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AMP
SDSM&T

Laboratory Safety Manual

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1.0 General Laboratory Safety Practices

1.1 Laboratory Awareness

Be alert to unsafe conditions and actions, and call attention to them so that corrections can be made as soon as possible.

Pour more concentrated solutions into less concentrated solutions to avoid violent reactions.

Be familiar with the appropriate measures you should take when you or someone in your lab is working with or is exposed to the following:

- Corrosive Chemicals
- Radiation Materials
- Carcinogens
- Metal Powders
- Compressed Gases
- Toxic Chemicals
- Reactive Chemicals
- Flammable Substances

1.2 Personal Safety

1.2.1 Respiratory & Body Protection

1) Use fume hoods whenever possible.
2) Safety goggles/glasses shall be worn in the laboratory as needed.
3) Laboratory coats shall be worn in the laboratory as needed.
4) Gloves should be worn as needed.

1.2.2 Personal Hygiene

1) Wash hands before entering & leaving the laboratory area.
2) Launder clothing worn in laboratory separately from other clothing.
3) Never use your mouth to pipette chemicals or powders.
4) Long hair must be pulled back. No jewelry (e.g., bracelets, rings, watches, cuffs) or ties are to be worn in close proximity to open flames or operating electrical machinery.
5) Keep exposed skin covered. Shorts, skirts, or open-toed shoes should **NOT** be worn in the laboratory.

1.3 Fire Prevention

Be aware of ignition sources in your laboratory area (open flames, heat, electrical equipment, electric static charge).

Purchase and store flammable reagents in the smallest quantities possible.

Store flammable liquids in appropriate safety cabinets and/or safety cans.

Do not store incompatible reagents together (e.g., acids with flammables).

Make sure that all electrical cords are in good condition. All electrical outlets should be grounded and should accommodate a 3-pronged plug.

1.4 Housekeeping

Eliminate safety hazards by maintaining laboratory work areas in a good state of order.

All equipment should be inspected before use.

All projects must be accompanied by a note stating the work order number and the person assigned to the project.

If experiments are to be continued after working hours or overnight, they need to be continuously monitored. Place a note next to the experimental apparatus indicating the the work order number, the duration of the experiment, all powders and chemicals involved, your name, and a number where you can be reached in case of an emergency.

Keep the laboratory floors dry at all times. Immediately attend to spills of chemicals/powders and notify other lab workers of potential slipping hazards.

All machinery under repair and adjustment should be properly locked out and tagged prior to servicing. ONLY authorized personnel should do service work.

1.5 Emergency Procedures

In the event of an emergency, remember one number: **9-911**. By calling this number, a variety of emergency response departments can then be alerted to your situation.

Be sure the names and phone numbers of lab personnel to be contacted in an emergency is posted on the outside of the laboratory door(s).

Be familiar with the location and use of the following safety devices:

- Safety Shower
- Eye Wash Station
- Fire Alarm
- Protective Respiratory Gear
- Fume Hood
- Spill Cleanup Kit
- Fire Extinguishers

If a spill occurs during normal working hours, call the Campus Physical Plant at 2251 to inform them.

If an after hours spill occurs, call Campus Security at 6100 for assistance.

Clean up all small spills immediately. If a large chemical spill occurs that you are unable to clean-up call **9-911**.

If volatile, flammable, or toxic materials spill, shut off flames and spark-producing equipment at once.

1.6 Waste Collection

Minimize wastes at the source by limiting the quantities of materials purchased and used.

Deposit all waste in designated containers. Be able to recognize these containers, and know which ones are appropriate for the wastes you generate.

If there are questions regarding waste disposal, call the Campus Chemical Materials Manager at 1242.

1.7 Visitors

All visitors should be closely supervised and escorted at all times while in the vicinity of the laser system.

1.8 After Hours Operations

If work is being conducted after hours, before 7:30am or after 4:00pm let the other laboratory personnel know of your presence. Avoid carrying out experimental laboratory work in an unoccupied building. At no time should there be less than two personnel in the laboratory at one time.

2.0 Personal Protective Equipment

2.1 Eye Protection

Because your eyes successfully navigate treacherous situations every day, it's easy to relax your guard in the laboratory environment. After all, for those people not used to wearing glasses, it can be regarded as a burdensome task to wear unattractive, often restrictive eye wear.

However, the laboratory is likely to be the most health-threatening place that you can encounter. Splashing chemicals and flying objects are poised to interact with your eyes at any moment, and your eyes frequently get the short end of the deal. For this reason, eye protection is an important consideration.

This eyewear should offer front protection for laboratory personnel and visitors, and must meet federal specifications. If you don't have safety glasses, tell your supervisor.

2.2 Use & Maintenance of Eyewear

Eyewear should be as comfortable as possible, fit snugly over the eyes and around the face, and not interfere with the movement of the wearer. Where it is appropriate, signs should be posted outside the door stating that eye protection is required before entering the room.

2.2.1 Eyewear protection should be worn when using:

Including but not limited to:

- Cryogenic Materials
- Caustics, Irritants or Corrosives
- Metal Powders
- UV Light
- Toxic Chemicals
- Carcinogens
- Flammable Materials
- Lasers

2.2.2 Eye protection should be worn when performing these machine shop operations:

Including but not limited to:

- Welding
- Drilling
- Sanding/Grinding
- Sawing
- Soldering
- Hydraulic
- Pneumatic
- Woodworking
- Machining

Eye safety equipment should be capable of being cleaned and disinfected.

Eye protection should always be kept in good condition and checked frequently.

2.3 Corrective & Contact Lens

2.3.1 Corrective Lenses

Laboratory workers whose vision requires the use of corrective lens should wear safety eye protection of one of the following types:

1) Prescription safety glasses with protective lenses.
2) Safety eyewear that can be worn over prescription glasses without disturbing the adjustment of the glasses.

2.3.2 Contact Lenses

Laboratory personnel who must wear contact lenses while performing laboratory work should be aware of the following potential hazards:

1) It is virtually impossible to remove contacts from the eyes following a chemical spill affecting the eye area.
2) Contact lenses will interfere with emergency flushing procedures.
3) Contacts may trap and collect fumes and solid materials on the eyes.
4) If chemicals contact the eye area and the laboratory worker is unconscious, rescue personnel may be unaware that contact lenses are present.

Use of contact lenses shall be used in conjunction with eye protection that fits snugly over the eyes and around the face.

2.4 Protective Clothing *(Reserved for Future Use)*

2.4.1 Lab Coat

The lab coat is designed to protect the clothing and skin from powders and chemicals that may be spilled or splashed. It should always be properly fitted to the wearer and is best if it is knee length. There are several different types of lab coats for different types of protection.

- Cotton – protects against flying objects, sharp or rough edges, and is a good fire retardant.
- Wool – protects against splashes of molten materials, small quantities of acid, and small flames.
- Synthetic Fibers – protects against sparks, infrared and ultraviolet radiation. However synthetic fiber lab coats can adversely magnify the effects of some laboratory hazards. For instance, some solvents may dissolve particular classes of synthetic fibers, thereby diminishing the protective ability of the coat. In addition, on contact with flames, some synthetic fibers will melt. This molten material can cause painful skin burns and release irritating fumes.
- Aluminized and Reflective Clothing – protects against radiant heat.

The construction of the material must also be considered (twill, felt, plain, etc.), as various manufacturers rate the materials differently. Lab coats should be made with snaps/fasteners which afford the wearer quick removal in the event of an emergency.

2.5 Hand Protection

It is a good idea to always get into the habit of wearing protective gloves in the laboratory. Aside from acting as a shield between hands and hazardous materials, some gloves can also absorb perspiration and protect the hands from heat. Certain glove types can dissolve when in contact with solvents, it is important to take extra care in matching the protective glove with the nature of the job. Before

use, check to make sure the gloves (especially latex gloves) are in good condition and free from holes, punctures, and tears.

2.5.1 Glove Types

Gloves should be selected on the basis of the material being handled and The particular hazard involved.

- Plastic – protects against light corrosives and irritants.
- Latex – provides light protection against irritants (some people can have an allergic reaction to latex that can lead to a serious medical condition.
- Natural Rubber – protects against light corrosive material and electric shock.
- Neoprene – for working with solvents, oils, or light corrosive material.
- Cotton – absorbs perspiration, keeps objects clean, provides some fire retarding properties.
- Asbestos – insulates or resists heat. (Note: This material should be labeled with the proper warning sign because it is a known carcigen.) If your laboratory has asbestos gloves that are in need of disposal, seal gloves in a plastic bag.
- Zetex – when handling small burning objects. These are a good replacement for asbestos gloves.

When working with extremely corrosive material, wear thick gloves. Take extra precaution in checking for holes, punctures, and tears.

2.5.2 Glove Removal & Disposal

Care should be taken when removing gloves. Peel the glove off the hand, starting at the wrist and working toward the fingers. Keep the working surface of the glove from contacting skin during removal. Disposable gloves should be discarded in designated containers.

2.6 Foot Protection

Foot protection is designed to prevent injury from corrosive chemicals, heavy objects, electrical shock, as well as giving traction on wet floors. If a corrosive chemical or heavy object were to fall on the floor, the most vulnerable portion of the body would be the feet. For this reason, shoes that COMPLETELY COVER AND PROTECT the foot are required.

Fabric shoes, such as tennis shoes, absorb liquids readily. If chemicals happen to spill on fabric shoes, remove the footwear immediately.

When selecting footwear for the lab, choose sturdy leather shoes that cover the foot. These will provide the best protection.

2.6.1 The following shoe types should NOT be worn in the laboratory:

- Sandals
- Clogs
- High Heels
- Shoes that expose the foot IN ANY WAY

2.6.2 The following are RECOMMENDED types of footwear:

- Safety Toe Shoes (steel-toed) – protect against crushing injuries caused by impact from any object during work activities (e.g., lifting heavy objects, using power tools, etc.).
- Treated shoes, Rubber Boots, or Plastic Shoe Covers – protect against corrosive chemicals.
- Insulated Shoes – protects against electric shock.
- Rubber Boots with wooden soles – provide traction in wet conditions where the possibility of slipping exists.

Safety Toe Shoes, Rubber Boots or Plastic Shoe Covers can prevent contamination.

2.7 Ear Protection

Ear protection should be worn where the noise level is consistently above 85 decibels (dB). Areas where excessive noise is present should be posted with signs indicating ear protection is required. Ear protectors should be readily available and composed of rubber or plastic.

2.8 Respiratory Protection *(Reserved for Future Use)*

Because certain laboratory procedures can produce noxious fumes and contaminants, respiratory protection may be required in your work environment.

2.8.1 Respiratory Program

When engineering controls cannot successfully minimize or eliminate the potentially harmful fumes, a respiratory protection program should be established. For more information contact the Director of Facilities Services at 2251.

A respiratory program must cover many issues, including:

- Medical evaluations.
- Education and training in the use of respiratory equipment.
- Proper storage and cleaning practices to ensure optimum protection.
- Equipment adjustment to assure the user of a proper fit and to maximize protection against fumes and contaminants.

2.8.2 Respiratory Types

There are many respirator types available to laboratory workers. These protective devices range from a disposable dust mask to a self-contained

breathing apparatus (SCBA).

3.0 Lab Safety Equipment

On the job, eyes, face, hands and feet are no match for metal powders, toxic fumes, chemicals or falling objects. All work performed in a laboratory is potentially dangerous; however, there are many things laboratory workers can do to minimize the danger. Using the appropriate personal protective and laboratory safety equipment are important safety precautions that one can take to work safely and effectively.

3.1 Chemical Fume Hoods

Chemical fume hoods capture, contain, and expel emissions generated by hazardous chemicals. In general, it is a good idea to conduct all laboratories chemical experiments in a fume hood. While you may be able to predict the release of undesirable or hazardous effluents, in some laboratory operations surprises can always happen. Therefore, the fume hood offers an extra measure of protection.

Before use, check to see that your hood has an inspection tag. This will tell you the date of the most recent hood evaluation. If the fume hood in your lab does not appear to be in good working order hold a paper tissue inside the fume hood to indicate if airflow is present.

Certain laboratory procedures may require the use of perchloric acid. The use of this material may cause the formation of explosive perchlorate crystals. Special fume hoods, commonly known as **Perchloric Acid Fume Hoods**, **MUST** be used for this purpose. These hoods have self-contained wash-down units to inhibit crystal formation.

The purpose of a laboratory fume hood is to prevent the escape of contaminants into the laboratory. This is accomplished by drawing air from the laboratory, past the operator, into the hood. The concentration of the contaminant in the actual breathing zone of the operator must be kept as low as possible. The ability of the hood to provide adequate protection is dependent upon the following prime concerns; the control velocity at the hood face, the air movement and flow patterns in the room, the effect of the operator on the air flow pattern at the hood face and the turbulence within the hood.

3.1.1 The Control Velocity at the Hood Face

Face velocities of 80-100 fpm (feet per minute) will provide adequate containment of laboratory contaminants, if the overall installation can be rated as "good" in the reference to the other listed performance factors (see 2 and 3 below). Control velocities must overcome the particle kinetics of aerosols, the molecular diffusion of gases and vapors, and all other "normal" activities that take place inside and outside of the hood. The vector of the

air at the face of the hood must be inward and perpendicular to the face. Flows lower than 80 fpm do not provide the safety factors desired for normal conditions such as operator movements. Flows higher than 100 fpm are not required for "good" laboratory arrangements and do not improve performance for poor arrangements.

3.1.2 Air Movement & Flow Patterns in the Room

The effect of air movement within the laboratory on the performance of hoods is directly related to hood location and the influence of air supply systems. Hood locations must be away from doors, windows, and pedestrian traffic. Air from these sources can have velocities several orders of magnitude greater than the hood face velocity, creating the potential for drag out or displacement of contaminated air from the hood. Air from outlets such as ceiling and/or wall diffusers, must either be controlled to assist in the performance of the hood or directed so that the energy is lost before entering the zone of influence. Air from the makeup systems should not exceed 20-25 fpm in the hood face area (measured with the hood exhaust "off"). If these criteria are judged satisfactory, the system then can be considered "good" and the required face velocities of 80-100 fpm are valid.

3.1.3 The Effect of the Operator on the Air Flow Pattern at the Hood Face

The turbulent air patterns resulting from the passage of makeup air around an operator standing in front of a hood, have tremendous effects on the air flow characteristics. Serious losses of contaminants from the hood can occur unless the low-pressure area in front of the operator is minimized via the proper use of makeup air and the assurance of sufficient capture velocity at the face of the hood.

3.1.4 Turbulence Within the Hood

As air enters the hood, it is drawn past equipment and sources of contamination toward the exhaust slots. At an airflow greater than needed to provide a good vector and containment, excessive turbulence can cause a "rolling effect" in the hood chamber. This increases the potential for greater mixing of contaminated air and room air at the face of the hood. Under poor laboratory hood arrangements, greater turbulence can result in excessive spill-out of contaminated air into the room. For this reason, it is obvious those substandard hood operations cannot be upgraded merely by increasing airflow.

3.1.5 Recommended Work Practices

1) All laboratory workers with access to a laboratory chemical fume hood should be familiar with its use.
2) Always work at least six inches back into the hood (six inches beyond the sash line) keeping the sash line between your body and your work.
3) Set the adjustable baffles on the back wall of the hood so that the one on

top is about 3/4 of an inch from the ceiling of the hood compartment, and the lower baffle is fully open. This setting will provide the most uniform flow distribution through the hood face for most laboratory operations. A notable exception is the performance of experiments resulting in the discharge of effluents with high thermal buoyancy.

4) Don't use laboratory chemical fume hoods as chemical storage cabinets – keep the work surfaces clean and uncluttered.
5) Beware of situations when the hood requires sash position mark to denote a minimally acceptable face velocity. This practice is often necessary because the hood cannot deliver the required velocity in the fully open position. However, any time the sash mark must be posted lower than 18 inches up from the hood work surface, there are probably basic (and possibly critical) deficiencies that should be investigated and rectified.

3.1.6 Maintenance

1) Fume hoods should be surveyed on a monthly basis.
2) The hood should always be in good condition and capable of routine use. Any hood or component of ventilation not properly functioning must be taken out of service and clearly tagged.
3) The lab worker should not be able to detect strong odors released from materials in the hood area. If odors are detected, check to make sure that the ventilation fan is turned on.
4) An emergency plan should exist in case of hood ventilation malfunction.
5) All protective clothing should be worn when working with chemicals in the hood. In addition to gloves, safety glasses, and lab coats, a face shield will provide an extra measure of safety from reactive chemicals.
6) Solid objects or materials should not be allowed to enter the exhaust ducts at the rear of the hood, as they can become lodged in the duct or fan.

3.2 Chemical Storage Cabinets

Storage of flammables and corrosives in the lab should be limited to as small a quantity as possible. They should be stored in ventilated cabinets that meet OSHA 1910.106d and NFPA 30 specifications.

3.2.1 Use & Maintenance

1) Chemicals should **NEVER** be stored in alphabetical order (unless already separated out into compatible groups). This system may contribute to the high probability of incompatible materials being stored next to one another.
2) Incompatible reagents should not be stored next to each other.
3) Storage outside the cabinet should be kept to a minimum.
4) The vent cap on chemical storage cabinets should not be removed from its location unless the cabinet is attached to an existing ventilation system.

5) Glass containers should be stored on the bottom shelf of storage cabinets, if possible.

3.2.2 Types of Cabinets

- Flammable liquid cabinets - designed for storage of flammable or combustible liquids.
- Acid/Corrosive cabinets - designed for corrosion resistance.
- Bulk storage cabinets - can be used for storage of flammable and corrosive liquids outside the laboratory setting.

3.3 Individual Storage Containers

Selecting the best means of storage for chemical reagents will, to a great extent, depend on that reagent's compatibility with the container.

A safety can is an approved container of no more than five gallons (19 liters) capacity. It has a spring closing lid and spouts cover, and is designed to safely relieve pressure buildup within the container.

Vent caps may be purchased for original manufacturer's glass containers to help minimize explosion hazards.

3.4 Refrigerators *(Reserved for Future Use)*

While domestic refrigeration units are appropriate for keeping foods cold, they are not designed to meet the special hazards presented by flammable materials. Therefore, laboratory refrigerators should be carefully selected for specific chemical storage needs.

To prevent potential safety hazards, the length of storage of any material should be kept to a minimum. In addition, refrigerators should be inspected every six months.

3.4.1 Use & Maintenance

1) Each refrigerator, freezer, or cooler should be prominently labeled with appropriate hazard signs to indicate whether it is suitable for storing hazardous chemicals. To be on the safe side, label chemical hazard refrigerators with the sign ***"For Chemical Storage Only. No Food or Drink Allowed."***
2) If radioactive materials are to be stored, a refrigerator must be clearly labeled ***"Caution, Radioactive material. No Food or Beverage may be stored in this unit."***
3) The containers placed in the refrigerator should be completely sealed or capped, securely placed, and permanently labeled. Avoid capping materials with aluminum foil, corks, and glass stoppers.
4) Refrigerators should be frost free to prevent water drainage.

3.4.2 Types of Refrigerators

- Because ignitable vapors can build up in refrigerators, it is important to store materials in specially designed units. These refrigerators will have self-contained electrical elements to avoid speak-induced explosions.
- Explosion proof refrigerators are specifically designed for hazardous environments, featuring enclosed motors to eliminate sparking.

3.5 Eye Wash Stations

Eye wash stations provide an effective means of treatment when chemicals come in contact with the eyes. Eye wash stations should be readily available and accessible to all laboratory personnel.

The facility should be clearly marked and no more than 50 feet, or 15-30 seconds, away from every lab workstation. Laboratory workers should be able to locate the nearest eye wash facility with their eyes closed (eye injuries may involve temporary blindness).

Eye injury usually accompanies a skin injury. For this reason, eye wash stations should be located near the safety shower so that eyes and body can be washed.

3.5.1 Use & Maintenance

Water/eye solutions should not be directly aimed onto the eyeball, but rather, aimed at the base of the nose. This increases the chance of effectively rinsing the eyes free of chemicals (harsh streams of water may drive particles further into the eyes).

1) Eyelids have to be **forcibly** opened to ensure effective washing behind the eyelid.
2) Remove contact lenses as soon as possible to rinse eyes of any harmful chemicals.
3) Be sure to wash from the nose out to the ear, this will avoid washing any chemicals or powders back into the eye or into an unaffected eye.
4) Flood eyes and eyelids with water/eye solution for a minimum of 15 minutes.
5) Cover both of the victim's eyes with clean or sterile gauze.
6) Call Rescue Squad **9-911**.

Eye wash stations should be inspected every six months.

Plumbed eye wash stations should have protective covers to protect nozzles from airborne contaminants.

3.5.2 Types of Eye Wash Stations

- Gravity Feed Self-Contained - provides the laboratory worker with emergency eye wash treatment in areas inaccessible to plumbing.

- Faucet Mounted (pin or push plate activators) - provides continuous water flow while freeing hands to open eyelids. It turns a standard faucet into a practical emergency eye wash station.
- Laboratory Bench - sprays with a squeeze handle can be installed through the bench top for instant availability.
- Swivel Eye Wash - mounts on lab bench or counter top adjacent to a sink. It swivels 90 degrees over the sink for use, or out of the way for storage.

3.6 Safety Showers *(Reserved for Future Use)*

Safety showers provide an effective means of treatment in the event that chemicals are spilled or splashed onto the skin or clothing. Safety shower facilities should be installed wherever chemicals are present (e.g. acids, alkalis, or other corrosive materials) and must be readily available to all personnel.

3.6.1 Use & Maintenance

1) Safety showers should be in a **clearly marked and accessible** location. The facility should be no more than 50 feet, or 15-30 seconds, away from every lab workbench.
2) Laboratory workers should be able to locate the shower(s) with their eyes closed (emergency situations may leave victim temporarily blind).
3) Safety showers are operated by grasping a ring chain or triangular rod.
4) The pull mechanism is designed for people of all heights. It should always be accessible and hang freely.
5) Safety shower should supply a continuous stream of water to cover the entire body.
6) Individuals should remove clothing, including shoes and jewelry, while under an operating shower.
7) Safety showers should be located AWAY from electrical panels or outlets.
8) If at all possible, safety shower facilities should be installed near appropriate drainage systems.

3.6.2 Types of Safety Showers

- Ceiling/Wall Emergency Shower - provides a continuous water flow and mounts directly to overhead vertical pipes or horizontal wall pipes.
- Deck Mounted Drench Hose - is hand operated for quick spot washing of injuries.
- Floor Mounted Emergency Combination - eye wash/face and body mounts directly to horizontal wall pipes.

3.7 Fire Safety Equipment

3.7.1 Alarms

Alarms are designed so that all endangered laboratory personnel are alerted. All faculty, staff and students should become familiar with the EXACT LOCATION of the fire alarm stations nearest to their laboratory.

3.7.2 Extinguishers

Extinguishers are classified according to a particular fire type and are given the same letter and symbol classification as that of the fire.

- **TYPE A** Combustibles wood, cloth, paper, rubber and plastics
- **TYPE B** Flammable Liquids oil, grease and paint thinners
- **TYPE C** Energized Electrical Equipment electrophoresis
- **TYPE D** Combustible Metals (magnesium, titanium, sodium, lithium)

Multipurpose Extinguishers are highly recommended because they are an effective agent against Types A, B, and C fires. These are commonly known as ABC or Clean Guard.

Extinguishers should be identified by appropriate signage and securely located on the wall near an exit. Each month the Supervisor will sign off on all fire extinguishers. All extinguishers should be inspected at least every 12 months for broken seals, damage, low gauge pressure, or improper mounting. Units should be replaced or recharged if they have been used, damaged, or discharged.

How To Use A Fire Extinguisher

Fire extinguishers are not designed or intended to extinguish large fires, but if used properly, can control or extinguish a small fire. A small fire is defined as one that could occur in a standard office trash can. When a fire or suspected fire, i.e., smoke, is discovered, the first reaction should always be to activate the fire alarm system, call 911, and evacuate the building according to the evacuation plan. Fire extinguishers are provided in all University buildings and can be used provided the person is properly trained to use the extinguisher. The following are guidelines in making the decision as whether to use the unit, and how to use the extinguisher.

Remember the "PASS" word.

1) **P**ULL THE PIN: Place your hand on the top of the cylinder and pull the pin. This will unlock the handle and allow you to activate the unit.
2) **A**IM: Point the nozzle of the hose at the base of the fire.
3) **S**QUEEZE: the handle (lever) releasing the fire-fighting agent.
4) **S**WEEP: the nozzle from side to side over the fire. Keep the nozzle/hose directed at the base of the flame. Empty the fire extinguisher onto the fire.

Personal Safety Precautions:

- Never reach over the fire.
- Never allow the fire to get between you and the exit from the room.
- Never enter an unknown area to fight a fire, especially in a chemistry lab.
- Always notify the proper fire officials.

If there are any questions on how to obtain an extinguisher or to have an extinguisher inspected, call the Director of Facilities Services at 2251.

3.7.3 Sprinklers

Due to the presence of pyrophoric materials, the sprinkler systems have been disconnected in the Laser Processing Lab and Control Areas.

4.0 Properties of Hazardous Chemicals & Materials

4.1 Flammability

Flammability is a measure of how easily a gas, liquid, or solid will ignite and how quickly the flame, once started, will spread. The more readily ignition occurs, the more flammable the material. Flammable liquids themselves are not flammable, rather vapors from the liquids are combustible. There are two physical properties of a material that indicates its flammability: flash point and volatility (boiling point).

The **flash point** of a material is the temperature at which a liquid (or volatile solid) gives off vapor in quantities significant enough to form an ignitable mixture with air. Given an external source of ignition (i.e., spark, flame), a material can ignite at temperatures at or above its flash point. The flash point of ethyl ether, a highly flammable solvent is –49 °F; kerosene has a flash point between 100 and 150 °F. Flammable gases have no flash point, since they are already in the vapor phase.

The **volatility** of a material is an indication of how easily the liquid or solid will pass into the vapor stage. Volatility is measured by the **boiling point** of the material – the temperature at which the vapor pressure of the material is equal to the atmospheric pressure. The term volatility is often mistakenly used as a synonym for flammability. There are some materials that are volatile but not flammable, such as water, chloroform, and mercury.

Some materials are **pyrophoric**, meaning that they can ignite spontaneously with no external source of ignition. Potassium metal, for example, can react with the moisture in air. This reaction causes hydrogen gas to be evolved, and the heat generated by the reaction can be hot enough to ignite the hydrogen.

4.1.1 Labeling & Information

1) Each container of flammable liquid should be properly labeled before use.
2) The label indicating flammability is represented by a flame.
3) Flammability information can be found in the Material Safety Data Sheet under Fire and Explosion Data. Flash point and boiling point information can be found in the section entitled Physical Properties.

4.1.2 Storage

1) Flammable materials should never be stored near acids.
2) Storage areas should be cool enough to prevent ignition in the event that vapors mix with air. Adequate ventilation should be provided to prevent vapor build up.
3) Avoid storage of flammable materials in conventional (non-explosion proof) refrigerators. Sparks generated by internal lights or thermostats may ignite flammable material inside the refrigerator, causing an extremely dangerous explosion hazard.
4) Storage areas should have spill cleanup materials and proper fire fighting equipment nearby.
5) Storage areas should be inspected monthly for deficiencies, and storage of flammable materials should be kept to a minimum.
6) **NO SMOKING** signs should be clearly posted where flammable materials are used and stored.
7) Flammable liquids can be separated into categories based on their flash point and boiling point. Based on these classifications, OSHA has published permissible limits for specific flammable liquid storage containers.

4.1.3 Handling

1) Use gloves and safety goggles when handling flammable liquids or vapors.
2) Dispensing of flammable or combustible liquids should only be carried out under a fume hood or in an approved storage room.
3) When transferring or using a flammable liquid, all ignition sources should be eliminated from the area.
4) **DO NOT** use water to clean up flammable liquid spills.
5) **DO NOT** dispose of flammable or combustible liquids in the sink or drain.

4.2 Corrosivity

Gases, liquids, and solids can exhibit the hazardous property of corrosivity. Corrosive chemicals can burn, irritate, or destructively attack living tissue. When inhaled or ingested, lung and stomach tissue are affected.

- Corrosive gases are readily absorbed into the body through skin contact and inhalation.
- Corrosive liquids are frequently used in the laboratory and have a high potential to cause external injury to the body.

- Corrosive solids cause delayed injury because they dissolve rapidly in moisture on the skin and in the respiratory system. The effects of corrosive solids depend largely on the duration of contact.

Materials with corrosive properties can be either acidic (low pH) or basic (high pH).

4.2.1 Labeling & Information

1) The corrosive label depicts the corrosion of a hand and/or a bar of steel.
2) Information on corrosivity can be found in the Material Safety Data Sheet under Health Effects and First Aid.

4.2.2 Storage

1) Segregate acids from bases, and corrosive materials from both organic and flammable materials.
2) Store corrosive materials near the floor to minimize the danger of falling from shelves.
3) Store in cool, dry, well-ventilated areas, away from sunlight. The storage area should not be subject to rapid temperature changes.

4.2.3 Handling

1) Wear adequate protective equipment (rubber gloves and splash proof eye protection). If splashing is a definite hazard, face shields must also be worn.
2) Corrosive materials should be handled in a fume hood to protect from the possible generation of hazardous or noxious fumes.
3) Add reagents slowly. Always add acids to water (never water to acid). During the addition of reagents, allow acid to run down the side of the container and mix slowly.
4) Corrosive materials should be transported in unbreakable containers.

4.3 Reactivity

Explosive materials are chemicals that cause a sudden, almost instantaneous release of large or small amounts of pressure, gas and heat when subjected to sudden shock, pressure or high temperature.

Some substances, under certain conditions of shock, temperature or chemical reaction can explode violently. Such explosions present many hazards to laboratory personnel.

Before working with explosive materials understand their chemical properties, know the products of side reactions, the incompatibility of certain chemicals and monitor possible environmental catalysts (such as temperature changes).

4.3.1 Labeling & Information

1) Information on explosives can be found in the Material Safety Data Sheet under Fire and Explosion Data.

4.3.2 Storage & Handling

EXPLOSION HAZARDS!!! Avoid the following:

- Allowing picric acid to dry out**.**
- Mixing flammable chemicals with oxidants.
- Flammable gas leaks.
- Heating compressed or liquefied gas.
- Uncontrollable fluctuating temperatures during experiments using explosive chemicals.
- Bringing hot liquid (i.e., oil) into sudden contact with a material possessing a lower boiling point.
- Contacting flammable materials with catalysts (i.e., acids or bases catalyze an explosive polymerization of acrolein).
- Explosive peroxide decomposition products from building up in solvent containers during storage.
- Mixing nitric acid with acetone.
- Distilling ethers unless free from peroxides.

4.3.3 Plan a Procedure for Working with Explosive Materials

The following elements should be included in the plan:

- Insert experimental apparatus into a dry glove box.
- Keep specified fire extinguishing equipment near the explosive material workspace.
- Determine all explosive hazards prior to experimental work, including the stability of reactants/products.

4.4 Toxicity

The concept of toxicity is unique because it can be applicable to all chemical substances used in the laboratory. The terminology explained below can not only assist laboratory workers in assessing the degree of hazard, but it can also provide guidance in the selection of appropriate personal protective equipment.

As defined, toxicity is the ability of a substance to cause damage to living tissue, impairment of the central nervous system, severe illness or in extreme cases, death when ingested, inhaled or absorbed through the skin.

The administration of a particular dosage of a chemical and the subsequent response by experimental animals can help predict that chemical's toxic effect on humans. The dose-response behavior is represented by a dose-response curve which demonstrates that not all individuals will respond to a particular dose of a chemical in the same manner. Some people will be more sensitive than others. A specific dosage that may be lethal to one person may not be lethal to another,

therefore an average measure of toxicity must be denoted.

4.4.1 LD_{50}

The point on the curve where 50% of the test animals have died as a result of a particular chemical dosage is referred to as the Lethal Dose50, or LD_{50}. The LD_{50} is usually indicated in terms of milligrams of substance ingested per kilogram of body weight (mg/kg). The lower the LD_{50}, the more toxic the material.

Inhalation of toxic substances can cause a great deal of tissue damage. Each lung is composed of a large surface area of folded tissue that can be vulnerable to assault by toxic vapors and airborne particles. The toxicity of a substance via inhalation is measured by threshold limit values (TLV's). These values are determined by the American Conference of Governmental Industrial Hygienists (ACGIH) and are expressed in parts per million (ppm) of the substance in air or milligrams of substance per cubic meter of air. There are two major types of threshold limit values: the time-weighted average (TWA) and the short-term excursion limit (STEL).

The toxicity of a substance via absorption can be determined several ways. Often, the threshold limit values of a substance will have a skin notation, indicating they are rapidly absorbed by the skin. Absorption can also be indicated by the solubility of the material in water. Materials that are extremely soluble in water can dissolve in skin moisture and be transported throughout the skin's surface. For instance, dimethyl sulfoxide (DMSO) rapidly absorbs into the skin. If any toxic materials are present in this solvent or on the surface of the skin, DMSO will transport these contaminants into the body as well.

A substance can have either acute or chronic toxicity. A substance that is acutely toxic will have immediate effects on the health of an over-exposed individual. A substance that has chronic toxicity will eventually affect the health of a person due to long-term exposure to that material.

4.4.2 TWA

The TWA of a substance is the average concentration to which a worker can be exposed throughout an eight-hour work day without adverse effects.

An important point to keep in mind is that the adverse effects of over-exposure to a material can range from headache or nausea to more severe disabilities. For this reason, time-weighted averages should be considered only as a guide in controlling health hazards in the laboratory, not as definitive marks between safe and dangerous concentrations.

4.4.3 STEL

The STEL of a substance is the maximum amount to which a worker can be exposed in a fifteen-minute period without adverse effects. Again, this is intended only as a rough guideline.

4.5 Poisons

A poisonous compound is a substance that causes death or serious injury in the event that relatively small amounts are inhaled, ingested or have contacted the skin. All substances can be poisonous in varying quantities (e.g., a little cyanide or a lot of toothpaste).

4.5.1 Labeling & Information

1) Any substance that carries the international poison symbol (skull and crossbones) should be treated as hazardous.
2) Information on the poisonous nature of chemicals can be found in the MSDS section Health Hazard Data.

4.5.2 Storage & Handling

1) Treat poisonous compounds with extreme caution. Wear protective safety glasses and gloves and work in a well ventilated fume hood.
2) Wash hands frequently.

5.0 Special Classes of Materials

5.1 Carcinogens

A carcinogen is an agent capable of causing cancer as designated by the Occupational Safety and Health Administration (OSHA). The list of designated carcinogenic chemicals are constantly being modified. Long-term exposure to carcinogenic substances can result in cancers of various types. A number of substances have been found to be capable of producing cancer following exposure by inhalation, ingestion or skin contact.

5.1.1 Labeling & Information

The following terms are used to describe carcinogenic materials:

- Sufficient positive - those chemicals that were found to promote and increase incidence of malignant tumor in a multiple species or strain of lab animals.
- Limited positive - those chemicals found to promote either malignant tumors in a single strain or benign tumors in single of multiple species or strain.
- Inadequate - has insufficient evidence to make a decision.
- Equivocal - has almost no supporting evidence.
- Negative - has (limited or sufficient) significant negative evidence.

Entrances into areas where known carcinogens are used in appreciable quantities shall be posted:

Cancer Suspect Agent
Authorized Personnel Only

5.1.2 Storage & Handling

1) Containers should be clearly labeled and kept in a separate (preferably locked) storage location. Immediate work areas should be clearly demarcated with warning signs.
2) All work surfaces that are used should be covered with stainless steel, plastic trays or dry absorbent plastic-backed paper.
3) Laboratory supervisors and/or faculty advisors are responsible for training laboratory workers on proper handling techniques.
4) Each laboratory worker must adhere to proper operations, emergency procedures, monitoring of lab work and required medical examinations. Medical records must be accurately maintained when working with carcinogens.
5) If you believe that you have been exposed to a substance labeled as carcinogenic notify your supervisor immediately.
6) Before working with a suspected or known carcinogen obtain health hazard information for each compound. In addition, compile spill cleanup emergency procedures for your laboratory.
7) **Exercise extreme caution**. Wear personal protective equipment and work in a well-ventilated area.
8) Visitors should be notified about carcinogen use in the laboratory work area.

5.2 Compressed Gases

Compressed gases can be hazardous because each cylinder contains large amounts of energy and may have high flammability and toxicity potential.

5.2.1 Labeling & Information

1) Compressed gas containers may be labeled in five ways:
   - Flammable gas - labels show a flame on red label.
   - Non-flammable gas - labels depict a gas canister on a green background.
   - Poisonous gas - labels show skull and crossbones.
   - Oxygen-containing gas - labels are designated by a flaming letter “O”.
   - Chlorine gas - labels are distinctly marked.
2) Know the contents of the cylinder and be familiar with the properties of the gas.
3) The contents of the cylinder or compressed gas should be clearly marked and identified with proper labels or tags on the shoulder of the cylinder. Those cylinders or compressed gases that do not comply with identification requirements should be returned to the vendor.

4) If two labels are associated with one cylinder, affix the labels 180° apart on the shoulder of each cylinder. Label all empty cylinders EMPTY or MT and date the tag.
5) All regulators, gauges, valves and manifolds must be designed for the particular pressures and gases involved. They should bear the inspection seal of either Underwriters' Laboratories (UL) or Factory Mutual Engineering Division of Associated Factory Mutual Fire Insurance Companies (FM).

5.2.2 Storage & Handling

1) All cylinders should be stored in cool, dry and well-ventilated surroundings away from all flammable substances including oil, greases and gasoline. **DO NOT** subject any part of a cylinder to a temperature higher than 125 °F.
2) Cylinders should not be located where objects may strike or fall on them.
3) Cylinders should not be stored in damp areas, near salt, corrosive chemicals, fumes, heat or direct sunlight. Store cylinders by gas type separating oxidizing gases from flammable gases.
4) All cylinders and compressed gases (full or empty) should be properly fastened and supported by straps, belts, buckles or chains to prevent them from falling and causing bodily harm. A maximum of two cylinders per restraint is recommended.
5) **DO NOT SMOKE** in areas where there are flammable gases being used or stored.
6) **DO NOT** extinguish a flame caused by a gas until the gas source has been shut off.
7) A cylinder should only be moved while strapped to a wheel cart to ensure stability. When storing or moving cylinders, always attach safety caps.
8) **DO NOT** heat the cylinder or place a cylinder where it may become part of an electrical circuit. Compressed gases must be handled as high-energy sources and dangerous projectiles.
9) All cylinders should be checked for damage prior to use. **DO NOT** repair damaged cylinders yourself. Damaged or defective cylinders, valves, etc., must be taken out of use immediately and returned to the manufacturer for repair.
10) Each regulator valve should be inspected annually. Never force valve or regulator connections. Threads and the configuration of valve outlets are different for each family of gases to prevent mixing of incompatible gases.
11) **DO NOT** use lubrication on valve regulators.

5.3 Cryogenic Materials

Cryogenic materials have special properties that make them particularly hazardous to use in the solid, liquid or gaseous state.

5.3.1 Storage & Handling

1) The severely cold temperatures associated with cryogenic liquids (-60 °C to -270 °C) can damage living tissue on contact and embrittle structural materials.
2) Liquefied under pressure, cryogenic liquids must be kept in specially designed high-pressure vessels that contain fittings to relieve pressure. When in contact with a moist area, ice formation can plug pressure release devices and pose an explosion hazard. For this reason, store vessels in a dry place and periodically check for ice formation.
3) Cryogenic liquids present fire and explosion hazards. A flammable mixture, cooled in the presence of air with liquid nitrogen or liquid oxygen, can cause oxygen to condense and thereby present an explosion hazard. Keep away from ignition sources. Flammable liquids will support combustion in both the liquid and gaseous states.
4) If allowed to depressurize, cryogenic liquids will rapidly and violently expand.
5) Store and work with cryogenic liquids in a well-ventilated area. These liquids can cause asphyxiation as evaporating CO_2 is concentrated around cryogenic materials.
6) Safety glasses and face shields should be used. For handling of cryogenic liquids, use potholders instead of gloves (as gloves can freeze to the skin).
7) Cushion glassware in a protective covering to prevent injury caused by flying glass in the event of implosion/explosion.
8) Transport fragile cryogenic containers with caution.

6.0 Chemical Labeling

Labels will be the primary initial source of warning for employees when handling hazardous chemical substances. Federal and State regulations mandate that all labels on original/stock containers of hazardous chemicals include the name of the hazardous chemical, appropriate hazard warning(s) and the name and address of the manufacturer, importer or other responsible party.

6.1 Proper Chemical Labeling

Laboratory supervisors should ensure that all incoming containers of hazardous materials bare a label specifying:

- Appropriate hazard warnings.
- Identification of the chemical in the container and identification of the hazardous component(s).
- Name, address, and telephone number of the chemical manufacturer, importer or responsible party (e.g. principle investigator).
- Date of receipt or generation of the chemical.

Laboratory workers should not remove or deface labels on containers of hazardous

chemicals.

When chemicals are transferred from the manufacturer's original container to a secondary container, that new container should be appropriately labeled as to chemical identity and hazard warning(s).

6.2 Chemical Labeling – Hazard Information

Hazard warnings found on the labels of hazardous chemical containers may be composed of pictures, symbols, words or any combination thereof which convey the hazard(s) of the chemical.

6.3 Picture Hazard Warnings

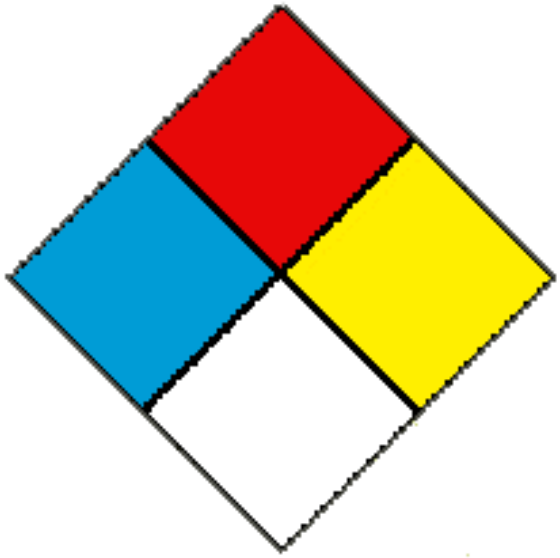
Picture hazard warnings help to identify the properties and classes of hazardous compounds. Examples include the flaming letter "O" (oxidizer), hand/bar of steel (corrosive) and a skull and crossbones (poison).

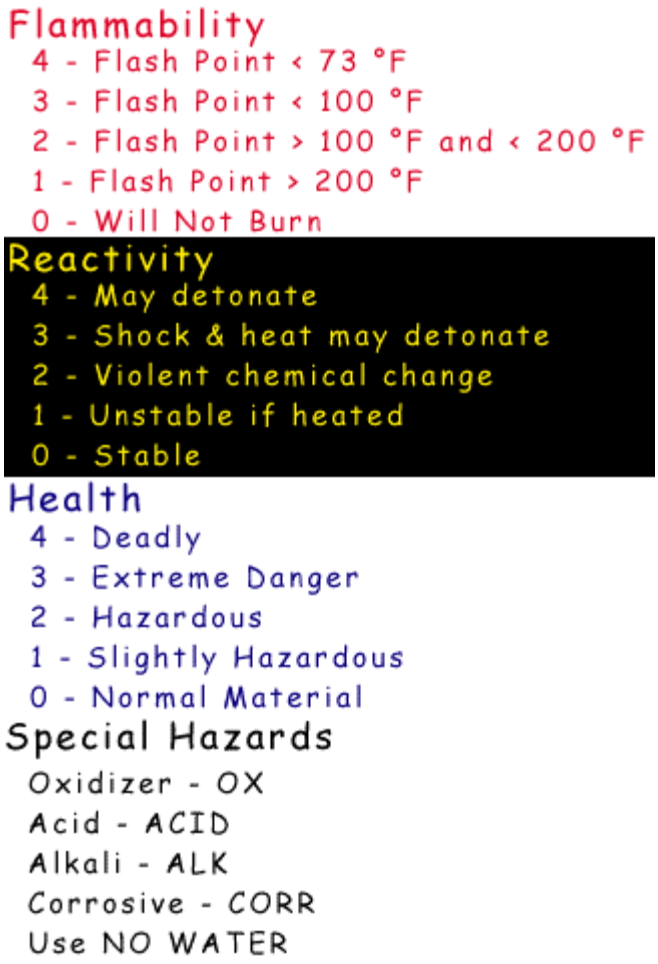
6.4 Symbol Hazard Warnings

Symbol hazard warnings provide basic information in determining what precautionary measures to use when handling hazardous chemical substances and/or dealing with a fire.

The National Fire Protection Association (NFPA) uses a symbol design as a diamond-shaped label containing four differently colored squares.

A number (0 - 4) or an abbreviation is added to each square indicating the order of hazard severity.





6.5 Word Hazard Warnings

Word hazard warnings contain a word or words intended to capture the worker's immediate attention (e.g. flammable, poison, fatal if swallowed). These word labels should be in English, but other languages may be used where needed.

Signal words are warnings used to designate the degree of hazard.

- **DANGER** – Highest degree of hazard (red text)
- **WARNING** – Intermediate degree of hazard (orange text)
- **CAUTION** – Lowest degree of hazard (yellow text)

7.0 Material Safety Data Sheets

When using MSDS you must apply your own good professional judgment to the information that they contain. MSDS include information and procedures that usually only apply to industrial settings, these situations will most likely not occur in the laboratory environment. Even so, MSDS are a valuable source of information when you have questions or concerns about any chemical or material that you work with. It is a good idea to consult the MSDS for any new chemical that is introduced into your work

routine, this is a quick and easy way to familiarize yourself to any hazards or precautions that you should take when working with a new substance.

MSDS will tell you of any special procedures that may be required for the safe handling of a specific substance. If you are taking any medications, if you are pregnant, or if you have a medical condition such as an allergy talk with your supervisor and physician for specific instructions.

7.1 MSDS Requirements

A MSDS must include the following information:

- The identity of substance designated on the container label.
- Single substance -- chemical and common names.
- Mixtures tested as a whole -- chemical and common names of all ingredients which are health hazards, in concentrations of 1% or greater.
- Mixtures untested as a whole -- chemical and common names of all ingredients which are health hazards and which are in concentrations of 1% or greater, carcinogens in concentration of 0.1% or greater.
- Physical and chemical characteristics of the hazardous chemicals.
- Physical hazards (potential for fire, explosion, etc.).
- Known acute and chronic health effects and related health information.
- Primary routes of entry into the body.
- Information on exposure limits.
- Whether OSHA, the International Agency for Research on Cancer, or the National Toxicology Program considers a hazardous chemical a carcinogen.
- Precautions for safe handling.
- Generally acceptable control measures (engineering controls, work practices, personal protective equipment).
- Emergency and first aid procedures.
- Date of MSDS preparation, or most recent change.
- Name, address and phone number of the party responsible for preparing and distributing the MSDS.

A MSDS may be used for similar mixtures with essentially the same hazards and contents.

7.2 MSDS Availability

Copies of MSDS must be readily accessible in the laboratory during work hours.

If a new chemical or powder has been purchased, the original MSDS from each vendor must be filed in the laboratory area. A copy of the MSDS must be forwarded to the AMP Center Director's Office where it will be kept on file for future use.

8.0 Information & Training

In accordance with Federal and State regulations, all personnel (working with or around chemicals) have the *"right to be informed and trained"* on the chemical hazards present in their work area. The responsibility for apprising workers of the necessary precautions to take when using or handling hazardous materials rests with the Supervisor, Laboratory Manager or Faculty Member in charge. Ultimately your safety depends on you! So take the time to learn about the hazards, the precautions to be taken and carry out your role safely. If you have questions, ask your Supervisor, Senior Engineer or Faculty Member.

8.1 Employee Orientation

Supervisors will provide general background training as required.

Powder, Laser, Robot and Laboratory safety information and training should be provided at the time of a worker's initial arrival to the work area and prior to new exposure situations. This can only be done by the Supervisor, Senior Engineer or Faculty Member in charge.

8.2 Employee Information

Before beginning work, all workers (working with or around powders and chemicals) should know about the following:

- All procedures in the work area where hazardous materials are present.
- Location and availability of known reference material on the hazards, safe handling, storage and collection of waste of hazardous chemicals found in the work area. These references include the Material Safety Data Sheets.
- How to review MSDS, where they are kept and how to obtain a MSDS for a particular chemical.
- Signs and symptoms associated with exposures to hazardous chemicals used in the work area.
- Permissible Exposure Limits (PEL) for OSHA regulated substances or recommended exposure limits for other hazardous chemicals where there is no specific OSHA standard.

8.3 Employee Training

All workers (working with or around powders and chemicals) have the *"right to be informed and trained"* on any potentially hazardous chemical or product used in their work area. The training should include:

- Methods and observations that may be used to detect the presence or release of a hazardous chemical (i.e., continuous monitoring devices, visual appearances, or odors of hazardous chemicals when being released).
- Physical and/or health hazards associated with hazardous materials in the work area.
- Safety measures workers (working with or around chemicals) may use to protect themselves such as appropriate work practices, emergency procedures and personal protective equipment.

8.4 Attendance Verification

Supervisors, Senior Engineer or Faculty Members who provide specific training would be well advised to keep a signed statement from employees/students indicating that they have received the appropriate training. A form that you may use is available from The Director of the AMP Center.

9.0 Chemical Waste Collection

The Environmental Protection Agency (EPA) is closely scrutinizing academic institutions these days. Under EPA regulations, those individuals who continue to dump chemical waste down the drain will face stiff fines and a possible jail term. This punishment will be levied against the offending laboratory employee, not the University.

9.1 Waste Segregation

We prefer to keep certain types of chemicals separated at the time of collection. This method not only lowers disposal costs for the University, but also decreases the chances of incompatible materials being added together.

Do not put acidic or basic waste (pH <3 or >9) in metal cans. Metal cans corrode in a very short time. Keep acids and bases separate from hydrocarbons and ethers.

When possible, keep all carcinogens/mutagens/teratogens separate from other waste. Keep aqueous wastes separate from organic solvents. Keep halogenated solvents and wastes separate from non-halogenated solvents.

9.2 Containers & Labels for Hazardous Waste

Do not put hazardous waste down the sink or in the trash. If you are not sure if a chemical or powder is hazardous, ask a Supervisor or call the Campus Chemical Materials Manager at 1242.

All chemical and powder waste must be deposited in properly labeled waste containers. Each waste container MUST be marked with a **HAZARDOUS WASTE STICKER**. In addition to waste stickers, all waste containers MUST contain a **WASTE DISPOSAL LABEL**. This includes chemicals or powders still in their original containers.

9.3 Potential Accidents

Ethers tend to form extremely explosive compounds over time. Therefore, date all ether cans. Do not keep an open ether can for more than 1 month or an unopened can for more than 12 months. If you have an old ether can, label as waste and call the Campus Chemical Materials Manager for proper disposal procedures.

Do not attempt to open any bottles of DRY picric acid. **This is an extreme explosion hazard!!!** Any dry bottles of picric acid should be labeled as waste.