stock that is unlikely to break.

Tenoning Machines

Tenoning machines use cutter heads or saw blades to cut projections (tenons) on pieces of stock. Each tenon can be inserted into a cavity (mortise) or another piece of wood to form a mortise and tenon joint.

For stationary machines guarding is utilized to prevent operator contact with the cutter head or saw blade. Feed chains and sprockets shall be enclosed except for the portion of the chain conveying stock. The cutting heads and blades should be guarded to prevent operator contact.

Mortising Machines

Mortising machines use cutter heads or chains to cut cavities into a piece of wood. Generally a tenon is inserted to make a mortise and tenon joint.

To lessen the possibility of operator contact with the boring bit or mortising chain a number of guards are used. The boring bits should be enclosed with a guard that covers the bit and chuck above the material being worked. Operating treadles should be covered with U-shaped guards to prevent accidental tripping. The top of the cutting chain and driving mechanism should be enclosed. Safety bit chucks with no projecting screws should be used.

Handheld Production Tools

Handheld production tools include sanders, jigsaws, routers, drills, circular saws, and pneumatic nailers /staplers. Typically handheld tools are not as inherently dangerous as larger stationary tools of the same type. However potential hazards related to handheld tools do exist and cause more injuries than their larger stationary cousins.

Sanders

Handheld sanders finish stock by using a coated abrasive surface to remove material. A belt sander uses a system of pulleys to move the abrasive across the stock. Typically the sanding belt is pressed toward the wood which is located on a work table. Orbital sanders operate in the same manner but utilize a disk rather than a belt.

Abrasion injuries may occur when the operator's hands contact the abrasive material. The moving parts of the sander should be enclosed to prevent fingers from coming into contact with nip points.

Precautions

- Worn or frayed belts or disks should be replaced.

Jig Saws

Jigsaws are useful for precision cutting of intricate curves and patterns on thin stock. The thin blades move rapidly up and down. A hold down adjusts to the thickness of the material being cut.

Jig saws are not considered as dangerous as many other saws. However, contact with the blade at the point of operation can cause injuries. The blade should be guarded.

Precautions

- Make turns slowly.
- Use a narrower blade for sharp turns.

Routers – Handheld

Routers are used for cutting and shaping, making frame and panel doors and milling moldings. Routers have spindles that turn variously shaped small diameter cutting tools at high speeds. The bit is made of steel or carbide. It is held in a collet chuck and protrudes through a flat smooth base that slides on the surface of the work. Routers may be used in conjunction with a router table.
The most serious injury occurs when the operators hand contact the cutting bit. As much guarding as possible should be utilized.
Work Practices

- Never start routing at the end grain.
- Increase speed to prevent kickbacks.

Drills

A drill uses a multiple cutting edged rotating tool to cut a hole in the stock. Normally drills have variable speeds.

One of the most common accidents occurs when the operator attempts to hand hold stock while drilling. When the drill enters the stock it can catch and twist the stock from the operator. The result is an uncontrolled piece of wood. Guarding is especially difficult because of the nature of the tool. Whenever possible a hold down apparatus should be used rather than the hands.

Circular Saws

Circular saws are used for strait sawing. They can be used for crosscutting or rip sawing.

Injuries can occur if the operator's hands slip while cutting stock or if they are in the line of cutting. Kickbacks are another major cause of injuries. They are more likely to occur when ripping or cutting poor quality lumber. When ripping, a spreader should be used to prevent material from squeezing the blade or kicking back during ripping. If the saw kicks back anti-kickback fingers should be used to hold down the stock.

Precautions

- Use the proper blade for the cutting being performed.
- Properly support stock.
- Operate saw at proper speed.
- Maintain and sharpen blades.
- Remove damaged blades from service.

Pneumatic Nailers /Staplers

Pneumatic nailers are powered by compressed air at pressures up to 100psi. The major cause of injuries is related to the nail or staple being used.
To prevent injuries the nailers/stapler must be equipped with a device to keep fasteners from being ejected unless the muzzle is pressed against the work surface. A positive locking device attaching the air hose to the tool should be utilized. If an air hose greater than ½ inch in diameter is used a safety excess flow valve should be installed at the source of the air supply to reduce pressure in the event of hose failure.

Gluing Wood

A variety of glues are used for laminating and joining wood. These include contact adhesives, casein glue, epoxy glues, formaldehyde-resin glues (e.g., formaldehyde-resorcinol), hide glues, and white glue (polyvinyl acetate emulsion), and the cyanoacrylate "instant" glues.

Hazards

- Epoxy glues are moderately toxic by skin and eye contact, and by inhalation. Amine hardeners (as well as other types of hardeners) can cause skin allergies and irritation in a high percentage of the people using them. Inhalation can cause asthma and other lung problems.
- Cyanoacrylate glues: These are moderately toxic by skin or eye contact. They can glue the skin together or glue the skin and other materials together, sometimes requiring surgical separation. Eye contact can cause severe eye irritation. Their long term hazards are not well studied, especially with respect to inhalation.
- Formaldehyde-resin glues: Resorcinol-formaldehyde and urea-formaldehyde glues are highly toxic by eye contact and by inhalation, and moderately toxic by skin contact. The formaldehyde can cause skin and respiratory irritation and allergies, and is a known human carcinogen. The resin components may also cause irritation. Even when cured, any unreacted formaldehyde may cause skin irritation and sanding may cause decomposition of the glue to release formaldehyde. Formaldehyde can be a problem when working with fiber-board and plywood.
- Contact adhesives: Extremely flammable contact adhesives contain hexane, which is highly toxic by chronic inhalation, causing peripheral nerve damage. Other solvents in contact adhesives are mineral spirits or naphtha, and 1,1,1-trichloroethane (methyl chloroform), which are moderately toxic by skin contact, inhalation and ingestion.
- Water-based glues: Water-based contact adhesives, casein glues, hide glues, white glue (polyvinyl acetate), and other water-based adhesives are slightly toxic by skin contact, and not significantly or only slightly toxic by inhalation or ingestion.
- Dry casein glues: These are highly toxic by inhalation or ingestion, and moderately toxic by skin contact since they often contain large amounts of sodium fluoride and strong alkalis.

Precautions

- Avoid formaldehyde resin glues because of allergic reactions and the carcinogenicity of formaldehyde.
- Use water-based glues rather than solvent-type glues whenever possible.
- Wear gloves or barrier creams when using epoxy glues, solvent-based adhesives, or formaldehyde-resin glues.

THREE DIMENSIONAL PRINTING

3D printing, an additive manufacturing technology, has made rapid prototyping and small-scale manufacturing easier and more accessible. However, this revolutionary process does not come without hazards.

3D printing refers to various processes used to create or replicate an object by using successive layers of material (usually plastics) to create an object. Objects can be of any shape or geometry are produced from a 3D model or from a design fed into the 3D printer by a computer.

With 3D printing, an object can be made by using the following methods:

- Extruding
- Sintering
- Curing

Extruding involves using continuous filament of a thermoplastic material as the feedstock. Sintering is an additive manufacturing procedure that uses a laser as a power source. Curing uses a liquid resin as the feed material and the object is built layer-by-layer and cured; this process takes place slowly.

ABS vs. PLA Feedstock

Each 3D printer is designed to use certain types of materials. The most common type of desktop 3D printer technology joins thin strands, or filaments, made of ABS (Acrylonitrile Butadiene Styrene) or compostable materials, such as PLA, a biodegradable thermoplastic aliphatic polyester derived from corn starch tapioca. Using a computer-generated image, a 3D printer heats and melts the feed material, placing layers of filament on top of one another to form a precise 3D replica of the image.

The materials being fed into the machine (feedstock) can have inherent hazards and may release vapors and gases that may be more hazardous, for example, after they are heated during the 3D printing process.

- Consult the 3D printer manual to be sure you are using the proper feedstock.
- Review safety data sheets for feedstock materials before using.
- Double check what vapors or gases are generated when heating.

3D Printing Emissions: Nanoparticles & Vapors

To reduce the potential for Nano particles to aerosolize or be inhaled by users, it is best to purchase 3D printers with an enclosure or have an enclosure made. 3D printers should also have dedicated local exhaust.

Nanoparticles (ultrafine particles less than 1/10,000 of a millimeter) are one of the by-products emitted during the 3D printing process. Recent studies have shown that 3D printing using a low-temperature polylactic acid (PLA) feedstock can release 20 billion particles per minute, while a higher temperature acrylonitrile butadiene styrene (ABS) feedstock can release 200 billion.

Nanoparticles are of concern for the following reasons:

- They are very small and easily accumulate in the lungs
- They have large surface areas
- Can interact with the body's systems, including the skin, lungs, nerves and the brain.

Exposures to nanoparticles at high concentrations have been associated with adverse health effects, including total and cardio-respiratory mortality, strokes and asthma symptoms. While PLA feedstock is designed to be biocompatible, the thermal decomposition products of ABS feedstock have been shown to have toxic effects on lab rodents.

Chemical Vapors

3D printers are best located in a room that has additional ventilation.

Heating of certain thermoplastic filament can generate toxic vapors and vapors with high volatile organic compounds (VOCs). Most 3D printers do not come with an enclosure, exhaust ventilation or any filters. The following should be assessed before purchasing and installing a 3D printer:

- Building/Room where 3D printer will be located
- Placement of the 3D printer in the space itself
- Selection of printing feedstock

Other 3D Printing Hazards

- Hot surfaces - print head block and UV lamp
- High voltage - UV lamp connector, electric outlet safety certified and ground wire.
- Ultraviolet radiation - UV lamp. Don't look at the lamp; make sure the UV screen is intact.
- Moving parts - printing assembly.

Engineering and Administration Controls

A NIOSH Research Rounds publication recently published a study that discusses health and safety considerations when working around 3D printers. Particle emissions are the focus, especially when multiple printers are running simultaneously. Another consideration is toxic vapors that can be generated by heating plastics. Safety recommendations include the following:

- Use 3D printers ONLY in properly ventilated areas.
- Task ventilation may be useful for some styles of 3D printers.
- Choose low-emitting printers and feed materials/filament when possible.
- Wear proper personal protective equipment. Have a risk assessment to determine what is required.
- Purchase and use the manufacturers supplied controls, such as an interlocked enclosure. (Enclosures appear to be more effective at controlling emissions than just a machine cover.)
- Maintain a safe distance from the printer to minimize the inhalation of emitted particles.
- Turn off the printer if the printer nozzle jams, and allow the printer to ventilate before removing the cover.

Laser Printers vs. 3D Printers

Laser printers produce images or text on paper by using heat to melt toner powder, which is composed of carbon, plastic, and metals such as iron. Laser printers emit a large amount of particles and asthma-related chemicals. Several factors influence the hazards, such as toner and paper type.

The latest investigations have found that 3D printers' emissions may combine to form new compounds, including a chemical linked to asthma. 3D printers can emit smaller particles than those from laser printers (that use plastic toner). These findings, like those in a preceding study, suggest the need to take precautions to reduce emissions from desktop 3D printers in the home and office.

Alkaline Bath Management

Some 3D printers, like the Stratysus Dimension, require the use of an alkaline bath (corrosive) to remove the extra material surrounding each 3D printed item. Before installing or using an alkaline bath, make sure you have the following:

Chemical Waste Disposal

Hazardous waste management is ruled by increasingly stringent and complex regulations. The proper management of chemical and hazardous wastes is the responsibility of the generator of the waste. Indiscriminate disposal by pouring waste chemicals down the drain or adding them to mixed refuse for landfill burial is not allowed. Hoods shall not be used as a means of disposal for volatile chemicals. All wastes shall be collected and stored according to the Hazardous Waste Plan. Hazardous waste shall be stored in a safe and secure area with the proper labels attached.

Most commonly used organic solvents (e.g., acetone, methanol, toluene, mineral spirits, turpentine) and paints are considered hazardous waste and cannot be disposed of with regular trash or poured down the drain. For further information, see Longwood University's Hazardous Waste Plan. If you have hazardous waste to be disposed of, contact Environmental Health & Safety at 434.395.2471 for instructions.

RELATED DOCUMENTS

- Longwood University Policy 5601 Environmental, Occupational, Health and Safety
- Longwood University Policy 5602 Safety Rules Enforcement
- Longwood University EHS Chemical Hygiene Plan
- Longwood University EHS Hazard Communications Program
- Longwood University EHS Hazardous Waste Plan
- Longwood University EHS Electrical Safe Work Practices and Arc Flash Protection
- Longwood University EHS Personal Protective Program
- Longwood University EHS Hot Work Policy

REFERENCE MATERIALS

References

- *Art Painting and Drawing*, Angels Babin, M.S.
- *Photographic Processing Hazards*, Michael McCann, Ph.D., CIH
- *Ceramics*, Michael McCann, Ph.D., CIH
- *Lithography, Intaglio and Relief Printing*, Angela Babin, M.S.; Michael McCann, Ph.D., CIH; and Devora Neumark
- *Woodworking Hazards* and *Traditional Sculpting Hazards*, by Michael McCann, Ph.D., CIH and Angela Babin, M.S.
- *The Artist's Complete Health and Safety Guide*, Monona Rossol, MS, MFA
- *Artist Beware*, Michael McCann, Ph.D., CIH
- *Overexposure: Photography Hazards*, Susan Shaw and Monona Rossol
- *Making Art Safely*, M. Spandorfer, D. Curtiss, J. Snyder, MD
- *Stage Fright: Health & Safety in Theater*, Monona Rossol, MS, MFA
- *Health Hazards Manual for Artists*, Michael McCann, Ph.D., CIH

Resources

- Center for Safety in the Arts
  http://artsnet.heinz.cmu.edu:70/0/csa
- ACTS: Arts, Crafts and Theater Safety
  http://www.caseweb.com/acts/
- Princeton University Theater Operations Manual
  http://www.princeton.edu/-ehs/theater/Title.html
- Rutgers University Visual Art Safety Training Manual – 2012
  https://ipo.rutgers.edu/sites/default/files/Art-Safety-Manual-RU%202012.pdf
- University of Vermont 3D Printer Safety
  https://www.uvm.edu/riskmanagement/3d-printer-safety
- Pictures
  https://www.canva.com/