

**Department of Biological & Ecological
Engineering**

LABORATORY

SAFETY

MANUAL

**Prepared by:
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*Adapted from the Astoria Seafood Research & Education Center Laboratory Safety Manual
(Prepared by: Dr. Christina A. Mireles DeWitt)*

Originally adapted from the Oklahoma State University Laboratory Safety Manual.

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This document describes the Chemical Hygiene Plan for

The Department of Biological & Ecological Engineering, 116 Gilmore Hall, Corvallis, OR 97330-3906

at Oregon State University, as required by Title 29 Code of Federal Regulations Part 1910, Subpart Z, Section .1450 (29 CFR 1910.1450), "Occupational Exposures in Laboratories" referred to as the "Laboratory Standard".

In order to comply with the Laboratory Standard, Oregon State University has established a chemical hygiene plan to ensure that employees are protected from health hazards associated with hazardous materials in the laboratory and to ensure that exposures are kept below the permissible exposure limits specified in 29 CFR part 1910, subpart Z. Questions regarding this plan should be directed to:

John P. Bolte, Department Head, 116 Gilmore Hall, Rm 116, (541)-737-2041

(name, title, campus address and campus phone number).

This plan is made readily available to the employees of the OSU Department of Biological & Ecological Engineering and upon request to the Assistant Secretary of the Occupational Safety and Health Administration.

A review and evaluation of this Chemical Hygiene Plan is conducted at least annually and this Chemical Hygiene Plan is updated as necessary.

The person responsible for implementation of this Plan, including the assignment of the Departmental Chemical Hygiene Officer, is:

John P. Bolte, Department Head, 116 Gilmore Hall, Rm 116, (541)-737-2041

(name, title, campus address and campus phone number).

The Departmental Chemical Hygiene Officer for this plan is:

Frank W.R. Chaplen, Unit Safety Coordinator, 116 Gilmore Hall, Rm 203, 541-737-1015

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ALL EMERGENCIES - Chemical, Medical, or Fire..... 911

Biological Safety Officer, 541-737-4557

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CHAPTER 1.0 - EMERGENCY RESPONSE

During the course of normal laboratory operations there is always the potential for an emergency situation to arise. These emergencies can be the result of a chemical spill, fire, or the need for medical assistance. In the event of an emergency, an emergency response plan should be implemented. This plan would include evacuation of the facility if such action is deemed appropriate. Internal communication is very important during any emergency situation. It is essential that all employees know how to act and react during the emergency. To accomplish this, it is necessary that a written Emergency Response Plan be developed and that all employees are trained and participate in drills. All accidents, regardless of severity, should be reported and investigated. Key elements of an emergency procedure plan are summarized by the acronym NEAR; **N**otify, **E**vacuate, **A**ssemble, **R**eport.

SECTION 1.1 - CHEMICAL SPILLS

All chemical spills shall be reported in writing to the OSU Environmental Health & Safety Hazardous (OSU HAZMAT), regardless of size. The report shall include the date, time, location, chemical(s) and their volume, and names of all persons involved, including any visitors who were exposed and personnel involved in the clean up. A copy of this report shall also be kept by the Departmental Chemical Hygiene Officer.

A. Emergency Spills

A chemical spill is classified as an Emergency Spill whenever it:

1. Causes personal injury or chemical exposure that requires medical attention;
2. Causes a fire hazard or uncontrollable volatility;
3. Requires a need for breathing apparatus of the supplied air or self-contained type to handle the material involved;
4. Involves or contaminates a public area;
5. Causes airborne contamination that requires local or building evacuation;
6. Causes a spill that cannot be controlled or isolated by laboratory personnel;
7. Causes damage to university property that will require repairs;
8. Involves any quantity of metallic mercury;
9. Cannot be properly handled due to lack of local trained personnel and/or equipment to perform a safe, effective cleanup;
10. Requires prolonged or overnight cleanup;
11. Involves an unknown substance; or
12. Enters the land or water.

Although the following tactics are prioritized in terms of usual preferred action sequences, each spill incident is unique and involves persons with varying levels of spill expertise and experience. Thus, for any individual incident, isolation of the spill and/or securing the area might best occur prior to or simultaneously with contacting campus police.

1. **Call 911 for Assistance.** Notify the police dispatcher of location of the spill and, if known, the chemical spilled. In addition, you should **notify** the **Chemical Safety Officer** for chemical spills or the **Biological Safety Officer** for BSL2 spills (NOTE: The Department of Biological & Ecological Engineering currently has no BSL2 organisms).
2. Don't panic! Always send for help first, *if possible*.
3. If the spill presents an immediate danger, leave the spill site and warn others, control entry to the spill site, and wait for response.
4. Remove contaminated clothing. Flush skin/eyes with water at least 15 minutes to 30; use soap for intermediate and final cleaning of skin areas.
5. Protect yourself, then remove injured person(s) to fresh air, if safe to do so.
6. Notify nearby persons and evacuate as necessary. Prevent entry, as necessary, by posting a guard in a safe area and/or shutting doors.

7. If flammable vapors are involved, do not operate electrical switches unless to turn off motorized equipment. Try to turn off or remove heat sources, where safe to do so.
8. If the substance involved is an unknown, then emergency spill response procedures are limited to self-protection, notification of Police at 911 for response, isolation of the chemical, and evacuating and securing the area involved.
9. Do not touch the spill without protective clothing.
10. Where the spill does not present immediate personal danger, try to control the spread or volume of the spill. This could mean shutting a door, moving nearby equipment to prevent further contamination, repositioning an overturned container or one that has a hole in the bottom or side, creating a dike by putting an absorbent around a spill or opening the sashes on the fume hoods to facilitate removal of vapors.
11. Never assume gases or vapors do not exist or are harmless because of lack of smell.
12. Increase ventilation by opening closed fume hood sashes to the 12 inch or full open position. Exterior doors may be opened to ventilate non-toxic vapors.
13. Use absorbents to collect substances. Reduce vapor concentrations by covering the surface of a liquid spill with absorbent. Control enlargement of the spill area by diking with absorbent.

B. Minor Spills

Minor spills are those spills which do not fit the requirements for Emergency Spills.

The following general procedures should be used for all minor spills:

1. Attend to any persons who may have been contaminated. If these persons require medical attention this is an Emergency Spill (See above).
2. Notify persons in the immediate area about the spill.
3. Evacuate all nonessential personnel from the spill area.
4. If the spilled material is flammable, turn off ignition and heat sources.
5. Avoid breathing vapors of the spilled material. If respiratory protection is necessary this is an Emergency Spill (See above).
6. Leave on or establish exhaust ventilation if it is safe to do so.
7. Secure supplies to effect cleanup.
8. Don appropriate personnel protective equipment.
9. Spilled Liquids
 - a. Confine or contain the spill to a small area. Do not let it spread.
 - b. For small quantities of inorganic acids or bases, use a neutralizing agent or an absorbent mixture (e.g., soda ash or diatomaceous earth). For small quantities of other materials, absorb the spill with a nonreactive material (such as vermiculite, clay, dry sand, or towels).
 - c. For larger amounts of inorganic acids and bases, flush with large amounts of water (providing the water will not cause additional damage). Flooding is not

recommended in storerooms where violent spattering may cause additional hazards or in areas where water-reactive chemicals may be present.

- d. Mop up the spill, wringing out the mop in a sink or a pail equipped with rollers.
- e. Carefully pick up and clean any cartons or bottles that have been splashed or immersed.
- f. If needed, vacuum the area with a HEPA filtered vacuum cleaner approved and designed for the material involved.
- g. If the spilled material is extremely volatile, let it evaporate and be exhausted by the laboratory hood (provided that the hood is authorized for use with the spilled chemical).

10. Spilled Solids

Generally, sweep spilled solids of low toxicity into a dust pan and place them into a container suitable for that chemical. Additional precautions such as the use of a vacuum cleaner equipped with a HEPA filter may be necessary when cleaning up spills of more highly toxic solids.

11. Dispose of residues according to safe disposal procedures. Remembering that personal protective equipment, brooms, dust pans, and other items may require special disposal procedures. (See Section 3.4 - "Chemical Waste").
12. Report the chemical spill in writing as required above.

C. Mercury Handling and Spill Clean Up

1. Health Effects

The ACGIH has established a TLV of 0.05 mg/m³, based on an 8-hour day and 40-hour week. The TLV for mercury also carries a "skin" notation, which indicates that metallic mercury can be absorbed into the body as well as through inhalation and ingestion into the skin. Mercury vapors are odorless, colorless, and tasteless. A quantity as small as 1 milliliter can evaporate over time, as raise levels in excess of allowable limits. Mercury poisoning from exposure by chronic inhalation can cause emotional disturbances, unsteadiness, inflammation of the mouth and gums, general fatigue, memory loss, and headaches. In most cases of exposure by chronic inhalation, the symptoms of poisoning gradually disappear when the source of exposure is removed. Improvement, however, may be slow and complete recovery may take years.

2. Storage and Handling

Because of the health effects of mercury, the extremely difficult and time-consuming procedures required to properly clean spills, every effort should be taken to prevent accidents involving mercury. Always store mercury in unbreakable containers and stored in a well-ventilated area. When breakage of instruments or apparatus containing mercury is a possibility, the equipment should be placed in an enameled or plastic tray or pan that can be cleaned easily and is large enough to contain the mercury. Transfers of mercury from one container to another should be carried out in a hood, over a tray or pan to confine any spills. If at all possible, the use of mercury thermometers should be avoided. If a mercury thermometer is required, many are now available with a Teflon[®] coating that will prevent shattering. Always wash hands after handling mercury to prevent skin absorption or irritation.

3. Air Monitoring

Any mercury spill has the potential to generate airborne concentrations in excess of regulated levels. Contact the **Chemical Safety Officer** for air monitoring of the spill area

before cleanup to determine the airborne concentration. Large spills or spills with elevated vapor levels may dictate cleanup by a qualified contractor.

4. Protective Clothing

For small spills, a laboratory coat, safety glasses, and gloves should be used. Gloves made of the following have been rated as excellent for protection against elemental mercury:

Chlorinated polyethylene (CPE)	Polyvinyl Chloride (PVC)
Polyurethane	Nitrile Rubber, (also known by several brand names)
Viton	Neoprene
Butyl Rubber	

If mercury has been spilled on the floor, the workers involved in cleanup and decontamination should wear plastic shoe covers. EHS should be called immediately if a spill is extensive enough to require workers to kneel or sit where mercury has been spilled since Tyvek[®] or similar impermeable clothing will be required.

5. Spill Kits

Special spill kits are available from a variety of sources. If a spill kit is purchased, follow the manufacturer's directions. Alternatively, a kit can be assembled with the following components:

- a. protective gloves,
- b. mercury suction pump or disposable pipettes to recover small droplets,
- c. elemental zinc powder (or commercial amalgam material),
- d. dilute sulfuric acid (5-10%) in spray bottle,
- e. sponge or tool to work amalgam,
- f. plastic trash bag,
- g. plastic container (for amalgam), and
- h. plastic sealed vial for recovered mercury.

6. Clean Up Procedures

- a. Wearing protective clothing, pools and droplets of metallic mercury can be pushed together and then collected by a suction pump.
- b. After the gross contamination has been removed, sprinkle the entire area with zinc powder. Spray the zinc with the dilute sulfuric acid.
- c. Using the sponge, work the zinc powder/sulfuric acid into a paste consistency while scrubbing the contaminated surface and cracks or crevices.
- d. To minimize contamination of housekeeping items, stiff paper may be used to assist in cleaning up the amalgam.
- e. After the paste has dried, it can be swept up and placed into the plastic container for disposal.
- f. Rags, shoe covers, sponges, and anything used for the cleanup should be placed in the trash bag to be disposed of as contaminated material.

7. Waste Disposal

Call EHS for removal of the mercury waste and contaminated items.

SECTION 1.2 – RADIATION SPILLS

A. NOT APPLICABLE TO THIS FACILITY

SECTION 1.3 - BIOHAZARD SPILLS

A. Biological Spills

Biological spills outside biological safety cabinets will generate aerosols that can be dispersed in the air throughout the laboratory. These spills can be very serious if they involve microorganisms that require Biosafety Level 3 containment, since most of these agents have the potential for transmitting disease by infectious aerosols. To reduce the risk of inhalation exposure in such an accident, occupants should leave the laboratory immediately. The laboratory should not be reentered to decontaminate or clean up the spill for at least 30 minutes. During this time the aerosol may be removed from the laboratory via the exhaust ventilation systems, such as biological safety cabinets or chemical fume hoods, if present.

1. Spills on the Body
 - a. Remove contaminated clothing.
 - b. Vigorously wash exposed area with soap and water for one minute.
 - c. Obtain medical attention (if necessary).
 - d. Report the incident to the laboratory supervisor.
2. Biosafety Level 1 Organism Spill
 - a. Wear disposable gloves.
 - b. Soak paper towels in disinfectant and place over spill.
 - c. Place towels in a plastic bag for disposal.
 - d. Clean up spill area with fresh towels soaked in disinfectant.
3. Biosafety Level 2 Organism Spill (**NOTE: The Department of Biological & Ecological Engineering currently has no BSL2 organisms**)
 - a. Alert people in immediate area of spill.
 - b. Put on protective equipment. This may include a laboratory coat with long sleeves, back-fastening gown or jumpsuit, disposable gloves, disposable shoe covers, safety goggles, mask or full-face shield.
 - c. Cover spill with paper towels or other absorbent materials.
 - d. Carefully pour a freshly prepared 1 to 10 dilution of household bleach around the edges of the spill and then into the spill. Avoid splashing. Alternatively, Amphyl solution (1 to 200) can be utilized. Amphyl produces less volatile gas and is not as corrosive as bleach.
 - e. Allow a 15-minute contact period for the dilute bleach solution. A 10 min contact period for the dilute Amphyl solution.
 - f. After the spill has been absorbed, clean up the spill area with fresh towels soaked in disinfectant.
 - g. Place towels in a plastic bag and decontaminate in an autoclave.

SECTION 1.4 - LEAKING COMPRESSED GAS CYLINDERS

Occasionally, a cylinder or one of its component parts develops a leak. Most such leaks occur at the top of the cylinder in areas such as the valve threads, safety device, valve stem, and valve outlet.

If a leak is suspected, do not use a flame for detection; rather, a flammable-gas leak detector or soapy water or other suitable "snoop" solution should be used. If the leak cannot be remedied by tightening a valve gland or a packing nut, emergency action procedures should be effected. Laboratory workers should never attempt to repair a leak at the valve threads or safety device; rather, they should consult with the supplier for instructions.

If the substance in the compressed gas cylinder is not inert, or is hazardous, then use the procedures in Section 1.1 - "Chemical Spills".

If the substance in the compressed gas cylinder is inert, or non-hazardous, contact the supplier for instructions.

SECTION 1.5 - FIRES

Fires are a common emergency in a chemistry laboratory.

In the event of a fire, do the following things:

- A. Assist any person in immediate danger to safety, if it can be accomplished without risk to yourself.
- B. Immediately activate the building fire alarm system. This will automatically notify the Fire Department and sound the fire alarm bells or horns to evacuate the building. It is best to have these people respond and not to be needed than to have them arrive too late for potential rescue.
- C. If the fire is small enough, use a nearby fire extinguisher to control and extinguish the fire. Don't fight the fire if these conditions exist:
 - a. The fire is too large or out of control.
 - b. If the atmosphere is toxic.
- D. If the first attempts to put out the fire do not succeed, evacuate the building immediately.
- E. Doors, and if possible, windows, should be closed as the last person leaves a room or area of a lab.
- F. Do not use elevators; use building stairwells.
- G. When they hear the fire alarm sound, all personnel in the affected areas shall evacuate the building immediately.
- H. Upon evacuating the building, personnel shall proceed to the designated meeting area (at least 150 feet from the affected building) where the supervisors are responsible for taking a head count and accounting for all personnel.
- I. No personnel will be allowed to re-enter the building without permission of the Fire Department.
- J. You must report all fires to the Chemical Safety Officer at OSU Environmental Health & Safety. All fires will be investigated by OSU Environmental Health & Safety Officers and/or the local fire marshal.

SECTION 1.6 - MEDICAL EMERGENCIES

Personal injury is not uncommon in laboratories. These injuries are usually minor cuts or burns but can be as severe as acute effects of chemical exposure or incidents such as heart attacks or strokes.

The initial responsibility for first aid rests with the first person(s) at the scene, who should react quickly but in a calm and reassuring manner. The person assuming responsibility should immediately summon medical help (be explicit in reporting suspected types of injury or illness, location of victim, and type of assistance required). Send people to meet the ambulance crew at likely entrances of the building. The injured person should not be moved except where necessary to prevent further injury.

The names of persons in your area trained in CPR and First Aid should be posted by your telephone.

The number to call for medical emergencies (**911**) shall also be posted by your telephone.

All first aid, chemical exposures, and medical emergencies shall be reported as required in Section 1.7 - "Accident Reporting."

Prevention of injuries should be a major emphasis of any laboratory safety program. Proper training will help prevent injuries from glassware, toxic chemicals, burns and electrical shock. In the event of any type of injury beyond that which first aid can treat, call 911 for medical assistance.

A. General

1. First aid is defined as any one-time treatment and any follow up visit for the purpose of observation, treatment of minor scratches, cuts, burns, splinters, and so forth, which do not ordinarily require medical care.
2. First aid equipment should be readily available in each laboratory. See Section 2.2-D, "First Aid Kits," for additional information.
3. Following any first aid, a nurse or physician qualified to handle chemical emergencies should provide further examination and treatment. The location and phone number of emergency services and the Oregon Poison Control Center (1-800-522-4611) should be clearly posted.
4. It is recommended that each laboratory have at least one person trained in basic first aid and cardiopulmonary resuscitation.
5. Someone knowledgeable about the accident should always accompany the injured person to the medical facility and a copy of any appropriate MSDS(s) shall accompany the victim.
6. Minor injuries requiring first aid should always be reported to a supervisor and recorded on an Report of Accident/Illness Form (see appendix K), which must be submitted to Personnel Services. Reasons for this are as follows.
 - a. A minor injury may indicate a hazardous situation which should be corrected to prevent a serious future injury.
 - b. It is important to document a minor injury as having been "work related" if the injury later leads to serious complications, such as from an infected cut.

B. Personal Protection During First Aid

1. OSHA requires adherence to "Universal Precautions" when employees respond to emergencies which provide potential exposure to blood and other potentially infectious materials. "Universal Precautions" stresses that all patients should be assumed to be infectious for HIV and other bloodborne pathogens.
2. Persons responding to a medical emergency should be protected from exposure to blood and other potentially infectious materials. Protection can be achieved through adherence to work practices designed to minimize or eliminate exposure and through the use of personal protective equipment (i.e., gloves, masks, and protective clothing), which provide a barrier between the worker and the exposure source. For most situations in which first aid is given, the following guidelines should be adequate.
 - a. For bleeding control with minimal bleeding and for handling and cleaning instruments with microbial contamination, disposable gloves alone should be sufficient.
 - b. For bleeding control with spurting blood, disposable gloves, a gown, a mask, and protective eye wear are recommended.
 - c. For measuring temperature or measuring blood pressure, no protection is required.
3. After emergency care has been administered, hands and other skin surfaces should be washed immediately and thoroughly with warm water and soap if contaminated with blood, other body fluids to which universal precautions apply, or potentially contaminated articles. Hands should always be washed after gloves are removed, even if the gloves appear to be intact.

SECTION 1.7 - ACCIDENT REPORTING

ALL injuries shall be reported to laboratory management and Environmental Health & Safety personnel. Minor injuries many times are not reported because they are perceived to be embarrassing or that "careless actions" lead to the accident. However, minor injuries can sometimes lead to more serious complications that only become evident at a later time. Liability and insurance matters will be handled more effectively if initial accident documentation exists. In addition, all minor accidents should be investigated by safety and management personnel. Taking corrective action as a result of a minor accident may keep a major incident from happening. Without knowledge of all minor accidents, the desirable investigation is circumvented.

Employees should understand that the purpose of reporting and documenting accidents is not to affix blame, but instead to determine the cause of the accident so that similar incidents may be prevented in the future.

Follow the instructions for Report of Accident/Illness Form in Appendix K and submit the report as instructed. Notify either the OSU Chemical Safety Officer or Biological Safety Officer as appropriate.

CHAPTER 2.0 - GENERAL SAFETY

People who work in scientific laboratories are exposed to many kinds of hazards. This can be said of most workplaces; in some, the hazards are well recognized (those of ordinary fire, for example) and the precautions to be taken are obvious. Laboratories, however, involve a greater variety of possible hazards than do most workplaces, and some of those hazards call for precautions not ordinarily encountered elsewhere. Therefore, this manual has been provided to inform and guide the laboratory worker in safe practices which should help to avoid injury.

This chapter sets forth those practices which are deemed good safety practices common to all laboratory operations.

Section 2.1 - GENERAL SAFETY AND OPERATIONAL RULES

A. General Rules of Safety

1. No running, jumping, or horseplay in laboratory areas shall be permitted.
2. No employee shall work alone in a laboratory or chemical storage area when performing a task that is considered unusually hazardous by the laboratory supervisor or safety officer.
3. Spills shall be cleaned immediately. Specifics of emergency spill tactics are provided in the Emergency Response chapter of this manual (Chapter 1.0). Water spills can create a hazard because of the slip potential and flooding of instruments (particularly on the floor below.) Small spills of liquids and solids on bench tops shall be cleaned immediately to prevent contact with skin or clothing.
4. Ladders shall be in good condition and used in the manner for which they were designed. Wooden ladders shall not be covered with paint or other coating. (Structural defects may be hidden by the coating.)
5. Lifting of heavy items must be performed in the proper fashion, using the legs to lift, and not the back.
6. It is the responsibility of everyone working in the laboratory to make certain that the laboratory is left clean after work is performed.
7. Consult University Policy and Procedures for policy on children in the workplace or in areas of potentially high hazards.
8. Animals, except for those that are the subject of experimentation (approved by the Animal Experimentation Committee) are to be excluded from all University laboratory areas.

B. Personal Hygiene

1. Wash promptly whenever a chemical has contacted the skin. Know what you are working with and have the necessary cleaning/neutralization material on hand and readily available.
2. No sandals, open toed shoes or clogs shall be worn by laboratory personnel.
3. Clothing worn in the laboratory should offer protection from splashes and spills, should be easily removable in case of accident, and should be at least fire resistant. Nonflammable, nonporous aprons offer the most satisfactory and the least expensive protection. Lab jackets or coats should have snap fasteners rather than buttons so that they can be readily removed. These coats are to be fastened closed while working and removed prior to exit from the laboratory.
4. Laboratory clothing should be kept clean and replaced when necessary. Clothing should be replaced or laundered using appropriate decontamination procedures whenever contamination is suspected.
5. Lab coats are **not** to be worn outside the laboratory, especially in rest room or break facilities. Any lab coats, respirators, or other protective gear must be left in the lab areas. Employees must, as a matter of routine, be responsible for washing, cleaning, and any other decontamination required when passing between the lab and the other areas. Washing should be done with soap and water; **do not** wash with solvents.
6. Inhalation is one of the four modes of entry for chemical exposure. "Sniff-testing" should not be done.

7. **Never** pipette by mouth. **Always** use a bulb to pipette.
8. Do not drink, eat, smoke, or apply cosmetics in the laboratory or chemical storage areas.
9. Do not use ice from laboratory ice machines for beverages.
10. No food, beverage, tobacco, or cosmetics products are allowed in the laboratory or chemical storage areas at any time. Cross contamination between these items and chemicals or samples is an obvious hazard and should be avoided.

C. Housekeeping

As in many general safety procedures, the following listing of good housekeeping practices indicate common sense activities which should be implemented as a matter of course in the laboratory. These recommendations are designed for accident prevention.

1. THE AREA MUST BE KEPT AS CLEAN AS THE WORK ALLOWS.
2. Each laboratory employee shall be responsible for maintaining the cleanliness of his/her area.
3. Reagents and equipment items should be returned to their proper place after use. This also applies to samples in progress. Contaminated or dirty glassware should be placed in specific cleaning areas and not allowed to accumulate.
4. Chemicals, especially liquids, should never be stored on the floor, except in closed door cabinets suitable for the material to be stored. Nor should large bottles (2.5l or larger) be stored above the bench top
5. Reagents, solutions, glassware, or other apparatus shall **not** be stored in hoods. Besides reducing the available work space, they may interfere with the proper air flow pattern and reduce the effectiveness of the hood as a safety device
6. Counter tops should be kept neat and clean. Bench tops and fume hoods shall not be used for chemical storage. All work done in fume hoods shall be performed in the "Safety Zone", (6" minimum from the sash).
7. Stored items, equipment, and glass tubing shall not project beyond the front of shelf or counter limits.
8. Stored items or equipment shall not block access to the fire extinguisher(s), safety equipment, or other emergency items.
9. Stairways, hallways, passageways/aisles and access to emergency equipment and/or exits must be kept dry and not be obstructed in any fashion, including storage, equipment, phone or other wiring
10. No combustible material such as paper, wooden boxes, pallets, etc., shall be stored under stairwells or in hallways. Hallways shall be kept free of boxes and materials so that exits or normal paths of travel will not be blocked
11. Materials stored near aisles shall be restrained to prevent their falling
12. Mats and carpeting shall be kept in good condition.
13. All working surfaces and floors should be cleaned regularly.
14. All containers must be labeled with at least the identity of the contents and the hazards those chemicals present to users. If the contents of all containers are known we will no longer have an unknown waste disposal problem.

D. Electrical

The typical laboratory requires a large quantity of electrical power. This increases the likelihood of electrically-related problems and hazards. One must address both the electrical shock hazard to the facility occupants **and** the fire hazard potential. The following recommendations are basic to a sound electrical safety program in the laboratory.

1. All electrical equipment shall be properly grounded.
2. All electrical equipment shall be U.L. listed and/or F.M. approved.
3. Sufficient room for work must be present in the area of breaker boxes. All the circuit breakers and the fuses shall be labeled to indicate whether they are in the "on" or "off" position, and what appliance or room area is served.. Fuses must be properly rated
4. Equipment, appliance and extension cords shall be in good condition
5. Extension cords shall not be used as a substitute for permanent wiring
6. Electrical cords or other lines shall not be suspended unsupported across rooms or passageways. Do not route cords over metal objects such as emergency showers, overhead pipes or frames, metal racks, etc. Do not run cords through holes in walls or ceilings or through doorways or windows. Do not place under carpet, rugs, or heavy objects. Do not place cords on pathways or other areas where repeated abuse can cause deterioration of insulation
7. Multi-outlet plugs shall not be used unless they have a built-in circuit breaker. This causes overloading on electrical wiring, which will cause damage and possible overheating
8. Most of the portable multiple outlets are rated at 15 amps. Employees shall check when all connections are made to determine that the total input average will never exceed 15 amps. (The amperage on electrical equipment is usually stamped on the manufacturer's plate).
9. The Chemical Hygiene Officer should be notified of all building electrical repairs, splices, and wiring. Laboratory personnel should not perform any electrical work without approval from the Chemical Hygiene Officer.
10. Electrical standards may be obtained by referencing NFPA 70 - NATIONAL ELECTRICAL CODE.

E. Vacuum Operations

In an evacuated system, the higher pressure is on the outside, rather than the inside, so that a break causes an implosion rather than an explosion. The resulting hazards consist of flying glass, spattered chemicals, and possibly fire.

A moderate vacuum, such as 10 mm Hg, which can be achieved by a water aspirator, often seems safe compared with a high vacuum, such as 10^{-5} mm Hg. These numbers are deceptive, however, because the pressure differences between the outside and inside are comparable. Therefore any evacuated container must be regarded as an implosion hazard.

1. When working with a vacuum be aware of implosion hazards. Apply vacuum only to glassware specifically designed for this purpose, i.e., heavy wall filter flasks, desiccators, etc
2. Never evacuate scratched, cracked, or etched glassware. Always check for stars or cracks before use.

3. Vacuum glassware which has been cooled to liquid nitrogen temperature or below should be annealed prior to reuse under vacuum.
4. Rotary evaporator condensers, receiving flasks, and traps should be taped or kept behind safety shields when under a vacuum.
5. All condensers connected to rotary evaporators should at least be cooled with circulating ice water.
6. The use of a vacuum for the distillation of the more volatile solvents, e.g. ether, low boiling petroleum ether and components, methylene chloride, etc., should be avoided whenever possible. In situations requiring reduced pressure, two alternatives should be considered; 1) Utilization of Rotovac System, or 2) Solvent recovery via atmospheric pressure distillation (preferred method).
7. Water, solvents, or corrosive gases should not be allowed to be drawn into a building vacuum system.
8. When a vacuum is supplied by a compressor or vacuum pump to distill volatile solvents, a cold trap should be used to contain solvent vapors. Cold traps should be of sufficient size and low enough temperature to collect all condensable vapors present in a vacuum system. If such a trap is not used, the pump or compression exhaust must be vented to the outside using explosion proof methods.
9. After completion of an operation in which a cold trap has been used, the system should be vented. This venting is important because volatile substances that have been collected in the trap may vaporize when the coolant has evaporated and cause a pressure buildup that could blow the apparatus apart.
10. After vacuum distillations, the pot residue must be cooled to room temperature before air is admitted to the apparatus.
11. All desiccators under vacuum should be completely enclosed in a shield or wrapped with friction tape in a grid pattern that leaves the contents visible and at the same time guards against flying glass should the vessel collapse. Various plastic (e.g., polycarbonate) desiccators now on the market reduce the implosion hazard and may be preferable.

F. Handling Glassware

1. Glass breakage is a common cause of injuries in laboratories. Only glass in good condition should be used.
2. Discard or send for repair all broken, chipped, starred or badly scratched glassware. Hand protection should be used when picking up broken glass. For disposal of broken glass see Section 2.5 - "Safety Practices for Disposal of Broken Glassware".
3. Clean all glassware before sending for repair.
4. When using glass tubing, all ends should be fire polished. Lubricate tubing with glycerin or water before inserting into rubber stoppers or rubber tubing.
5. Protect hands with leather gloves when inserting glass tubing. Hold elbows close to the body to limit movement when handling tubing.
6. Do not store glassware near the edge of shelves. Store large or heavier glassware on lower shelves.
7. Use glassware of the proper size. Allow at least 20% free space. Grasp a three-neck flask by the middle neck, not a side neck.
8. Do not attempt to catch glassware if it is dropped or knocked over.

9. Conventional laboratory glassware must never be pressurized.

SECTION 2.2 - GENERAL SAFETY EQUIPMENT

Workers in a laboratory environment are surrounded by physical and chemical hazards, and the potential for accident and injury is always present. Adequate safety equipment in good working order shall be provided to prevent accidents and injury.

A. Fire Extinguishers

The Chemical Hygiene Officer is responsible for the procurement, placement, inspection, and maintenance of all fire extinguishers in this facility.

1. Laboratory personnel should be adequately trained regarding pertinent fire hazards associated with their work. (See Section 7.1 - "Training")
2. Fire extinguishers must be clearly labeled to indicate the types of fire they are designed to extinguish. The following codes as presented in NFPA 10 "Portable Fire Extinguishers" are:
 - Class A-fires in ordinary combustible materials such as wood, cloth, paper, rubber, and many plastics.
 - Class B-fires in flammable liquids, oils, greases, tars, oil-base paints, lacquers and flammable gases.
 - Class C-fires that involve energized electrical equipment where the electrical conductivity of the extinguishing medium is of importance; when electrical equipment is de-energized, extinguishers for class A or B fires may be safely used.
 - Class D-Fires of combustible metals such as magnesium, titanium, zirconium, sodium, lithium and potassium.
3. Fire extinguishers of the "Halon" type are specially designed so they leave no residue that could damage instruments or computers. (However, the area should be thoroughly ventilated before being reoccupied.)
4. Fire extinguishers should never be concealed from general view or blocked from access.
5. OSU Environmental Health & Safety will install all fire extinguishers. Once a fire extinguisher has been installed, EHS will inspect and maintain the device.
6. If an employee notices a fire extinguisher discharged or not fully charged, an extinguisher with the safety pin pulled out, an extinguisher obstructed from view, or one not hanging in its proper location, please notify Environmental Health & Safety at 4-7241.

B. Safety Showers

If all protective measures fail and an employee receives a chemical splash to their body, then safety showers should be provided throughout the laboratory for immediate and thorough washing of the body.

1. Employees should familiarize themselves with the location of the nearest safety shower.
2. Employees should be familiar with the operation of the safety showers.
3. Safety showers are designed to flood the entire body in the event of a clothing fire or a major spill of a chemical. In either case, an employee should simply stand under the shower and activate the shower. Flood the affected area for a minimum of 15 to 30 minutes.

4. In the case of a corrosive liquid spill, the employee should remove the affected portion of clothing to reduce potential contact. Removal of clothing should be done while the individual is under the activated shower.
5. The departmental chemical hygiene officer or laboratory supervisor should be notified as soon as possible if the employee required the use of the safety shower.
6. Safety showers are tested annually by the Chemical Hygiene Officer.

C. Eyewash Fountains

If all protective measures fail and an employee receives a chemical splash to their eyes, then eye wash fountains should be provided throughout the laboratory for immediate and thorough washing of the eyes.

1. Employees should familiarize themselves with the location and operation of the nearest eyewash fountain.
2. If the employee is wearing contact lenses: See Section 2.3.A-4.
3. Always flood the eyes for at least 15 to 30 minutes to be sure there is no residue of the corrosive liquid. Flush from the eye outward.
4. After thorough washing, the proper authorities should be notified and subsequent medical care for the employee should be seriously considered. This is because serious damage may have already occurred before the eye was thoroughly rinsed and/or the damage may not be immediately apparent.
5. Eyewash fountains should be tested weekly by laboratories for proper operation and to prevent formation of bacteria.
6. Eyewash fountains are checked annually, by the Chemical Hygiene Officer.

D. First Aid Kits

1. First aid kits, which should be located in conspicuous places (with location clearly marked) in the laboratory, are to be used for the immediate response to **minor** injuries, such as cuts or minor burns. All injury victims have the option of obtaining medical treatment or consultation.
2. Minor injuries requiring first aid shall always be reported to a supervisor
 - a. A minor injury may indicate a hazardous situation which should be corrected to prevent a more serious injury.
 - b. It is important to document a minor injury as having been "work related" for the purpose of obtaining Worker's Compensation, should the injury lead to later, more serious, complications.
3. The location and phone number of emergency services and the Oregon Poison Control Center (1-800-222-1222) should be clearly posted.
4. A designated party should be responsible for monitoring and maintaining the first aid kit(s). There should be a log attached to the kit indicating the last inspection date and by whom the kit was inspected.
5. First aid kit contents should include items such as Band-aids[®], sterile gauze pads, bandages, scissors, antiseptic wipes or ointments, and a first aid card. All kits should also contain examination gloves for response to emergencies in which blood is present. Pocket masks for CPR procedures are also recommended.

6. The following items are **not** recommended for use in a first-aid kit:
 - a. Iodine - Tissue damage can be caused by improper use.
 - b. Ice Pack Compress - If there is swelling of soft tissue, or other need for an ice pack, the person should be examined by a physician.
 - c. Ammonia Inhalants - If an individual is unconscious, obtain help -- **do not use ammonia.**
 - d. Tourniquet - Not required for minor injuries; use the pressure technique until medical assistance is available.
7. Laboratories where **high-voltage** equipment is in use should have available an emergency electrical response board. This will contain an instruction card and a non-conductive stick to turn off the equipment and remove the shock victim from contact with the source
8. Laboratories using material for which the immediate administration of an antidote or neutralizing agent is manifested (such as hydrofluoric acid and calcium gluconate) should be considered. Additionally, these procedures should be included in the laboratory Chemical Hygiene Plan and have the appropriate special handling procedures outlined under the CHP as "Special Handling Procedures."

F. Ventilation Hoods

1. Laboratory Hoods

Work that involves hazards and noxious materials which are toxic, odoriferous, volatile or harmful shall be conducted within a laboratory hood.

The primary purpose of a laboratory hood is to keep toxic or irritating vapors and fumes out of the general laboratory working area. A secondary purpose is to serve as a shield between the worker and equipment being used when there is the possibility of an explosive reaction. This is done by lowering the sash of the hood.

- a. Hood ventilation systems are best designed to have an airflow of not less than 60 ft/min (linear) and not more than 120 ft/min (linear) across the face of the hood. Flow rates of higher than 125 ft/min can cause turbulence problems and are not recommended. If possible, a mark will have been placed on the hood so the sash can be drawn to a point where 100 linear ft/min can be achieved.
- b. Avoid creation of strong cross drafts (100 fpm) caused by open doors and windows, air conditioning and/or heating vents, or personnel movement. Drafts will pull contaminants from the hood and into the laboratory.

100 FPM is generally not perceptible (100 fpm is approximately 3 mph, a normal walking pace). Air conditioning and heating vents and personnel traffic all create airflows in excess of 200 FPM, often much higher. Therefore, laboratory activity in the hood area should be minimized while the hood is in use.
- c. **DO NOT ADJUST BAFFLES** unless you have been instructed to do so by your departmental Chemical Hygiene Officer. Do not remove baffles.
- d. When not in use, the sash of the hood should be kept closed. While performing work in the hood, the sliding sash should be kept at the height designated to provide the minimum face velocity required (usually 100 lfm). This will ensure maximum velocity of air flow into the hood and out of the laboratory.
- e. Work should be performed as deeply within the fume hood as possible. Equipment, reagents, and glassware should be placed as far back in the hood as

is practical without blocking the rear baffle. Solid objects placed at the face of the hood cause turbulence in the air flow. Therefore, each hood should have a clearly marked "safety zone" 6 inches from the front in which no work should be conducted or equipment placed.

- f. ONLY ITEMS NECESSARY TO PERFORM THE PRESENT EXPERIMENT SHOULD BE IN THE HOOD. The more equipment in the hood, the greater the air turbulence and the chance for gaseous escape into the lab.
- g. When instrumentation is utilized for a process inside a hood, all instruments should be elevated a minimum of two inches from the hood base to facilitate proper air movement.
- h. The purpose and function of a hood is **NOT** to store chemicals or unused items. The fume hood is not a storage cabinet
- i. Hoods shall not be used as a means of disposing of toxic or irritating chemicals, but only as a means of removing small quantities of vapor which might escape during laboratory operations. If vaporization of large quantities of such materials is a necessary part of the operation, a means of collecting the vapor by distillation or scrubbing should be considered, rather than allowing it to escape through the hood vent. The collected liquid can then be disposed of as a liquid waste.
- j. Some hoods are constructed of stainless steel. These are usually "perchloric acid hoods" or "radioisotope hoods." Never use perchloric acid in a hood not designed for that use. Perchloric acid hoods have a wash-down feature which should be used after each use of the hood and at least every two weeks when the hood is not in use. Date of wash-down should be recorded by the laboratory.
- k. Always look to assure fan motor power switch is in the "on" position before initiating experiment. Note: Some hoods do not have individual "on/off" switches and remain "on" continuously.
- l. Do not use infectious material in a chemical fume hood.
- m. Exhaust fans should be spark-proof if exhausting flammable vapors and corrosive resistant if handling corrosive fumes.
- n. Controls for all services (i.e., vacuum, gas, electric, water) should be located at the front of the hood and should be operable when the hood door is closed.
- o. Radioactive materials may not be used in the hoods without prior approval of the Radiological Safety Officer.
- p. An emergency plan should be prepared in the event of ventilation failure or other unexpected occurrence such as fire or explosion in the hood.

ALWAYS ASSURE THE HOOD IS OPERATIONAL BEFORE INITIATING AN EXPERIMENT.

2. Biological Safety Cabinets

Biological Safety cabinets are among the most effective, as well as the most commonly used, primary containment devices in laboratories working with infectious agents.

Class I and II biological safety cabinets, when used in conjunction with good microbiological techniques, provide an effective partial containment system for safe manipulation of moderate and some high-risk microorganisms.

It is imperative that Class I and II biological safety cabinets are tested and certified in *situs*, any time the cabinet is moved, and at least annually thereafter. Certification at locations other than the final site may attest to the performance capability of the individual cabinet or model but does not supersede the critical certification prior to use in the laboratory.

As with any other piece of laboratory equipment, personnel must be trained in the proper use of the biological safety cabinets. Of particular note are those activities which may disrupt the inward directional airflow through the work opening of Class I and II cabinets. Aerosol particles can escape the cabinet in various ways. Among these are repeated insertion and withdrawal of workers' arms in and from the work chamber, opening and closing doors to the laboratory or isolation cubicle, improper placement or operation of materials or equipment within the work chamber, or brisk walking past the cabinet while it is in use. Strict adherence to recommended practices for the use of biological safety cabinets is as important in attaining the maximum containment capability of the equipment as is the mechanical performance of the equipment itself. Always decontaminate the hood using procedures adopted by the laboratory after each use or at the end of the work day.

BIOLOGICAL SAFETY CABINETS ARE NOT CHEMICAL FUME HOODS AND SHALL NOT BE USED AS SUCH.

G. Flammable-Liquid Storage Cabinets

Cabinets designed for the storage of flammable liquids should be properly used and maintained. Read and follow the manufacturer's information and also follow these safety practices:

- a. Store only compatible materials inside a cabinet.
- b. Do not store paper or cardboard or other combustible packaging material in a flammable-liquid cabinet.
- c. The manufacturer establishes quantity limits for various sizes of flammable-liquid storage cabinets; do not overload a cabinet.

NFPA Guidelines and OSHA Standards on Flammable Liquids are utilized as standards for Worker/Fire Protection at Oregon State University. In all laboratory work with flammable liquids the requirements of 29 CFR (H)-(L), NFPA 30, and NFPA 45 should be consulted and followed. Oregon State University Environmental Health Services is the local authority having jurisdiction in these matters, and should be contacted for further assistance

H. Safety Shields

Safety shields should be used for protection against possible explosions, implosions or splash hazards. Laboratory equipment should be shielded on all sides so that there is no line-of-sight exposure of personnel.

Provided its opening is covered by closed doors, the conventional laboratory exhaust hood is a readily available built-in shield. However, a portable shield should also be used when manipulations are performed, particularly with hoods that have vertical-rising doors rather than horizontal-sliding sashes.

Portable shields can be used to protect against hazards of limited severity, e.g., small splashes, heat, and fires. A portable shield, however, provides no protection at the sides or back of the equipment and many such shields are not sufficiently weighted and may topple toward the worker when there is a blast (permitting exposure to flying objects). A fixed shield that completely surrounds the experimental apparatus can afford protection against minor blast damage.

SECTION 2.3 - PERSONAL PROTECTIVE EQUIPMENT

OSHA's new final standard on personal protective equipment, 29CFR 1910.132, Subpart I (here-after referred to as the standard), imposes several new and important requirements relating to basic safety and health programs. The standard adds new general requirements for the selection and use of personal protective equipment (PPE). Included in these requirements are the following:

- Employers must conduct a hazard assessment to determine if hazards present necessitate the use of PPE.
- Employers must certify in writing that the hazard assessment was conducted.
- PPE selection must be made on the basis of hazard assessment and affected workers properly trained.
- Defective or damaged PPE must not be used.
- Established training requirements for employees using PPE must be established. This should include requirements for employees to demonstrate an understanding of the training.
- Employer must certify in writing that training programs were provided and understood.

At Oregon State University, the office of Environmental Health and Safety may be contacted to assist departments with their hazard assessment and the required PPE training.

A variety of laboratory personal protective equipment is commercially available and commonly used in laboratories. However, for the equipment to perform the desired function, it must be used and managed properly. Laboratory supervisors and/or departmental chemical hygiene officers shall determine a need for such equipment, monitor its effectiveness, train the employees, and monitor and enforce the proper use of such equipment.

A. Eye Protection

Eye protection is mandatory in all areas where there is potential for injury. This applies not only to persons who work continuously in these areas, but also to persons who may be in the area only temporarily, such as maintenance or clerical personnel. All eye protective equipment shall comply with the requirements set forth in the American National Standard for Occupational and Educational Eye and Face Protection, Z 87.1-1968, and the Oregon Eyeglass Protection Law of 1961.

1. The type of eye protection required depends on the hazard. For most situations, safety glasses with side shields are adequate. Where there is a danger of splashing chemicals, goggles are required. More hazardous operations include conducting reactions which have potential for explosion and using or mixing strong caustics or acids. In these situations, a face shield or a combination of face shield and safety goggles or glasses should be used
2. Plastic safety glasses should be issued to employees who do not require corrective lenses.
3. For persons requiring corrective lenses, safety glasses ground to their prescription are available in a safety frame. Contact Environmental Health Services for additional information about availability. Please note that the wearing of safety glasses does not excuse the employee from the requirement of wearing safety goggles
4. It is recommended that contact lenses not be permitted in the laboratory. The reasons for this prohibition are:
 - a. If a corrosive liquid should splash in the eye, the natural reflex to clamp the eyelids shut makes it very difficult, if not impossible, to remove the contact lens before damage is done.

- b. The plastic used in contact lenses is permeable to some of the vapors found in the laboratory. These vapors can be trapped behind the lenses and can cause extensive irritation.
- c. The lenses can prevent tears from removing the irritant.

If Departmental Chemical Hygiene Officer chooses to allow contact lenses to be worn, they shall be protected by goggles designed specifically for use with contact lenses. (The protective goggles for use with contact lenses fit loosely around the eyes and have no vents for access by vapors.) If chemical vapors contact the eyes while wearing contact lenses, these steps should be followed:

- (1) Immediately remove the lenses.
 - (2) Continuously flush the eyes, for at least 15 to 30 minutes.
 - (3) Seek medical attention.
5. Although safety glasses are adequate protection for the majority of laboratory operations, they are not sufficient for certain specific operations where there is danger from splashes of corrosive liquids or flying particles. Examples are: washing glassware in chromic acid solution, grinding materials, or laboratory operations using glassware where there is significant hazard of explosion or breakage (i.e., in reduced or excess pressure or temperature). In such cases, goggles or face shields shall be worn if there is need for protection of the entire face and throat.
6. If, despite all precautions, an employee should experience a splash of corrosive liquid in the eye, the employee is to proceed (with the assistance of a co-worker, if possible) to the nearest eyewash fountain and flush the eyes with water for at least 15 to 30 minutes. Flush from the eye outward. During this time, a co-worker should notify the proper authorities.
7. Visitors shall follow the same eye protection policy as employees. If they do not provide their own eye protection, it is the laboratory's responsibility to provide adequate protection. It should be the responsibility of the employee conducting the tour to enforce this policy. After use safety glasses/goggles used by visitors should be cleaned prior to reuse.

B. Clothing

The following guidelines for laboratory clothing are offered strictly from a safety standpoint.

- 1. Due to the potential for ignition, absorption, and entanglement in machinery, loose or torn clothing should be avoided unless wearing a lab coat.
- 2. Dangling jewelry and excessively long hair pose the same type of safety hazard.
- 3. Finger rings or other tight jewelry which is not easily removed should be avoided because of the danger of corrosive or irritating liquids getting underneath the piece and producing irritation.
- 4. Lab coats should be provided for protection and convenience. They should be worn at all times in the lab areas. Due to the possible absorption and accumulation of chemicals in the material, lab coats should not be worn in the lunchroom or elsewhere outside the laboratory.
- 5. Where infectious materials are present, closed (snapped) lab coats and gloves are essential.

6. Shoes shall be worn at all times in the laboratories. Sandals, open-toed shoes, and shoes with woven uppers, shall not be worn because of the danger of spillage of corrosive or irritating chemicals.
7. Care should be exercised in protective clothing selection; some protective clothing has very limited resistance to selected chemicals or fire.
8. Consult the MSDS for a chemical to find out the recommended clothing or PPE for a particular chemical. (Examples are latex, nitrile, or PVC gloves, or aprons.)

C. Aprons - Rubber or Plastic

Some operations in the laboratory, like washing glassware, require the handling of relatively large quantities of corrosive liquids in open containers. To protect clothing in such operations, plastic or rubber aprons may be supplied. A high-necked, calf- or ankle-length, rubberized laboratory apron or a long-sleeved, calf- or ankle-length, chemical- and fire-resistant laboratory coat should be worn anytime laboratory manipulation or experimentation is being conducted. Always wear long-sleeved and long-legged clothing; do not wear short-sleeved shirts, short trousers, or short skirts.

D. Gloves

When handling chemicals, it is recommended that the correct gloves be used to protect the worker from accidental spills or contamination. If the gloves become contaminated they should be removed and discarded as soon as possible. There is no glove currently available that will protect a worker against all chemicals.

Protection of the hands when working with solvents, detergents, or any hazardous material is essential in the defense of the body against contamination. Exposure of the hands to a potentially hazardous chemical could result in burns, chafing of the skin due to extraction of essential oils ("de-fatting"), or dermatitis. The skin could also become sensitized to the chemical and once sensitized, could react to lesser quantities of chemicals than otherwise would have any effect. It is well documented that primary skin irritations and sensitizations account for significantly greater numbers of lost time incidents on the job than any other single type of industrial injury.

Proper selection of the glove material is essential to the performance of the glove as a barrier to chemicals. Several properties of both the glove material and the chemical with which it is to be used should influence the choice of the glove. Some of these properties include: permeability of the glove material, breakthrough time of the chemical, temperature of the chemical, thickness of the glove material, and the amount of the chemical that can be absorbed by the glove material (solubility effect). Glove materials vary widely in respect to these properties; for instance, neoprene is good for protection against most common oils, aliphatic hydrocarbons, and certain other solvents, but is unsatisfactory for use against aromatic hydrocarbons, halogenated hydrocarbons, ketones, and many other solvents.

Gloves of various types are available and should be chosen for each specific job for compatibility and breakthrough characteristics. An excellent information is Guidelines for the Selection of Chemical Protective Clothing published by the American Conference of Governmental Industrial Hygienists (ACGIH) or information provided by glove manufacturers.

1. Selection

For concentrated acids and alkalis, and organic solvents, natural rubber, neoprene or nitrile gloves are recommended. For handling hot objects, gloves made of heat-resistant materials (leather or Nomex) should be available and kept near the vicinity of ovens or muffle furnaces. A hot object should never be picked up with rubber or plastic gloves. Special insulated gloves should be worn when handling very cold objects such as liquid N₂ or CO₂. Do not use asbestos containing gloves.

2. Inspection

Before each use, gloves should be inspected for discoloration, punctures, and tears. Rubber and plastic gloves may be checked by inflating with air and submersing them in water to check for air bubbles.

3. Usage

Gloves should always be rinsed with a compatible solvent, soap and water prior to handling wash bottles or other laboratory fixtures.

4. Cleaning

Before removal, gloves should be thoroughly washed, either with tap water or soap and water.

5. Removal

Employees shall remove gloves before leaving the immediate work site to prevent contamination of door knobs, light switches, telephones, etc. When gloves are removed, pull the cuff over the hand.

SECTION 2.4 - COMPRESSED GAS SAFETY

Many laboratory operations require the use of compressed gases for analytical or instrument operations. Compressed gases present a unique hazard. Depending on the particular gas, there is a potential for simultaneous exposure to both mechanical and chemical hazards. Gases may be combustible, explosive, corrosive, poisonous, inert, or a combination of hazards. If the gas is flammable, flash points lower than room temperature compounded by high rates of diffusion (which allow for fast permeation throughout the laboratory) present a danger of fire or explosion. Additional hazards of reactivity and toxicity of the gas, as well as asphyxiation, can be caused by high concentrations of even "harmless" gases such as nitrogen. Since the gases are contained in heavy, highly pressurized metal containers, the large amount of potential energy resulting from compression of the gas makes the cylinder a potential rocket or fragmentation bomb. In summary, careful procedures are necessary for handling the various compressed gases, the cylinders containing the compressed gases, regulators or valves used to control gas flow, and the piping used to confine gases during flow.

A. Identification

1. The contents of any compressed gas cylinder shall be clearly identified for easy, quick, and complete determination by any laboratory worker. Such identification should be stenciled or stamped on the cylinder or a label, provided that it cannot be removed from the cylinder. Commercially available three-part tag systems can be very useful for identification and inventory. No compressed gas cylinder shall be accepted for use that does not legibly identify its contents by name. Color coding is not a reliable means of identification; cylinder colors vary with the supplier, and labels on caps have little value as caps are interchangeable. If the labeling on a cylinder becomes unclear or an attached tag is defaced to the point the contents cannot be identified, the cylinder should be marked "contents unknown" and returned directly to the manufacturer.
2. All gas lines leading from a compressed gas supply should be clearly labeled to identify the gas, the laboratory served, and the relevant emergency telephone numbers. The labels should be color coded to distinguish hazardous gases (such as flammable, toxic, or corrosive substances) (e.g., a yellow background and black letters). Signs should be conspicuously posted in areas where flammable compressed gases are stored, identifying the substances and appropriate precautions (e.g., HYDROGEN - FLAMMABLE GAS - NO SMOKING - NO OPEN FLAMES).

B. Handling and Use

1. Since gas cylinders are tall and narrow, they shall be secured at all times to prevent tipping. Cylinders may be attached to a bench top, individually to the wall, placed in a holding cage, or have a non-tip base attached.
2. When new cylinders are received, they should be inspected. During this inspection, one should insure the proper cap is securely in place and the cylinder is not leaking. Cylinders shall have clear labels indicating the type of gas contained. If the cylinders are acceptable, they shall be stored in a proper location. If a leaking cylinder is discovered, move it to a safe place (if it is safe to do so) and inform the Chemical Hygiene Officer. You should also call the vendor as soon as possible. Under no circumstances should any attempt be made to repair a cylinder or valve.
3. Cylinders containing flammable gases such as hydrogen or acetylene shall not be stored in close proximity to open flames, areas where electrical sparks are generated, or where other sources of ignition may be present. Cylinders containing acetylene shall never be stored on their side. An open flame shall never be used to detect leaks of flammable gases. Hydrogen flame is invisible, so "feel" for heat. All cylinders containing flammable gases should be stored in a well-ventilated area.
4. Oxygen cylinders, full or empty, shall not be stored in the same vicinity as flammable gases. The proper storage for oxygen cylinders requires that a minimum of 50 feet be maintained between flammable gas cylinders and oxygen cylinders or the storage areas be separated, at a minimum, by a fire wall five feet high with a fire rating of 0.5 hours.

Greasy and oily materials shall never be stored around oxygen; nor should oil or grease be applied to fittings.

5. Standard cylinder-valve outlet connections have been devised by the Compressed Gas Association (CGA) to prevent mixing of incompatible gases. The outlet threads used vary in diameter; some are internal, some are external; some are right-handed, some are left-handed. In general, right-handed threads are used for non-fuel and water-pumped gases, while left-handed threads are used for fuel and oil-pump gases. To minimize undesirable connections, only CGA standard combinations of valves and fittings should be used in compressed gas installations; the assembly of miscellaneous parts should be avoided. The threads on cylinder valves, regulators and other fittings should be examined to ensure they correspond and are undamaged.

Cylinders should be placed with the valve accessible at all times. The main cylinder valve should be closed as soon as it is no longer necessary that it be open (i.e., it should never be left open when the equipment is unattended or not operating). This is necessary not only for safety when the cylinder is under pressure, but also to prevent the corrosion and contamination resulting from diffusion of air and moisture into the cylinder after it has been emptied.

Cylinders are equipped with either a hand wheel or stem valve. For cylinders equipped with a stem valve, the valve spindle key should remain on the stem while the cylinder is in service. Only wrenches or tools provided by the cylinder supplier should be used to open or close a valve. At no time should pliers be used to open a cylinder valve. Some valves may require washers; this should be checked before the regulator is fitted.

Cylinder valves should be opened slowly. Main cylinder valves should never be opened all the way.

When opening the valve on a cylinder containing an irritating or toxic gas, the user should position the cylinder with the valve pointing away from them and warn those working nearby.

6. Regulators are gas specific and not necessarily interchangeable. Always make sure that the regulator and valve fittings are compatible. If there is any question as to the suitability of a regulator for a particular gas, check with the Chemical Hygiene Officer or call your vendor for advice. After the regulator is attached, the cylinder valve should be opened just enough to indicate pressure on the regulator gauge (no more than one full turn) and all the connections checked with a soap solution for leaks. Never use oil or grease on the regulator of a cylinder valve.
7. Piping material shall be compatible with the gas being supplied. Copper piping shall not be used for acetylene, nor plastic piping for any portion of a high pressure system. Do not use cast iron pipe for chlorine; do not conceal distribution lines where a high concentration of a leaking hazardous gas can build up and cause an accident. Distribution lines and their outlets should be clearly labeled as to the type of gas contained. Piping systems should be inspected for leaks on a regular basis. Special attention should be given to fittings as well as possible cracks that may have developed.
8. A cylinder should never be emptied to a pressure lower than 172 kPa (25 psi/in²) (the residual contents may become contaminated if the valve is left open). When work involving a compressed gas is completed, the cylinder must be turned off, and if possible, the lines bled. When the cylinder needs to be removed or is empty (see above), all valves shall be closed, the system bled, and the regulator removed. The valve cap shall be replaced, the cylinder clearly marked as "empty," and returned to a storage area for pickup by the supplier. Empty and full cylinders should be stored in separate areas.
9. Where the possibility of flow reversal exists, the cylinder discharge lines should be equipped with approved check valves to prevent inadvertent contamination of cylinders connected to a closed system. "Sucking back" is particularly troublesome where gases are used as reactants in a closed system. A cylinder in such a system should be shut off

and removed from the system when the pressure remaining in the cylinder is at least 172 kPa (25 psi/in²). If there is a possibility that the container has been contaminated, it should be so labeled and returned to the supplier.

10. Liquid bulk cylinders may be used in laboratories where a high volume of gas is needed. These cylinders usually have a number of valves on the top of the cylinder. All valves should be clearly marked as to their function. These cylinders will also vent their contents when a preset internal pressure is reached, therefore, they should be stored or placed in service where there is adequate ventilation. If a liquid fraction is removed from a cylinder, proper hand and eye protection must be worn and the liquid collected in a Dewar flask.
11. Always use safety glasses (preferably a face shield) when handling and using compressed gases, especially when connecting and disconnecting compressed gas regulators and lines.
12. All compressed gas cylinders, including lecture-size cylinders, shall be returned to the supplier when empty or no longer in use.

C. Transportation of Cylinders

The cylinders that contain compressed gases are primarily shipping containers and should not be subjected to rough handling or abuse. Such misuse can seriously weaken the cylinder and render it unfit for further use or transform it into a rocket having sufficient thrust to drive it through masonry walls.

1. To protect the valve during transportation, the cover cap should be screwed on hand tight and remain on until the cylinder is in place and ready for use.
2. Cylinders should never be rolled or dragged.
3. When moving large cylinders, they should be strapped to a properly designed wheeled cart to ensure stability.
4. Only one cylinder should be handled (moved) at a time.

D. Cryogenic Liquids

A number of hazards may be present from the use of cryogenic liquids in the laboratory. Employees should be properly trained in these hazards prior to use. The transfer of liquefied gases from one container to another should not be attempted for the first time without the direct supervision and instruction of someone experienced in the operation.

1. Fire/Explosions
 - a. Neither liquid nitrogen nor liquid air should be used to cool a flammable mixture in the presence of air because oxygen can condense from the air and lead to a potentially explosive condition.
 - b. Adequate ventilation must always be used to prevent the build-up of vapors of flammable gases such as hydrogen, methane, and acetylene.
 - c. Adequate ventilation is also required when using gases such as nitrogen, helium, or hydrogen. In these cases, oxygen can be condensed out of the atmosphere creating a potential for explosive conditions.
2. Pressure

Cylinders and other pressure vessels used for the storage and handling of liquefied gases should not be filled to more than 80% of capacity, to prevent the possibility of thermal expansion and the resulting bursting of the vessel by hydrostatic pressure.

3. Embrittlement of Structural Materials

Appropriate impact-resistant containers must be used that have been designed to withstand the extremely low temperatures.

4. Contact With and Destruction of Living Tissue

Even very brief contact with a cryogenic liquid is capable of causing tissue damage similar to that of thermal burns. Prolonged contact may result in blood clots that have potentially serious consequences. In addition, surfaces cooled by cryogenic liquids can cause severe damage to the skin. Gloves and eye protection (preferably a face shield) should be worn at all times when handling cryogenic liquids. Gloves should be chosen that are impervious to the fluid being handled and loose enough to be tossed off easily. Appropriate dry gloves should be used when handling dry ice. "Chunks" or cubes should be added slowly to any liquid portion of the cooling bath to avoid foaming over.

5. Asphyxiation

As the liquid form of gases warm and become airborne, oxygen may be displaced to the point that employees may experience oxygen deficiency or asphyxiation. Any area where such materials are used should be well ventilated. For this same reason, employees should avoid lowering their heads into a dry ice chest. (Carbon dioxide is heavier than air, and suffocation can result.)

SECTION 2.5 - SAFETY PRACTICES FOR DISPOSAL OF BROKEN GLASSWARE

Inspect all glassware before use. Do not use broken, chipped, starred or badly scratched glassware. If it cannot be repaired, discard it in containers specifically designated for broken glass. All broken glass requires special handling and disposal procedures to prevent injury not only to lab personnel, but members of the janitorial staff as well.

All broken glass shall be disposed in rigid, puncture proof containers such as a cardboard box with taped seams, or a plastic bucket or metal can with a sealing lid. All broken glass disposal containers shall be clearly marked "DANGER - BROKEN GLASS" Limit quantities to no more than approximately 15 to 20 pounds so that lifting of the container will not create a situation that could cause back injury.

1. Food, beverage, and uncontaminated glassware: Dispose in a rigid, puncture proof container such as a box with sealed or taped edges or a metal or thick plastic can or bucket with a sealing lid. Label container "DANGER - BROKEN GLASS".
2. Radioactive glassware: Contact the Radiological Safety Officer for specific instructions.
3. Glassware with biological contamination: Glassware that has been in contact with infectious agents may include: used slides, cover slips, test tubes, beakers, pipettes, etc. Contaminated glassware shall be disinfected before disposal. Dispose in a rigid, puncture proof container such as a box with sealed or taped edges or a metal or thick plastic can or bucket with a sealing lid. Label container "DANGER - BROKEN GLASS". Contact the Biological Safety Officer if you require further information.
4. Glassware with chemical contamination: Empty the contents of the glassware into a suitable container if safe to do so. (See Section 3.4 - "Chemical Waste" for disposal procedures.) Contact the OSU Chemical Safety Officer for assistance with decontamination and disposal of the contaminated glassware.

SECTION 2.6 - CENTRIFUGE SAFETY

Does your lab have a centrifuge? Have you been instructed in proper use of this valuable tool? Are you aware that 90% of centrifuge failures are the result of user errors? These errors may result in lost samples and damaged equipment as well as a risk to you the lab user and your lab.

This partial checklist is submitted for your convenience and, if appropriate, should be included in your lab's Chemical Hygiene Plan, possibly in the Special Procedures section.

Protocol calls for centrifugation. The following are suggested steps. (First review the owner's manual--if manual not available, obtain a copy before proceeding.)

1. Which centrifuge
2. Which rotor
3. Correct tube size and adapter
4. What speed & length of time

After the above selections have been made, and the owner's manual and centrifuge log consulted (especially critical on ultra centrifuge), insure the tube fits properly in the rotor. This is important because up to 600,000 G forces may be generated during the centrifugation procedure.

Insure you are using the appropriate level of containment. Is the material potentially infectious/radioactive? If so, are you using aerosol containment tubes? Are you loading and unloading the rotor in a biological safety cabinet?

Suggested steps to follow BEFORE starting the centrifuge:

1. Insure centrifuge bowl and tubes are dry.
2. Is the centrifuge spindle clean?
3. Avoid overfilling of tubes and bottles
4. Insure rotor is properly seated on drive hub.
5. Make sure tubes are properly balanced in rotor ($\frac{1}{2}$ gram at 1 G is roughly equivalent to 250 Kg @ 500,000 G's).
6. Are O-rings properly attached to the rotor? Is the vacuum grease fresh?
7. Has the rotor been properly secured to drive?
8. Is the centrifuge lid shut properly?

After the above steps are taken and the centrifuge has started, make sure the run is proceeding normally before you leave the area.

Once the centrifuge run is complete, make sure the rotor has STOPPED completely before you open the centrifuge lid; then check for spills. If infectious material was placed in the centrifuge, WAIT 10 minutes before opening the centrifuge lid. If leak or damage has occurred, close the lid and plan proper decontamination and cleanup. For biological spills, contact the Biological Safety Officer.

Maintenance/Cleaning:

1. Keep rotors clean and dry. If spills occur, make sure rotor has been cleaned/decontaminated. If salts or corrosive materials were used, ensure they have been removed from the rotor.
2. Avoid mechanical scratches. The smallest, scarcely visible scratch allows etching to enlarge the fracture, which is subject to enormous rupturing forces at high G's--a vicious cycle leading to rotor explosion.
3. Avoid bottle brushes with sharp metal ends and harsh detergents when cleaning aluminum rotor heads.
4. After proper clean-up, rinse the rotor with de-ionized water.

Inspections:

1. Check the rotor for rough spots, pitting, and discoloration. If discovered, check with the manufacturer before using. Use professional rotor inspection services frequently.
2. Consult the centrifuge manufacturer and centrifuge log for the derating schedule for the rotor. Remember - an unlogged ultra-speed centrifuge is a ticking time bomb.

CHAPTER 3.0 - CHEMICAL HYGIENE PLAN

The Occupational Safety and Health Administration (OSHA), part of the Department of Labor, administers a variety of regulations. These regulatory requirements are published in and referred to as the Code of Federal Regulations (CFR). The Code of Federal Regulations is a codification of the general and permanent rules published in the Federal Register by the Executive departments and agencies of the Federal Government. The Code is divided into 50 titles which represent broad areas subject to Federal regulation. Each title is divided into chapters with each chapter further subdivided into parts, subparts and sections. Part 1910 of Title 29 (cited as "29 CFR 1910"), section 1450 of subpart Z, "Occupational Exposures to Hazardous Chemicals in Laboratories", referred to as the "Laboratory Standard", specifically addresses mandated regulatory requirements. Many educational institutions, colleges, universities, industry, and other organizations that use hazardous chemicals in their laboratories are now required by the Laboratory Standard to develop Chemical Hygiene Plans

The development of a detailed written chemical hygiene plan is necessary to establish continuity, to train personnel, and to help ensure that all employees recognize and comply with work place safety. It is extremely difficult to effectively communicate and enforce requirements without a detailed written chemical hygiene plan.

An effective chemical hygiene plan necessitates that mechanisms be in place and functioning to ensure that safety policies and procedures are being adhered to, personnel are meeting their safety responsibilities, and an effective form of monitoring and documentation is in place for confirmation purposes.

Laboratories are well advised to develop their written chemical hygiene plans in a manual form. This manual should provide policies and procedures that are feasible, specific, and encompass all the elements of laboratory activities in which the laboratory is engaged. The written safety manual should be distributed to appropriate employees and be a requirement of employee training programs.

The basic OSU Laboratory Safety Manual is intended to serve primarily as a general safety document for compliance with various state and federal environmental and occupational health and safety rules and regulations. **It is neither feasible nor technically valid to attempt to provide specific procedures or protocols in a general safety document. However, individual laboratories should be able to develop their own specific chemical hygiene plans by augmenting the OSU Laboratory Safety Manual**

The development of a detailed written chemical hygiene plan and the implementation of this plan within employee training programs should result in a safer working environment and contribute to a reduction in work place accidents and injuries.

Section 3.1 - OSU LABORATORY CHEMICAL SAFETY POLICY

A. Introduction

The State of Oregon adopted the Federal OSHA Standards, Title 29 of the Code of Federal Regulations (CFR) parts 1910 and 1926 (hereafter cited as 29 CFR 1910 and 29 CFR 1926), to apply to the state government and its political subdivisions. (Title 40 O.S. sections 401-424, Oregon statutes as amended.)

Oregon State University is therefore required by 29 CFR 1910 section 1450 of subpart Z (Occupational Exposures to Hazardous Chemicals in Laboratories) to develop a chemical hygiene plan for certain laboratories

The Laboratory Standard (29 CFR 1910.1450) does not apply to all laboratories, but where it applies, it supersedes the Hazard Communication Standard 29 CFR 1910.1200. Even though Oregon State University has already implemented the Hazard Communication Standard, the Laboratory Standard takes precedence in those areas to which it applies. There is no option of choosing between the two standards. If the Laboratory Standard applies to an area, it must be implemented. If the Laboratory Standard does not apply, then the Hazard Communication Standard does apply.

It is therefore the intent of this Laboratory Chemical Safety Policy to define the guidelines for the implementation of the Laboratory Standard.

B. Scope and Definitions

The OSU Laboratory Safety Chemical Policy applies only to certain laboratories. Many laboratories use hazardous chemicals. OSHA defines a hazardous chemical as a substance for which there is a statistically significant evidence, based on at least one scientific study, showing that acute or chronic harm may result from exposure to that chemical. This broad definition clearly applies to almost all, of the chemicals typically used in laboratories.

The purpose of the OSU Laboratory Safety Chemical Policy is to protect laboratory employees, while they are working in a laboratory, from harm due to potential exposure of hazardous chemicals. In addition to employees who ordinarily spend their full time working in a laboratory space, for the purposes of this policy "laboratory employee" also includes office, custodial, maintenance, and repair personnel, and others who, as part of their duties, regularly spend a significant amount of their time within a laboratory environment. The appropriate University administrative units shall determine what constitutes a "significant amount" of working time. This definition is subject to review at the time of an OSHA visit.

The OSU Laboratory Chemical Safety Policy does not apply to all places where hazardous chemicals are used. Only laboratories meeting the following four criteria are subject to the OSU Laboratory Chemical Safety Policy:

1. Chemical manipulations are carried out on a laboratory scale. That is, the work with chemicals is in containers of a size that could be easily and safely manipulated by one person.
2. Multiple chemical procedures or chemicals are used.
3. Protective laboratory practices and equipment are available and in common use to minimize the potential for employee exposure to hazardous chemicals.
4. The procedures involved are not part of a production process whose function is to produce commercial quantities of materials, nor do the procedures in any way simulate a production process.

This fourth criterion would normally exclude quality control laboratories in industrial operations because they "are usually adjuncts of production operations which typically perform repetitive procedures for the purpose of monitoring a product or a process" [FR 55, 3312 (January 31,

1990)]. This criterion also would normally exclude pilot plant operations, which are typically closely connected with production processes. However, if pilot plant operations are an integral part of a research function for the purpose of evaluating a particular effect (for example, "the operations do not proceed to production but remain part of the research activity"), then that pilot plant operation may be covered under the OSU Laboratory Chemical Safety Policy.

Some laboratories may also be required to meet the requirements of substance-specific federal standards in addition to the Laboratory Standard. One set of such standards is contained in OSHA's 29 CFR 1910.1000 - 1999.

Action level - A concentration for a specific substance, calculated as an eight (8) hour time-weighted average, which initiates certain required activities such as exposure monitoring and medical surveillance. Typically it is one-half that of the PEL for that substance

Acute - Severe, often dangerous conditions in which relatively rapid changes occur

Carcinogen - Any substance that causes the development of cancerous growths in living tissue, either those that are known to induce cancer in man or animals or experimental carcinogens that have been found to cause cancer in animals under experimental conditions.

Designated Area - An area which may be used for work with "select carcinogens, reproductive toxins, or substances which have a high degree of acute toxicity." A designated area may be the entire laboratory, an area of a laboratory, or a device such as a laboratory hood. A designated area shall be placarded to reflect the designated hazard.

Employee - An individual employed in a laboratory work place who may be exposed to hazardous materials in the course of his or her assignments.

Health Hazard - A substance for which there is statistically significant evidence based on at least one study conducted in accordance with established scientific principles that acute or chronic health effects may occur in exposed employees. This term includes carcinogens, toxic agents, reproductive toxins, irritants, corrosives, sensitizers, hepatotoxins, nephrotoxins, neurotoxins, agents which act on the hematopoietic systems, and agents which damage the lungs, skin, eyes, or mucous membranes.

MSDS - Material Safety Data Sheet.

(PEL) Permissible Exposure Limit - An exposure limit that is published and enforced by OSHA as a legal standard. PEL may be either a time-weighted-average (TWA) exposure limit (8 hour), a 15-minute short term exposure limit (STEL), or a ceiling (C). The PELs are found in Tables Z-1, Z-2, or Z-3 of 29 CFR 1910.100. This level of exposure is deemed to be the maximum safe concentration and is generally the same value as the threshold limit value (TLV).

(PPE) Personal Protective Equipment - Any devices or clothing worn by the worker to protect against hazards in the environment. Examples are respirators, gloves, and chemical splash goggles.

Respirator - A device which is designed to protect the wearer from inhaling harmful contaminants.

(STEL) Short Term Exposure Limit - Represented as STEL or TLV-STEL, this is the maximum concentration to which workers can be exposed for a short period of time (15 minutes) for only four times throughout the day with at least one hour between exposures.

(TLV) Threshold Limit Value - Airborne concentrations of substances devised by the ACGIH that represents conditions under which it is believed that nearly all workers may be exposed day after day with no adverse effect. TLVs are advisory exposure guidelines, not legal standards, that are based on evidence from industrial experience, animal studies, or human studies when they exist. There are three different types of TLVs: Time Weighted Average (TLV-TWA), Short Term Exposure Limit (TLV-STEL) and Ceiling (TLV-C). (See also PEL).

Time Weighted Average - (TLV-TWA, Threshold Limit Value-Time Weighted Average) The time weighted average airborne chemical concentration for a normal eight hour work day and a 40

hour work week to which nearly all workers may be repeatedly exposed, day after day, without adverse effect.

Toxic - Substances such as carcinogens, irritants, or poisonous gases, liquids, and solids which are irritating to or affect the health of humans.

C. University Responsibilities

Oregon State University has certain obligations. Among these the University must:

1. Keep records of employee exposures to hazardous chemicals.
 - a. Records should include measurements made to monitor exposures, if any, as well as any medical consultations and examinations, including written opinions.
 - b. These records shall be kept by Environmental Health Services' Hazard Communications Section, University Personnel Services, and the laboratory or Department in which the exposure occurred. Records should be indexed according to the employee's social security number.
 - c. Maintain these records as mandated in 29 CFR 1910.20, Access to Employee Exposure and Medical Records.
2. Provide University employees with:
 - a. Training and information regarding chemical and physical hazards.
 - b. Identification of other hazards (see Subparts D through T of 29 CFR).
 - c. Access to medical consultation and examinations. (See part F of this policy)
 - d. Respirators when necessary (see item 6 of this list).
3. For incoming hazardous chemicals:
 - a. Require that the incoming hazardous chemicals have adequate labels. Do not allow the removal or defacement of these labels.
 - b. Require that the MSDSs for incoming hazardous chemicals be on hand prior to receipt of hazardous chemicals whenever possible. Require that MSDSs be acquired for all hazardous chemicals on hand whenever possible.
 - c. Keep all material safety data sheets (MSDS) that the University receives.
 - d. Make MSDSs accessible to employees.
 - e. Maintain an accurate inventory of all chemicals in University laboratories.
4. When hazardous chemicals are generated in University laboratories:
 - a. If the hazardous properties are known, train University employees.
 - b. If the hazardous properties are not known, treat the chemical as though it is hazardous and provide protection as described in the laboratory Chemical Hygiene Plan.
 - c. If the chemicals are produced for use elsewhere, follow 29 CFR 1910.1200 and the various Environmental Protection Agency (EPA) and Department of Transportation (DOT) regulations that apply to that chemical.

5. If there is reason to believe that the action level, or PEL if there is no action level, has been exceeded for any chemical for which a substance-specific standard has been established, the University must measure the concentration of that chemical in the air.

If the level measured is greater than the PEL or action level, then:
 - a. Notify all affected laboratory employees of the results of the measurement, and
 - b. Comply with the OSHA exposure-monitoring provisions for that chemical, as stated in 29 CFR 1910.1000 through 1910.1199.
6. If respirators are necessary to keep exposures below the PEL or action level, follow the requirements of the Respiratory Protection Standard, 29 CFR 1910.134.
7. If select carcinogens, reproductive toxins, or acute toxins that are very highly toxic are used in the laboratory, identify and post one or more areas as "designated area(s)".
8. Require that each University Department or similar University administrative unit which has laboratories subject to the Laboratory Standard appoint a Departmental Chemical Hygiene Officer (DCHO).
 - a. These individuals should be qualified by training and experience to provide technical guidance in the development and implementation of the Chemical Hygiene Plan. This assignment can be a second title for a person who has other responsibilities.
 - b. The University President has the ultimate responsibility for chemical safety. The Departmental Chemical Hygiene Officers act as the representative of the University President in this capacity.
9. Assign to the DCHO's the duty to prepare, implement, and maintain a written program for their Department, called a chemical hygiene plan (CHP), setting forth the work practices, procedures, personal protective equipment, and other equipment that will protect employees from harm arising from hazardous chemicals used in the laboratories in their Department.
 - a. The CHP must be capable of keeping employee exposures below the PEL of chemicals as listed in 29 CFR 1910 Subpart Z.
 - b. The CHP must be readily accessible to employees.
 - c. The CHP must be reviewed at least annually and updated as necessary.

D. Individual Responsibilities

Responsibility for chemical hygiene rests at all levels including the:

1. *University President*, who has ultimate responsibility for chemical hygiene within Oregon State University and must, with other administrators, provide continuing support for University chemical hygiene.
2. *Supervisor of a College, Department or other administrative unit*, who is responsible for chemical hygiene in that unit.
3. *Departmental Chemical Hygiene Officers*, who have overall responsibility for chemical hygiene in all departmental laboratories including responsibility to:
 - a. Work with administrators and other employees to develop and implement appropriate chemical hygiene policies and practices;
 - b. Help project directors develop precautions and adequate facilities;

- c. Ensure that workers know and follow the chemical hygiene rules and document that appropriate training has been provided;
 - d. Determine the required levels of protective apparel and equipment and insure that this equipment is available and in working order;
 - e. Monitor procurement, use, and disposal of chemicals in the lab;
 - f. Ensure that the Hazard Communications Office receive copies of all MSDSs received.
 - g. Maintain an accurate Departmental Chemical Inventory List. Complete and mail the Departmental Chemical Inventory List survey forms to the Hazard Communication Office on a timely basis.
 - h. Provide regular, formal chemical hygiene and housekeeping inspections including routine inspections of emergency equipment;
 - i. Know the current legal requirements concerning regulated substances; and
 - j. Seek ways to improve the chemical hygiene program.
4. *Project director or director of other specific operation*, who has primary responsibility for chemical hygiene procedures for that operation, and is responsible for:
- a. Insuring that the Departmental Chemical Hygiene Officer receives copies of all MSDSs received.
 - b. Maintaining an accurate Laboratory Chemical Inventory List. Insure that the Departmental Chemical Hygiene Officer receives copies of this list as necessary.
 - c. Ensuring that workers know and follow the chemical hygiene rules,
 - d. Ensuring that protective equipment is available and in working order,
 - e. Ensuring that all containers in the work area are properly labeled,
 - f. Ensuring that MSDS's are maintained for each hazardous substance in the laboratory and ensuring that they are readily accessible to laboratory employees,
 - g. Ensuring that appropriate training has been provided to all employees,
 - h. Providing regular, formal chemical hygiene and housekeeping inspections including routine inspections of emergency equipment,
 - i. Knowing the current legal requirements concerning regulated substances,
 - j. Determining the required levels of protective apparel and equipment, and
 - k. Ensuring that facilities for use of any material being ordered are adequate.
5. *Laboratory worker*, who is responsible for:
- a. Planning and conducting each operation in accordance with safe procedures; and
 - b. Developing and maintaining good personal chemical hygiene habits.

E. The Content of the Chemical Hygiene Plan

The chemical hygiene plan shall include each of the following elements and shall also indicate the specific measures to be taken to ensure that University employees are protected.

1. Standard operating procedures relevant to all laboratory operations, to be followed by laboratory employees.
2. Statements of the criteria that will be used to determine and implement control measures to reduce employee exposure to hazardous chemicals. These measures include engineering controls, use of personal protective equipment, and personal hygiene practices. Criteria to reduce exposure to extremely hazardous chemicals used in the laboratory shall be specifically included.
3. A requirement that fume hoods and other protective equipment shall function properly and descriptions of the methods to be taken to make sure that such equipment is functioning properly.
4. Provisions for employee training and information.
5. Circumstances under which a laboratory practice requires prior approval from a supervisor before implementation.
6. Provisions for medical consultation and examination.
7. Designation of personnel responsible for implementation of the chemical hygiene plan.
8. Provisions for additional protection for employees when working with particularly hazardous substances, including:
 - a. Select carcinogens.
 - b. Reproductive toxins.
 - c. Substances with a high degree of acute toxicity.
9. Specific mention of the following provisions, including when appropriate:
 - a. Establishment of a designated area.
 - b. Use of containment devices such as fume hoods or glove boxes.
 - c. Procedures for safe removal and disposal of contaminated and hazardous waste; and
 - d. Decontamination procedures.

F. Exposure Assessments, Medical Consultations, and Examinations

1. Suspected Exposures to Toxic Substances

There may be times when employees or supervisors suspect that an employee has been exposed to a hazardous chemical to a degree and in a manner that might have caused harm to the victim. If the circumstances suggest a reasonable suspicion of exposure, the victim is entitled to a medical consultation and, if so determined in the consultation, also to a medical examination. All medical examinations and consultations shall be provided without cost to the employee, without loss of pay, and at a reasonable time and place.

- a. Criteria for Reasonable Suspicion of Exposure
 - (1) It is the policy of Oregon State University to promptly investigate all employee-reported incidents in which there is even a remote possibility of employee overexposure to a toxic substance.

- (2) Events or circumstances that might reasonably constitute overexposure include:
 - (a) A hazardous chemical leaked or was spilled or was otherwise rapidly released in an uncontrolled manner.
 - (b) A laboratory employee had direct skin or eye contact with a hazardous chemical.
 - (c) A laboratory employee manifests symptoms, such as headache, rash, nausea, coughing, tearing, irritation or redness of eyes, irritation of nose or throat, dizziness, loss of motor dexterity or judgment, etc., and some or all of the symptoms disappear when the person is taken away from the exposure area and breathes fresh air, and the symptoms reappear soon after the employee returns to work with the same hazardous chemicals.
 - (d) Two or more persons in the same laboratory work area have similar complaints.

b. Exposures

All exposure complaints and their disposition, no matter what the ultimate disposition may be, are to be documented by the respective Department Chemical Hygiene Officer using the Employer's First Notice of Injury Form and Employee Exposure Report Form. Copies of these forms shall be sent to University Personnel Services. If no further assessment of the event is deemed necessary, the reason for that decision shall be included on the Employee Exposure Report Form. If the decision is to investigate, a formal exposure assessment will be initiated by the Departmental Chemical Hygiene Officer. Environmental Health Services and University Personnel Services Office of Risk Management shall provide the Formal Exposure assessment.

(1) Exposure Assessment

In cases of emergency, exposure assessments are conducted after the victim has been treated, otherwise exposure assessments should be completed BEFORE medical consultations are undertaken.

NOTE: It is not the purpose of an exposure assessment to determine that a failure on the part of the victim, or others, to follow proper procedures was the cause of an exposure. The purpose of an exposure assessment is to determine that there was, or was not, an exposure that might have caused harm to one or more employees and, if so, to identify the hazardous chemical or chemicals involved. Other investigations might well use results and conclusions from an exposure assessment, along with other information, to derive recommendations that will prevent or mitigate any future overexposures. However, exposure assessments determine facts; they do not make recommendations.

- (a) Unless circumstances suggest other or additional steps, these actions constitute an exposure assessment:
 - i. Interview the complainant and also the victim, if not the same person.
 - ii. List the essential information about the circumstances of the complaint, including:
 - The chemical under suspicion.
 - Other chemicals used by victim.

- All chemicals being used by others in the immediate area.
- Other chemicals stored in that area.
- Symptoms exhibited or claimed by the victim.
- How these symptoms compare to symptoms stated in the materials safety data sheets for each of the identified chemicals.
- Were control measures, such as personal protective equipment and hoods, used properly?
- Were any air sampling or monitoring devices in place? If so, are the measurements obtained from these devices consistent with other information?

(b) Monitor or sample the air in the area for suspect chemicals.

(c) Determine whether the victim's symptoms compare to the symptoms described in the MSDS or other pertinent scientific literature.

(2) Notification of Results of Monitoring

Within 15 working days of receipt of the results of any monitoring, notify affected employees of those results.

2. Medical Consultation and Examination

If employees feel that they have been exposed to hazardous chemicals, employees are required to contact their respective departmental Chemical Hygiene Officer who will assist them in arranging for an Exposure Assessment if necessary. The Exposure Assessment will be utilized by the consulting physician to determine if further medical consultations and examinations are warranted.

The details of medical consultations and examinations are determined by the physician.

The purpose of a medical consultation is to determine whether a medical examination is warranted. When, from the results of an Exposure Assessment, it is suspected or known that an employee was overexposed to a hazardous chemical or chemicals, the employee should obtain medical consultation from or under the direct supervision of a licensed physician.

When warranted, employees also should receive a medical examination from or under the direct supervision of a licensed physician who is experienced in treating victims of chemical overexposure. The medical professional should also be knowledgeable about which tests or procedures are appropriate to determine if there has been an overexposure; these diagnostic techniques are called "differential diagnoses."

These provisions apply to medical consultations and examinations:

- a. All employees who work with hazardous chemicals must be provided an opportunity to receive medical consultation and examination when:
 - (1) The employee develops signs or symptoms associated with a hazardous chemical to which the employee may have been exposed in the laboratory.
 - (2) Monitoring, routine or otherwise, suggests that there could have been an exposure above the action level, or OSHA PEL if there is no action level, for a chemical for which an OSHA substance-specific standard has been established.
 - (3) There is a spill, leak, or other uncontrolled release of a hazardous chemical.
- b. Provide the physician with:
 - (1) The identity of the hazardous chemical or chemicals to which the employee may have been exposed (Formal Exposure Assessment if available).
 - (2) The exposure conditions.
 - (3) The signs and symptoms of exposure the victim is experiencing, if any.
- c. Ordinarily, physicians will furnish to the Oregon State University Personnel Services in written form:
 - (1) Recommendations for follow-up, if determined to be pertinent.
 - (2) A record of the results of the consultation and, if applicable, of the examination and any tests that were conducted.
 - (3) Conclusions concerning any other medical condition noted that could put the employee at increased risk.

- (4) A statement that the employee has been informed both of the results of the consultation or examination and of any medical condition that may require further examination or treatment.
- d. These written statements and records should not reveal specific findings that are not related to an occupational exposure.
- e. Documentation

All memos, notes, and reports related to a complaint of actual or possible exposure to hazardous chemicals are to be maintained as part of the record.
- f. Notification

Employees shall be notified of the results of any medical consultation or examination with regard to any medical condition that exists or might exist as a result of overexposure to a hazardous chemical.

G. Records and Recordkeeping

1. Employee Exposure and Medical Records

OSHA regulation 29 CFR 1910.20, Access to Employee Exposure and Medical Records, addresses the storage and access to employee exposure and medical records pertaining to toxic substances or harmful physical agents. The following is a summary of this regulation:

- a. The medical record for each employee is to be preserved and maintained for at least the duration of employment plus thirty years.
- b. Each employee exposure record shall be preserved and maintained for at least thirty years.
- c. Each analysis using employee exposure or medical records shall be preserved and maintained for at least thirty years.
- d. MSDSs and other descriptions of substances do not have to be retained as long as some record of the identity (chemical name if known) of the substance or agent, where it was used, and when it was used is retained for 30 years.
- e. If an employee or their designated representative, requests a copy of the employee's health record, the University is to provide a copy within 15 days of the request, or provide facilities to make copies at no cost, or loan the records to employee or designated representative so that copies can be made.

Section 3.2 - OSU HAZARDOUS CHEMICAL WASTE DISPOSAL POLICY

Oregon State University will conform to applicable regulations of the State of Oregon, United States Environmental Protection Agency, United States Department of Transportation, and United States Department of Labor with regard to the safe use, handling, transportation and disposal of chemical substances and waste.

The Department of Environmental Health & Safety is the campus unit and authority having jurisdiction for program oversight. For specific instructions, contact the Department of Environmental Health & Safety at (541)-737-2274.

SECTION 3.3 - CHEMICAL SAFETY

Working with potentially hazardous chemicals is an everyday occurrence in a laboratory setting. Hazardous situations can occur if employees are not educated in general chemical safety, toxicological information, and procedures for handling and storage for the chemicals they are using. This section of the laboratory manual addresses these educational components and spells out specific protocols to minimize hazardous chemical exposures.

A. Modes of Entry

There are four major modes of entry to chemicals: inhalation, skin absorption, injection, and ingestion. Inhalation and skin absorption are the predominant occupational exposures you may expect to encounter in the laboratory and will be discussed in some detail. Accidental injection of chemicals can be eliminated by good laboratory safety practices. Accidental ingestion of chemicals can be eliminated by a combination of good laboratory and hygienic practices such as washing hands and prohibiting foods, drinks, cosmetics, and tobacco products in the laboratory workplace (see Section 2.1 - "General Safety and Operational Rules"). All potential exposures, i.e., inhalation, skin absorption, injection, and ingestion, are discussed in the Material Safety Data Sheets available for each chemical or product. The hundreds of chemicals which employees are routinely exposed to during the course of their work in the laboratory can be divided into three main types: volatile solvents, corrosives, and toxic solids. The particular hazards associated with exposure to these materials, and ways to avoid them, are discussed in detail below.

B. Basic Chemical Classifications

1. Volatile Solvents

Organic solvents are perhaps the most ubiquitous chemicals found in the laboratory setting. The potential chronic health effects of some of these materials warrant special attention as one is likely to be exposed to more solvents than any other type of chemical. For safety purposes, these chemicals are generally subdivided into two categories: chlorinated and non-chlorinated. This is done mainly because the chlorinated solvents are, in general, not flammable while non-chlorinated solvents are often flammable. It should be kept in mind, however, that the chlorinated solvents do decompose when burned. This results in high concentrations of toxic vapors, such as phosgene and hydrogen chloride.

Keeping in mind the difference in flammability between these two classes of solvents, we can discuss the health effects common to both classes. The primary route of exposure to these materials is through inhalation. In general, high concentrations of the vapor, when inhaled, produce drowsiness, dizziness and headaches. This can occur quite quickly, since chemical vapors are rapidly absorbed. Most of the solvents will also act as upper respiratory and/or eye irritants. One physical property common to most solvents is odor. Unfortunately, the odor of a solvent offers little in the way of determining whether or not the environment is immediately hazardous. Solvent odor thresholds vary widely and acclimation or odor fatigue is often rapid. Odor is also not generally indicative of the degree of hazard that the material presents. Butyl mercaptan has such an extremely disagreeable odor that one cannot tolerate a concentration necessary to be injurious. Chloroform, however, has a sweet odor to many people and tolerance levels can far exceed safe levels.

Chronic effects of solvent exposure vary widely. Of most concern is the potential for lung, liver, and kidney damage posed by some solvents. This, in general, applies to solvents which are not water soluble. Examples of these solvents would be benzene, toluene, xylene, chloroform, carbon tetrachloride, and trichloroethylene. Instances of chronic disease caused by occupational exposure to these solvents have been documented. However, it must be kept in mind that everyone reacts differently and individual susceptibilities are quite variable.

Skin absorption is an additional mode of entry for which an exposure to a solvent may occur. Most commonly, solvents act to de-fat the skin. This will cause drying and cracking of the skin, and may lead to chronic dermatitis with prolonged and repeated

exposure. Some solvents can also act as corrosives. Most amines and phenols act in this manner.

In addition, many of the solvents (dimethyl sulfoxide and dimethyl formamide, for example) will penetrate the skin and be absorbed into the body. In this case, the effects of exposure will be analogous to inhalation exposure. Carbon disulfide, n-butyl alcohol, and phenol are common solvents which can penetrate intact skin. For those solvents, there will be a notation of skin exposure noted on the Material Safety Data Sheet. Most skin contact with solvents can be avoided by wearing gloves suitable for that chemical. It is important that the glove be resistant to the material being handled. Using the wrong glove can give a false sense of security and overexposure via the skin may result. If a solvent penetrates the glove, a prolonged contact will result due to slowed evaporation rates. Rubber and neoprene gloves can be classed as good general purpose gloves, but a chemical resistance chart and the MSDS should always be consulted (See also Section 2.3 - "Personal Protective Equipment").

Direct liquid contact by solvents in the eyes can be very serious. The victim could easily panic. Get them to the eye wash immediately and flush the eyes for at least 15 to 30 minutes. Medical assistance should also be summoned.

In summary, volatile solvents can pose inhalation, skin, and ingestion hazards. Some of the solvents may also be flammable, which could cause fire and/or explosion hazards. Whenever possible, use volatile solvents in a properly operating fume hood to eliminate inhalation hazards, use correct skin and eye protection and use good laboratory and hygienic technique to eliminate any possible ingestion of volatile solvents.

2. Acid and Bases

Common to all acids and bases is their corrosive action on human tissues. Minor exposures are generally reversible, although often painful for a short period of time. The reversibility of the effects of acid or base exposure will depend on three factors: the duration of exposure, concentration of the material, and the first aid methods used.

Exposure can occur through skin absorption or inhalation. With inhalation exposure, remove the victim from the area (try to keep the victim from breathing too deeply, as this may exacerbate the effects) and summon medical help.

Skin contact is the most common route of exposure. Here the concentration and type of acid are the most important factors. In concentrated forms, all types of corrosives may cause severe penetrating burns. Dilute solutions do not have the same warning properties as concentrated forms, so guard against exposure. One should be particularly careful with hydrofluoric acid (see Section 2.2-3).

Neoprene gloves provide the best protection from skin exposure to both acids and bases, but in all cases, follow the recommendations in the MSDS. When using or dispensing concentrated acids or bases, a lab coat or apron and a full face shield is required (see Section 2.3 - "Personal Protective Equipment") if you are not working in a hood.

If there is skin or eye contact with acids or bases, make sure to flush the area with water for 15 to 30 minutes and summon medical assistance.

3. Toxic Solids

Many of the chemicals used in the laboratory that are solid and toxic are used in solution, so skin absorption can be of a concern. This is particularly true when a substance is dissolved in a solvent which can penetrate the skin. Also, an oxidizing material dissolved in water can act directly on the skin causing irritation where the solid alone would be relatively less irritating. It is therefore important that proper personal protective equipment be worn (See Section 2.3 - "Personal Protective Equipment").

In the solid form, the greatest risk of exposure is through inhalation. This risk can be lessened by wearing the appropriate respirator and/or working in a fume hood.

C. Incompatible Chemicals

Certain hazardous chemicals cannot be mixed or stored safely with other chemicals due to potentially severe or extremely toxic reactions taking place. For example, keep oxidizing agents separated from reducing agents, initiators separated from monomers, and acids separated from alkalis, etc.

The chemical label and Material Safety Data Sheet will contain information on incompatibilities.

A list of incompatible chemicals is included in Appendix B.

D. Chemical Stability

Stability refers to the susceptibility of the chemical to decomposition. Ethers, liquid paraffins, and olefins can form peroxides on exposure to air and light. Since these chemicals are packaged in an air atmosphere, peroxides can form even though the containers have remained sealed. Some inorganic chemicals also are unstable.

Unless inhibitor was added by the manufacturer, closed containers of ethers shall be discarded after one year. See Section 3.4 - "Chemical Waste" for disposal procedures. Appropriate use of peroxide inhibitors is suggested.

Examples of potential peroxide forming materials are included in Appendix A.

E. Shock-Sensitive Chemicals

Shock-sensitive refers to the sensitivity of the chemical to decompose rapidly or explode when struck, vibrated, or otherwise agitated.

The label and Material Safety Data Sheet will indicate if a chemical is shock-sensitive.

Shock-sensitive chemicals should be procured as needed to minimize storage problems. Shock-sensitive materials should be considered individually and disposed of as soon as practical.

Many chemicals become increasingly shock-sensitive with age. The date received and date opened shall be clearly marked on all containers of shock-sensitive chemicals.

Inhibitors are not to be added to shock-sensitive materials unless specific instructions from the manufacturer are provided. See Section 3.4 - "Chemical Waste" for disposal procedures.

A partial list of potential shock-sensitive materials is included in Appendix C.

F. Material Safety Data Sheets

The Material Safety Data Sheet (MSDS) is a format for describing what chemical or product you are working with, potential chemical hazards, and ways of minimizing these hazards. These sheets shall be on hand in the laboratory for people who use these chemicals. Information that is contained in the Material Safety Data Sheets is also required by law to be conveyed to employees on a chemical-by-chemical basis.

MSDSs are generally written for chemicals that are used in the industrial setting and it will become apparent that some of the information provided on the MSDS may not be applicable to laboratory usage. The use of chemicals in a laboratory is generally in a more controlled environment than in the industrial setting and much smaller quantities of the chemical are being used at any one time. Nevertheless, a great deal of information on hazards associated with laboratory chemicals can be obtained by reading the MSDS. (See also Section 7.3 - "Material Safety Data Sheets")

G. Procurement of Chemicals

The achievement of safe handling, use, and disposal of hazardous substances begins with the persons who requisition such substances and those who approve their purchase orders. These persons must be aware of the potential hazards of the substances being ordered, know whether or not adequate facilities and trained personnel are available to handle such substances, and should ensure that a safe disposal route exists.

Before a new substance is received, information concerning its proper handling methods, including proper disposal procedures, should be given to all those who will be working with it. It is the responsibility of the laboratory supervisor to ensure that the facilities are adequate and that those who will handle any material have received proper training and education to do so safely.

For most substances, Material Safety Data Sheets, which give physical property data and toxicological information, can be obtained by request to the vendor. However, the quality and depth of information on these sheets varies widely.

The US Department of Transportation (DOT) requires that shippers furnish and attach DOT prescribed labels on all shipment of hazardous substances. These labels indicate the nature of the hazard(s) of the substance(s) shipped and thus provide some indication to receiving personnel of the type of hazard received.

No container or cylinder should be accepted that does not have an identifying label. For chemicals, it is desirable that this label correspond to ANSI Z129.1, which requires, at a minimum, the following components:

1. Identification of contents of container;
2. Signal word and summary description of any hazard(s);
3. Precautionary information - what to do to minimize hazard or prevent an accident from happening;
4. First aid in case of exposure;
5. Spill and cleanup procedures; and
6. If appropriate, special instructions to physicians.

Every effort should be made to ensure that this label remains on the container and legible.

H. Spill Prevention

A hazardous chemical spill means that an uncontrolled release of a hazardous chemical has occurred. The release may involve a gas, liquid, or solid, and usually requires some action be taken to control the point of release or the spread of the chemical. A chemical is hazardous if it possesses a physical or health threat to humans, the environment, or property. More specifically, a substance is considered hazardous when:

- a. It is flammable, explosive, or reactive;
- b. It generates harmful vapor or dust;
- c. It is a carcinogen;
- d. It is a corrosive and attacks skin, clothing, equipment, or facilities;
- e. It is poisonous by ingestion, inhalation or absorption.

Spills involving hazardous materials will require different tactics depending on the magnitude of the spill, the material's toxicity, reactivity, and flammability, routes of entry of the material into the body, and the promptness with which the spill can be safely managed.

For information on handling of chemical spills see Section 1.1 - "Chemical Spills."

Many spills can be prevented or controlled by careful planning, use of trays, and absorbent paper. (Remember, hoods don't prevent or control spills; they just relocate them!)

Proper techniques for transporting hazardous chemicals and proper storage techniques may help prevent spills.

I. Handling and Transportation of Chemicals

Many laboratory accidents occur through the simple operation of carrying chemicals from one place to another or transferring them from one container to another. The chemicals used in a laboratory are often corrosive, toxic, or flammable and any accident involving these has the potential for personal injury. Therefore, it is good practice to assume that **all** chemicals are potentially hazardous.

1. When large bottles of acids, solvents, or other liquids are transported within the laboratory without a cart, only one bottle should be carried at a time. The bottle should be carried with both hands, one on the neck of the bottle and the other underneath. Avoid the temptation to hook a finger through the glass ring on top of the bottle, allowing it to dangle while being transported. Never carry or attempt to pick up a bottle by the cap.
2. When transporting bottles within the laboratory, a wheeled cart may be used. Carts should be stable under load and have wheels large enough to negotiate uneven surfaces (such as expansion joints and floor drain depressions) without tipping or stopping suddenly. Do not place the bottles near the edge of the cart, nor should they be touching each other or other glassware during transport. Be cautious rolling the cart over door sills or other possible obstructions. Incompatible chemicals should not be transported on the same cart. A list of incompatible chemicals is included in Appendix B.
3. Freight-only elevators should be used, if possible, when transporting chemicals, to avoid exposure to persons on passenger elevators.
4. Special padded or rubber bottle carriers, pails, or carts should be used to prevent breakage by accidental striking against walls or floor, and to contain the material if breakage does occur.
5. Large quantities of concentrated mineral acids, e.g., sulfuric, nitric and hydrochloric acids, shall be kept in storage rooms, in cabinets for corrosive substances, or chemical transfer rooms. Bottles of concentrated acids must be carried from the aforementioned areas in an approved acid bottle carrier.
6. Organic solvents shall also be stored in specialized flammable storage areas. These solvents shall be carried from storage areas in special rubber carriers. Organic solvents can present fire hazards as well as inhalation hazards.
7. For information on transportation and storage of compressed gases see Section 2.4 - "Compressed Gas Safety."

J. Chemical Storage

The principle concerns in achieving proper storage are to maximize employee safety with regard to chemical compatibility, spill control, fire/explosion control, to provide security, identification, and provide a "user friendly" system with respect to point-of-use.

1. Every chemical in the laboratory should have a definite storage place and should be returned to that location after each use.
2. Storage must conform to compatibility restrictions as described in Appendix B. Typically, solvents, acids, bases, reactives, oxidizers, and toxins will be stored separately. Separation basically refers to physical separation of containers and isolation of potential

spills and releases with the goal of preventing chemical reactions. Ideally, separate cabinets or isolated areas within a central storage area should be utilized for segregated storage of incompatibles.

3. Adequate containment for spills and accidental releases shall be provided.
4. Hazardous chemicals should never be stored on the floor. Containers should be kept on low shelves or in cabinets. The shelves should have a lip on the forward edge to prevent bottles from slipping off. Chemicals tend to "creep" toward and over the edge of a shelf. Shelving units should be securely fastened to the wall or floors. Shelves should not be overloaded.
5. Utilize a compatible/suitable container for experiments, stored chemicals and collected wastes. In instances of corrosive wastes or halogenated solvents, the use of metal containers is often unsuitable, even if the solvents were originally shipped in metal containers. In these instances, plastic carboys (high density polyethylene) or lined metal containers may be more suitable. See the Material Safety Data Sheet for specific information.
6. There shall be constant vigilance for any sign of chemical leakage. Containers storing chemical waste must be inspected weekly for any sign of chemical leakage. Containers of all types should be free of rust and deformation.
7. Caps and covers for containers shall be securely in place whenever the container is not in immediate use.
8. Storage shall be physically secure.
9. NFPA labeling shall appear on cabinets and room doors at approximately waist level or lower to allow adequate visualization in dense smoke conditions.
10. All containers used for storage (even short term) shall be labeled in accordance with Hazard Communication regulations and NFPA and University fire codes. At a minimum, all containers must be labeled with regard to content and general hazard.
11. Flammable liquids in quantities greater than one liter should be kept in metal safety cans designed for such storage. The cans should be used only as recommended by the manufacturer, including the following safety practices:
 - a. Never disable the spring-loaded closure.
 - b. Always keep flame-arrestor screen in place; replace if punctured or damaged.
12. Flammable liquids shall not be stored in your laboratory unit in amounts greater than the limits for flammable liquid storage given in Section 8.1 - "Standard Operating Procedures."
13. Metal drums used for storage and dispensing of flammable chemicals shall be properly grounded. Ground cables shall be available and utilized in any lab using metal storage containers for flammable liquid storage.
14. Chemicals should be stored as close as feasible to the point of use in order to maximize efficiency and minimize transport distance. Chemical storage should be limited only to areas in which the particular chemical is used. Storage locations must be identified on an emergency floor plan posted in each work area and should be equipped with a fire extinguisher, spill kit, eye wash, first aid kit, and telephone or other communication system to allow for adequate emergency notification.
15. Small quantities of chemicals can be held at individual work stations if this quantity is to be promptly used in a test and does not compromise acceptable ambient organic vapor

levels or procedures for spill control and fire safety. These containers must be properly labeled.

16. Only limited quantities of chemicals and solvents should be stored in the laboratory. Large drums or multiple bottles of chemicals should be stored in a centralized chemical storage area.
17. Out-of-date chemicals shall be disposed of on a periodic basis to reduce overall hazard potential and minimize inventory tracking and updating. (See Section 3.4 - "Chemical Waste")

K. Prior Approval

Employees must obtain prior approval to proceed with a laboratory task from their laboratory supervisor and/or their Departmental Chemical Hygiene Officer whenever:

1. A new laboratory procedure or test is to be carried out.
2. It is likely that toxic limit concentrations could be exceeded.
3. There is a change in a procedure or test, even if it is very similar to prior practices. "Change in procedure or test" means:
 - a. A 10% or greater increase or decrease in the amount of one or more chemicals used.
 - b. A substitution or deletion of any of the chemicals in a procedure.
 - c. Any change in other conditions under which the procedure is to be conducted.

(Communication is critical; ensure employees are well informed.)

4. There is a failure of any of the equipment used in the process, especially of safeguards such as fume hoods or clamped apparatus.
5. There are unexpected results.
6. Members of the laboratory staff become ill, suspect that they or others have been exposed, or otherwise suspect a failure of any safeguards.

SECTION 3.4 - CHEMICAL WASTE

The OSU Environmental Health Services Hazardous Materials Section is responsible for coordinating the pickup of surplus and waste chemical substances from generating departments. To assure compliance with regulations, safe handling, and efficiency of operations, OSU has established the following standards applicable to the collection, storing, labeling, and packaging of these substances by departments. Under no circumstances will personnel pickup chemical substances that do not strictly follow the procedures and requirements listed in this section.

has been given the responsibility for determining the status of substances as surplus or hazardous wastes.

- Department personnel shall not accept any chemical, hazardous substance, or item(s) containing hazardous substances as gifts or donations on the behalf of the University without notifying prior to the transfer. This is to assure that no unanticipated future hazardous waste costs result from such a transfer.
- Department personnel shall not give or sell university property, including hazardous substances, to any person or organization outside the university except through the legally established procedures of the Purchasing Department.
- Under no circumstances is any person to dispose of a hazardous substance down the drain or in the refuse disposal system where the applicable regulations, procedures, and policies regarding its disposal as described in this document or the MSDS for the product prohibit this action or are unknown. Prior to disposal of hazardous substances (via sanitary sewer or as solid waste), the OSU Lab Safety Manual, applicable local and federal regulations, or the MSDS for the product shall be consulted. If any of the aforementioned documents prohibit drain or trash disposal, the material or product must be handled as hazardous waste.
- OSU will not pickup, or handle, surplus or hazardous substances that have not been properly identified, containerized, labeled, packaged, or manifested according to the procedures described herein.
- OSU cannot accept any unidentified substance(s) for disposal. However, OSU Environmental Health & Safety has made arrangements with our current waste contractor to conduct a hazard characterization for chemicals of unknown composition. The generating department shall make every effort to identify unknown chemicals prior to the characterization. In instances where unknown chemicals have been generated, the generating department shall provide a separate storage area to hold these materials until characterization can be conducted. Also, the generating department may be required to provide lab space and a fume hood for the characterization procedure.

A. Basic Procedures

1. Collect substances in original or other suitable primary container.
2. Properly label containers as to contents and hazards.
3. Properly store containers until ready for disposal.
4. When accumulation exceeds the available storage limits within the laboratory area, arrange for the transfer of the substances with your Departmental Chemical Hygiene Officer (DCHO) who shall coordinate the pickup with OSU.
5. The generator or DCHO shall prepare individual containers with a unique container number and complete the Chemical Surplus Removal Request Form.
6. Individual containers, except in prearranged situations, shall NOT be boxed together.

7. OSU will pick up surplus substances from the laboratory or collection area upon request only. In certain instances, OSU may request that a department store unwanted chemicals until a chemical pickup by a hazardous waste management firm is arranged.
8. OSU will then determine the status of substances as surplus, for reuse, for recycling, or for waste disposal.

B. Containers

A container refers to any of the following that serves as a primary container; or as an outer or secondary packaging over one or more primary containers.

- Any steel, plastic, or fiberboard drum
- Metal cans and pails
- Plastic carboys
- Steel cylinders and tanks
- Plastic-coated paper bags
- Plastic baggies
- Glass and plastic bottles, jars, vials
- Sturdy cardboard boxes
- Mercury containers

C. Container Condition

1. Where possible, materials should be kept in their original containers.
2. Containers shall be in good condition; leaking or damaged containers are not acceptable. If leaking or damaged, either repackage or call to determine the proper packaging for disposal.
3. Containers shall be equipped with a properly fitting cap or other closure means. **Properly secured** means with the original device or method provided by the manufacturer, or when unavoidable, with a substitute means of equal or better quality that will prevent leakage or incidental exposure during routine handling or in the event of the container tipping or falling over. Makeshift covers such as tape to hold down a screw cap or a rag stuffed in an opening are unacceptable.
4. Containers shall be compatible with substances contained therein.
5. Plastic bags, where acceptable as containers (double bagging is preferred), shall be without punctures or tears and shall be tightly sealed. Ordinary garbage (2 mil or less) bags shall not be used as a primary or secondary container for hazardous chemical waste.
6. Containers should be inspected weekly for signs of leaks or deterioration.
7. Compressed gas cylinders shall not be handled or transported until the regulating device is removed and the safety cap installed. Every effort should be made to return compressed gas cylinders to the manufacturer or original supplier.

D. Container Volumes and Sizes

1. Glass containers shall not exceed one gallon (4 liters) in size and shall not be filled into the neck of the fill/pour spout.
2. Where containers have flat tops, the liquid level shall be at least 1 inch from the fill/pour opening. Glass carboys are unacceptable.
3. Due to increased disposal costs, risks of handling larger containers, and restrictions by the University Waste Disposal Contractor, metal or plastic containers greater than 5 gallons (20 liters) in size require special approval by OSU.

4. Plastic baggies utilized as primary containers shall be packaged in a secondary container such as glass, hard plastic, metal, or cardboard box. Ordinary garbage bags (2 mil or less) shall not be used as a primary or secondary container for hazardous chemical waste.

E. Labeling of Containers

Please see Appendix J for an example Hazardous Chemical Surplus Tag.

1. Each container shall bear the Hazardous Chemical Surplus Tag which clearly and neatly indicates the chemical or common name of each substance which is at least 1% by volume of the total contents or mixture. Carcinogens or highly toxic substances which are 0.1% or more by volume must also be listed. Any amount of a heavy metal (e.g. As, Ba, Cd, Cr, Hg, Ni, Se, Ag, Th) greater than 1 part per million (1 ppm) in the container must be listed.
2. Indicate the strength or concentration of the substance where applicable. Example: Hydrochloric Acid may have a strength of 10%, 28%, 38%.
3. Do not use chemical formulas, chemical symbols, chemical equations or abbreviations.
4. Indicate the physical and/or health hazards of the substance, if known.
5. Indicate the name of the building, room, and principal investigator or person responsible for generating the waste (or someone with direct knowledge of the process).
6. In the instances of time sensitive substances such as ethers, the date of container opening or initial accumulation shall be included on the form.
7. Remove or obliterate any other labels or wordings not related to the current substance.
8. Do not allow the creation of "UNKNOWN" through lack of secure readable labeling.

F. Disposal of Empty Containers

Containers which are empty and no longer needed must be disposed of properly. Container disposal shall be as directed by 40 CFR 261.7 "Residues of hazardous waste in empty containers." Containers which have held acute hazardous materials as defined in 40 CFR 261.31, 261.32, or 261.33 require special handling. To assist you in determining if an empty container is regulated, here are some further guidelines.

A container shall be considered "empty" if all the following conditions exist (for this section, a container shall be considered to be a primary container or an inner liner):

1. The container contained none of the chemicals that are listed in 40 CFR 261.33(e) [attached] or Tri- Tetra- or Penta-phenol, *and*
2. All chemicals have been removed that can be removed using practices commonly employed to remove materials from that type of container eg pouring, pumping, aspirating, etc., *and*
3. There is less than one inch of residue left in the bottom of the container, *and*
4. There is less than 3% by weight of residue left in the container (0.3% for >110 gal. containers), *and*
5. For compressed gas cylinders only, when the pressure in the container approaches atmospheric.

If a container does contain chemicals listed below, or Tri- Tetra- or Penta-phenol, the container shall be considered empty only if the container has been triple rinsed using a solvent capable of removing the chemical or cleaned by another method that has been shown in the scientific literature to achieve equivalent removal. The rinsate then becomes a hazardous waste. If the container has not been cleaned as stated above, the container shall become hazardous waste.

Once a container has been declared "empty" by the above criteria, it can be placed in the normal refuse.

[Above adapted from 40 CFR 261.7]

P001	Warfarin & Salts > 0.3% 2H-1-Benzopyran-2-one, 4-Hydroxy-3-(3-oxo-1-phenylbutyl)-, & Salts, > 0.3% 4-Hydroxy-3-(3-oxo-1-phenylbutyl)-2H-1-benzopyran-2-one, & Salts, > 0.3% 3-(α -Acetylbenzyl)-4-hydroxycoumarin & Salts > 0.3% 81-81-2 *	P007	Muscimol 5-(Aminomethyl)-3-isoxazolol 3(2H)-Isoxazolone, 5-(Aminomethyl)- 5-(Aminomethyl)-3(2H)-isoxazolone 2763-96-4
P002	1-Acetyl-2-thiourea Acetamide, N-(Aminothioxomethyl)- N-(Aminothioxomethyl)acetamide 591-08-2	P008	4-Aminopyridine 504-24-5
P003	Acrolein 2-Propenal Acrylaldehyde Allyl Aldehyde 107-02-8	P009	Ammonium Picrate Phenol, 2,4,6-Trinitro-, Ammonium Salt 2,4,6-Trinitrophenol Ammonium Salt Picric Acid Ammonium Salt 131-74-8
* CAS Number For Parent Compound Only		P010	Arsenic Acid H_3AsO_4 7778-39-4
P004	Aldrin 1,4,5,8-Dimethanonaphthalene, 1,2,3,4,10,10-Hexachloro-1,4,4a,5,8,8a-hexahydro-, (1 α ,4 α ,4a β ,5 α ,8 α ,8a β)- 1,2,3,4,10,10-Hexachloro-1,4,4a,5,8,8a-hexahydro-1,4:5,8-dimethanonaphthalene (1R,4S,5S,8R)-1,2,3,4,10,10-Hexachloro-1,4,4a,5,8,8a-hexahydro-1,4:5,8-dimethanonaphthalene 2-Methyl-2-(methylthio)propionaldehyde O-(methylcarbamoyl)-oxime 1,2,3,4-Hexachloro-1,4,4a,5,8,8a-hexahydro-1,4,5,8-endo,exo-dimethanonaphthalene 309-00-2	P011	Arsenic Pentoxide Arsenic Oxide As_2O_5 1303-28-2
P005	Allyl Alcohol 2-Propen-1-ol Propenyl Alcohol 107-18-6	P012	Arsenic Trioxide Arsenic Oxide As_2O_3 1327-53-3
P006	Aluminum Phosphide AIP 20859-73-8	P013	Barium Cyanide $Ba(CN)_2$ 542-62-1
		P014	Thiophenol Benzenethiol 108-98-5
		P015	Beryllium 7440-41-7
		P016	Dichloromethyl Ether Methane, Oxybis[chloro- Oxybis[chloromethane] Bis(chloromethyl) Ether 542-88-1
		P017	Bromoacetone 2-Propanone, 1-Bromo- 1-Bromo-2-propanone 598-31-2
		P018	Brucine Dimethoxystrychnine 2,3-Dimethoxystrychnidin-10-one 357-57-3

P020 Dinoseb
Phenol, 2-(1-Methylpropyl)-4,6-dinitro-
2-(1-Methylpropyl)-4,6-dinitro-phenol
2-sec-Butyl-4,6-dinitrophenol
2,4-Dinitro-6-sec-butylphenol
88-85-7

P021 Calcium Cyanide $\text{Ca}(\text{CN})_2$
592-01-8

P022 Carbon Disulfide
Carbon Bisulfide
75-15-0

P023 Chloroacetaldehyde
Acetaldehyde, Chloro-
2-Chloro-1-ethanal
107-20-0

P024 p-Chloroaniline
Benzenamine, 4-Chloro-
4-Chlorobenzenamine
106-47-8

P026 1-(o-Chlorophenyl)thiourea
Thiourea, (2-Chlorophenyl)-
(2-Chlorophenyl)thiourea
1-(2-Chlorophenyl)-2-thiourea
5344-82-1

P027 3-Chloropropionitrile
Propanenitrile, 3-Chloro-
542-76-7

P028 Benzyl Chloride
Benzene, (Chloromethyl)-
(Chloromethyl)benzene
100-44-7

P029 Copper Cyanide $\text{Cu}(\text{CN})$
Cuprous Cyanide
544-92-3

P030 Cyanides (Soluble Cyanide Salts),
Not Otherwise Specified
(No CAS #)

P031 Cyanogen
Ethanedinitrile
Oxalonitrile
460-19-5

P033 Cyanogen Chloride $(\text{CN})\text{Cl}$
506-77-4

P034 2-Cyclohexyl-4,6-dinitrophenol
Phenol, 2-Cyclohexyl-4,6-dinitro-
Dinitrocyclohexylphenol
131-89-5

P036 Arsonous Dichloride, Phenyl-
Dichlorophenylarsine
Phenyl Arsonous Dichloride
Phenyldichloroarsine
696-28-6

P037 Dieldrin, & Metabolites
2,7:3,6-Dimethanonaphth[2,3-b]-
oxirene, 3,4,5,6,9,9-hexachloro-
1a,2,2a,3,6,6a,7,7a-octahydro-,
(1 α ,2 β ,2 α ,3 β ,6 β ,6 α ,7 β ,
7 α)-, & Metabolites
(1 α ,2 β ,2 α ,3 β ,6 β ,6 α ,7 β ,7 α)-
3,4,5,6,9,9-Hexachloro-1a,2,
2a,3,6,6a,7,7a-octahydro-2,7:3,
6-dimethanonaphth[2,3-b]-
oxirene, & Metabolites
(1R,4S,5S,8R)-1,2,3,4,10,10-
Hexachloro-1,4,4a,5,8,8a-hexa-
hydro-1,4:5,8-dimethano
naphthalene & Metabolites
1,2,3,4,10,10-Hexachloro-6,7-
epoxy-1,4,4a,5,6,7,8,8a-octa-
hydro-1,4-endo,exo-1,2,3,4,10,
10-hexa-8-dimethano
naphthalene, & Metabolites
60-57-1 *

* CAS Number For Parent Compound Only

P038	Diethylarsine Arsine, Diethyl- 692-42-2	P045	Thiofanox 2-Butanone, 3,3-Dimethyl-1-(methylthio)-, O-[(Methylamino)carbonyl]oxime O-[(Methylamino)carbonyl]oxime-3,3-dimethyl-1-(methylthio)-2-butanone 3,3-Dimethyl-1-(methylthio)-2-butanone-O-(methylamino)carbonyl oxime 39196-18-4
P039	Disulfoton Di-Syston O,O-Diethyl S-[2-(ethylthio)ethyl]-phosphorodithioate Phosphorodithioic Acid O,O-Diethyl S-[2-(ethylthio)ethyl] Ester 298-04-4	P046	Phentermine α,α -Dimethylphenethylamine Benzeneethanamine, α,α -Dimethyl- α,α -Dimethylbenzeneethanamine 122-09-8
P040	Thionazin O,O-Diethyl O-pyrazinylphosphorothioate Phosphorothioic Acid O,O-Diethyl O-pyrazinyl Ester O,O-Diethyl O-pyrazinylphosphorothioic Acid Ester 297-97-2	P047	4,6-Dinitro-o-cresol, & Salts Phenol, 2-Methyl-4,6-dinitro-, & Salts 2-Methyl-4,6-dinitrophenol, & Salts 534-52-1 *
P041	Paraoxon Diethyl-p-nitrophenylphosphate Phosphoric Acid Diethyl-4-nitrophenyl Ester Diethyl-4-nitrophenyl Phosphoric Acid Ester 311-45-5	P048	2,4-Dinitrophenol Phenol, 2,4-Dinitro- 51-28-5
P042	Epinephrine Adrenalin 1,2-Benzenediol, 4-[1-Hydroxy-2-(methylamino)ethyl]- 4-[1-Hydroxy-2-(methylamino)ethyl]-1,2-benzenediol 3,4-Dihydroxy-_-[(methylamino)methyl]benzyl Alcohol 1-Methylaminoethanolcatechol 51-43-4	P049	Dithiobiuret Thiomidodicarbonic Diamide [(H ₂ N)C(S)] ₂ NH 541-53-7
P043	Diisopropylfluorophosphate DMP Phosphorofluoridic Acid Bis(1-methylethyl) Ester Bis(1-methylethyl) Phosphorofluoridic Acid Ester Isofluorophate Phosphorofluoridic Acid Diisopropyl Ester 55-91-4	P050	Endosulfan 6,9-Methano-2,4,3-benzodioxathiepin, 6,7,8,9,10,10-Hexachloro-1,5,5a,6,9,9a-hexahydro-, 3-oxide 6,7,8,9,10,10-Hexachloro-1,5,5a,6,9,9a-hexahydro-6,9-methano-2,4,3-benzodioxathiepin-3-oxide 1,4,5,6,7,7-Hexachloro-5-norbornene-2,3-dimethanol Cyclic Sulfite 115-29-7
P044	Dimethoate Phosphorodithioic Acid O,O-Dimethyl S-[2-(methylamino)-2-oxoethyl] Ester O,O-Dimethyl-S-(N-methylcaramoylmethyl)phosphorodithioate 60-51-5		

* CAS Number For Parent Compound Only

P051	Endrin, & Metabolites 2,7:3,6-Dimethanonaphth[2,3-b]- oxirene, 3,4,5,6,9,9-Hexachloro- 1a,2,2a,3,6,6a,7,7a-octahydro-, (1 α ,2 β ,2 α ,3 α ,6 α ,6 β ,7 β , 7 α)-, & Metabolites 3,4,5,6,9,9-Hexachloro-1a,2,2a,3, 6,6a,7,7a-octahydro-2,7:3,6-di- methanonaphth[2,3-b]oxirene & Metabolites 1,2,3,4,10,10-Hexachloro-6,7- epoxy-1,4,4a,5,6,7,8,8a-octa- hydro- <i>endo,endo</i> -1,4:5,8-dimeth- anonaphthalene, & Metabolites (1R,4S,5R,8S)-1,2,3,4, 10,10- Hexachloro-1,4,4a,5,6,7,8,8a- octahydro-6,7-dimethano naphthalene & Metabolites 72-20-8 *	P062	HETP Hexaethyl Tetraphosphate Tetraphosphoric Acid Hexaethyl Ester 757-58-4
		P063	Hydrogen Cyanide Hydrocyanic Acid 74-90-8
		P064	Methyl Isocyanate Methane, Isocyanato- Isocyanatomethane Isocyanic Acid Methyl Ester 624-83-9
		P065	Mercury Fulminate Fulminic Acid Mercury(2+) Salt Mercury Cyanate 628-86-4
		P066	Methomyl Ethanimidothioic Acid <i>N</i> -[[[(Methyl- amino)carbonyl]oxy]-, Methyl Ester <i>N</i> -[[[(Methylamino)carbonyl]oxy]- ethanimidothioic Acid Methyl Ester <i>N</i> -[(Methylcarbamoyl)oxy]thioacet- imidic Acid Methyl Ester <i>S</i> -Methyl- <i>N</i> -(methylcarbamoyloxy)- thioacetimidate 16752-77-5
* CAS Number For Parent Compound Only		P067	1,2-Propylenimine 2-Methylaziridine Aziridine, 2-Methyl 75-55-8
P054	Ethylenimine Aziridine 151-56-4	P068	Methylhydrazine Hydrazine, Methyl- 60-34-4
P056	Fluorine 7782-41-4	P069	Acetone Cyanohydrin 2-Methylactonitrile Propanenitrile, 2-Hydroxy-2- methyl- 2-Hydroxy-2-methylpropanenitrile 75-86-5
P057	Fluoroacetamide Acetamide, 2-Fluoro- 2-Fluoroacetamide 640-19-7	P070	Aldicarb Propanal, 2-Methyl-2-(methyl- thio)-, <i>O</i> -[[[(Methylamino)- carbonyl]oxime 2-Methyl-2-(methylthio)propanal <i>O</i> -[(methylamino)carbonyl]oxime 2-Methyl-2-(methylthio)propion- aldehyde <i>O</i> -(methylcarbamoyl)- oxime 116-06-3
P058	1080 Sodium Fluoroacetate Acetic Acid, Fluoro-, Sodium Salt Fluoroacetic Acid Sodium Salt 62-74-8	P071	Methyl Parathion Phosphorothioic Acid <i>O</i> , <i>O</i> -Di- methyl <i>O</i> -(4-nitrophenyl) Ester <i>O</i> , <i>O</i> -Dimethyl <i>O</i> -(<i>p</i> -nitrophenyl)- phosphorothioate 298-00-0
P059	Heptachlor 4,7-Methano-1H-indene, 1,4,5,6, 7,8,8-Heptachloro-3a,4,7,7a- tetrahydro- 1H-1,4,5,6,7,8,8-Heptachloro-3a, 4,7,7a-tetrahydro-4,7-methano- indene 76-44-8		
P060	Isodrin 1,4,5,8-Dimethanonaphthalene, 1, 2,3,4,10,10-Hexachloro-1,4,4a, 5,8,8a-hexa-hydro-, (1 α ,4 α ,4 $\alpha\beta$, 5 β ,8 β ,8 $\alpha\beta$)- (1 α ,4 α ,4 $\alpha\beta$,5 β ,8 β ,8 $\alpha\beta$)-1,2,3,4, 10,10-Hexachloro-1,4,4a,5,8,8a- hexahydro-1,4- <i>endo,endo</i> -5,8-di- methanonaphthalene 1,2,3,4,10,10-Hexachloro-1,4,4a, 5,8,8a-hexahydro-1,4- <i>endo</i> , <i>endo</i> -5,8-dimethanonaphthalene 465-73-6		

P072	ANTU _α-Naphthylthiourea Thiourea, 1-Naphthalenyl- 1-Naphthalenylthiourea 86-88-4	P089	Parathion Ethyl Parathion Phosphorothioic Acid O, O-Diethyl O-(4-nitrophenyl) Ester O, O-Diethyl O-(4-nitrophenyl)- phosphorothioic Acid Ester O, O-Diethyl O-(p-nitrophenyl)phos- phorothioate 56-38-2
P073	Nickel Carbonyl Nickel Tetracarbonyl Nickel Carbonyl Ni(CO) ₄ , (T-4)- 13463-39-3	P092	Phenylmercury Acetate Mercury, (Acetato-O)phenyl- (Acetato)phenylmercury Phenylmercuric Acetate 62-38-4
P074	Nickel Cyanide Ni(CN) ₂ 557-19-7	P093	Phenylthiourea Thiourea, Phenyl- 103-85-5
P075	Nicotine, & Salts Pyridine, 3-(1-Methyl-2-pyrroli- diny)-, (S)-, & Salts 3-(1-Methyl-2-pyrrolidinyl)pyridine, & Salts 54-11-5 *	P094	Phorate Phosphorodithioic Acid O, O-Di- ethyl S-[2-(ethylthio)methyl] Ester O, O-Diethyl S-[2-(ethylthio)- methyl]phosphorodithioate 298-02-2
P076	Nitric Oxide Nitrogen Oxide NO 10102-43-9	P095	Carbonic Dichloride Phosgene 75-44-5
P077	p-Nitroaniline Benzenamine, 4-Nitro- 100-01-6	P096	Hydrogen Phosphide H ₃ P Phosphine 7803-51-2
P078	Nitrogen Dioxide Nitrogen Oxide NO ₂ 10102-44-0	P097	Famphur Famophos O, O-Dimethyl-O-[p-dimethylsulfa- moyl]phenyl]phosphorothioate Phosphorothioic Acid O-[4-[(Di- methylamino)sulfonyl]phenyl] O, O-dimethyl Ester 52-85-7
P081	Nitroglycerine 1,2,3-Propanetriol Trinitrate 55-63-0	P098	Potassium Cyanide K(CN) 151-50-8
P082	N-Nitrosodimethylamine Methanamine, N-Methyl-N-nitroso- N-Methyl-N-nitrosomethanamine 62-75-9	P099	Potassium Silver Cyanide Argentate(1-), Bis(cyano-C)-, Potassium Potassium Bis(cyano-C)- argentate(1-) Potassium Dicyanoargentate (I) 506-61-6
P084	N-Nitrosomethylvinylamine Vinylamine, N-Methyl-N-nitroso- N-Methyl-N-nitrosovinylamine 4549-40-0	P101	Propanenitrile Ethyl Cyanide Propionitrile 107-12-0
P085	Octamethylpyrophosphoramidate Diphosphoramidate, Octamethyl- 152-16-9	P102	Propargyl Alcohol 2-Propyn-1-ol 107-19-7
P087	Osmium Tetroxide Osmium Oxide OsO ₄ , (T-4)- Osmic Acid 20816-12-0	P103	Selenourea 630-10-4
P088	Endothall 7-Oxabicyclo[2.2.1]heptane-2,3- dicarboxylic Acid 7-Oxalobicyclo-[2.2.1]-heptane- 2,3-dicarboxylic Acid 145-73-3	P104	Silver Cyanide Ag(CN) 506-64-9

* CAS Number For Parent Compound Only

P105	Sodium Azide NaN_3 26628-22-8	P114	Thallium (I) Selenite Selenious Acid Dithallium(1+) Salt 12039-52-0
P106	Sodium Cyanide $\text{Na}(\text{CN})$ 143-33-9	P115	Thallium (I) Sulfate Thallos Sulfate Sulfuric Acid Dithallium(1+) Salt 7446-18-6
P107	Strontium Sulfide SrS 1314-96-1	P116	Thiosemicarbazide Aminothiourea Hydrazinecarbothioamide 79-19-6
P108	Strychnine, & Salts Strychnidin-10-one, & Salts 57-24-9 *	P118	Trichloromethanethiol Methanethiol, Trichloro- 75-70-7
P109	Sulfotep Thiopyrophosphoric Acid Tetraethyl Ester Ethylthiopyrophosphate Tetraethyldithiopyrophosphate Thiodiphosphoric Acid Tetraethyl Ester Tetraethylthiodiphosphoric Acid 3689-24-5	P119	Ammonium Vanadate (V) Vanadic Acid Ammonium Salt Ammonium Metavanadate 7803-55-6
P110	Tetraethyl Lead Plumbane, Tetraethyl- Tetraethylplumbane 78-00-2	P120	Vanadium Pentoxide Vanadic Acid Anhydride Vanadium Oxide V_2O_5 1314-62-1
P111	TEPP Tetraethylpyrophosphate EthylPyrophosphate Diphosphoric Acid Tetraethyl Ester Pyrophosphoric Acid Tetraethyl Ester 107-49-3	P121	Zinc Cyanide $\text{Zn}(\text{CN})_2$ 557-21-1
P112	Tetranitromethane Methane, Tetranitro- 509-14-8	P122	Zinc Phosphide Zn_3P_2 > 10% 1314-84-7
P113	Thallic Oxide Thallium Oxide Tl_2O_3 Thallium Sequioxide 1314-32-5	P123	Toxaphene Chlorinated Camphene, Technical 8001-35-2

* CAS Number For Parent Compound Only

G. Storage of Waste Chemicals

Waste Chemicals shall be stored in the same manner and using the same procedures as other chemicals. It may be advantageous to further segregate chemical waste. A typical segregation of waste chemicals would be:

- Acids
- Caustics
- Chlorinated Solvents
- Non-chlorinated Solvents
- Mercury Wastes
- Oxidizing Agents
- PCB Wastes*
- Reactive Chemicals*
- Waste Oil
- Wastes with Heavy Metal Contamination

*Consult with Environmental Health & Safety regarding proper storage and disposal requirements.

These chemicals shall be accumulated in separate containers and need to be isolated from one another to some degree, at least to the extent that spills or leaks would remain isolated from other containers. This is particularly true of acids, bases, and solvents.

Mineral (inorganic) acids, straight-chain fatty acids, and bases should be neutralized by the laboratory generating these wastes. Neutralization procedures may be found in Appendix D - "Neutralization of Spent Acids and Bases."

H. "Bulking" or mixing of waste chemicals

Bulking or mixing of waste chemicals shall not be done without prior approval from OSU. Where permission has been granted by OSU, Standard Operating Procedures found in Section 8.1 of this manual are to be used as a guide.

I. Overpacking or "Boxing Up" of Multiple Chemical Containers

Laboratory personnel usually will not be involved in "boxing up" chemical containers inside overpack or boxes for transport, but where permission has been granted by OSU, Standard Operating Procedure will be found in Section 8.1 of this manual.

J. Hazard Identification

Each material shall be identified with a "Hazard Code" abbreviation to be used as a general description to provide information on handling hazards and responsive action in the event of an accident.

Each material shall be identified on the form by the hazard that most closely indicates the greatest hazard presented by the material. The following is a list of hazards and their definitions. The codes are listed on the form.:

Flammable: Any compressed gas, liquid, or any solid material (other than an explosive, heat sensitive or shock sensitive material) that is liable to cause fires through friction, absorption of moisture, spontaneous chemical changes, retained heat from processing, or which can be ignited readily, and when ignited burns so vigorously and persistently as to create a serious transportation hazard.

Examples: Acetone, methyl alcohol, dimethylamine, propane, sodium dithionite, nitrocellulose.

Corrosive: Any gas, liquid, or solid that causes destruction of human tissue or a liquid that has a severe corrosion rate on steel or aluminum. Aqueous solutions that have a pH equal to or less than 2 or equal to or greater than 12.5 are corrosive. Other liquids are defined as corrosive if they corrode SAE 1020 steel at a rate greater than 6.35 mm/year at 55°C.

Examples: Hydrochloric acid, sulfuric acid, acetic acid, sodium hydroxide.

Oxidizer: A substance such as chlorate, permanganate, inorganic peroxide, nitrocarbonate, or a nitrate that yields oxygen readily to stimulate the combustion of organic matter. (Organic peroxides are to be listed under "OTHER", and the hazard listed on the bottom of the form.)

Examples: Sodium nitrate, potassium permanganate, manganese dioxide.

Toxic: Substances such as carcinogens, irritants, or poisonous gases, liquids, and solids which are irritating to or affect the health of humans.

Examples: Phosgene, phenol, 1-naphthylamine, arsenic compounds, mercury.

Water Reactive: Substances that react violently when in contact with water. They can be either be flammable solids or corrosives. (Mark the label with both Water Reactive and flammable or corrosive).

Note: In many cases the water reactive material can be chemically treated, thereby removing the reaction characteristic. The material may still contain other hazardous constituents. Please contact for further information and guidance.

Examples: Lithium, potassium or sodium metal, antimony pentachloride, acetic anhydride, calcium carbide.

Carcinogens: Any substance that causes the development of cancerous growths in living tissue, either those that are known to induce cancer in man or animals or experimental carcinogens that have been found to cause cancer in animals under experimental conditions.

Examples: 1-Naphthylamine, benzidine, dimethyl sulfate.

Teratogens/Mutagens: Teratogens are agents that cause growth abnormalities in embryos, genetic modifications in cells, etc. Mutagens are substances that are able to induce mutations in DNA and in living cells.

Examples: Diethylstilbestrol (DES), diethyl sulfate.

Other: Special hazards such shock or heat sensitive, organic peroxides, pyrophorics (reacts with air), peroxide formers.

Examples: Picric acid, urea nitrate, 2,4-dinitrophenylhydrazine, benzoyl peroxide, phosphorus, isopropyl ether.

CHAPTER 4.0 - BIOLOGICAL HYGIENE PLAN

The Institutional Biosafety Committee Policies and Procedures manual has been developed by the Biological Safety Committee and the Biological Safety Officer and may be found at <http://oregonstate.edu/ehs/sites/default/files/pdf/ibcmanual-osu-9-26-2012.pdf>. The following sections provided in this manual are for advisory purposes only and do not necessarily reflect the full requirements of the Policies and Procedures Manual.

SECTION 4.1 - OSU LABORATORY BIOLOGICAL SAFETY POLICY

The Institutional Biosafety Committee Policies and Procedures manual “establishes policy for conducting biological research activities, defines responsibilities, and details procedures to be used by the Institutional Biosafety Committee in the review and oversight of biological research.”

Section 4.2 - BIOLOGICAL SAFETY

Microbiological and biohazard laboratories are special, often unique, work environments that may pose special infectious disease risks to persons in or near them. Personnel have contracted infections in the laboratory throughout the history of microbiological and biohazard research. A number of cases have been attributed to carelessness or poor technique in the handling of infectious materials.

The term "containment" is used in describing safe methods for managing infectious agents in the laboratory environment where they are being handled or maintained. Primary containment, the protection of personnel and the immediate laboratory environment from exposure to infectious agents, is provided by good microbiological technique and the use of appropriate safety equipment. The use of vaccines may provide an increased level of personal protection. Secondary containment, the protection of the environment external to the laboratory from exposure to infectious materials, is provided by a combination of facility design and operational practices. The purpose of containment is to reduce exposure of laboratory workers and other persons, and to prevent escape into the outside environment of potentially hazardous agents. The three elements of containment include laboratory practice and technique, safety equipment, and facility design.

A. Laboratory Practice and Technique

The most important element of containment is strict adherence to standard microbiological practices and techniques. Persons working with infectious agents or infected materials must be aware of potential hazards and must be trained and proficient in the practices and techniques required for safely handling such material. The director or person in charge of the laboratory is responsible for providing or arranging for appropriate training of personnel.

When standard laboratory practices are not sufficient to control the hazard associated with a particular agent or laboratory procedure, additional measures may be needed. The laboratory supervisor is responsible for selecting additional safety practices, which must be in keeping with the hazard associated with the agent or procedure.

Each laboratory should develop or adopt a bio-safety or operations SOP which identifies the hazards that will or may be encountered and which specifies practices and procedures designed to minimize or eliminate risks. Personnel shall be advised of special hazards and shall be required to read and follow the required practices and procedures. A scientist with training and knowledge in appropriate laboratory techniques, safety procedures, and hazards associated with handling infectious agents must direct laboratory activities.

Laboratory personnel, safety practices and techniques must be supplemented by appropriate facility design and engineering features, safety equipment and management practices.

1. Engineering controls shall be examined and maintained or replaced on a regular schedule to ensure their effectiveness.
2. Employees shall wash their hands immediately or as soon as possible after removal of gloves or other personal protective equipment and after hand contact with blood or other potentially infectious materials.
3. All personal protective equipment shall be removed immediately upon leaving the work area or as soon as possible if overtly contaminated and placed in an appropriately designated area or container for storage, washing, decontamination or disposal.
4. Used needles and other sharps shall not be sheared, bent, broken, recapped, or resheathed by hand. Used needles shall not be removed from disposable syringes.
5. Eating, drinking, smoking, applying cosmetics or lip balm, and handling contact lenses are prohibited in work areas where there is a potential for occupational exposure.
6. Food and drink shall not be stored in refrigerators, freezers, or cabinets where blood or other potentially infectious materials are stored or in other areas of possible contamination.

7. All procedures involving blood or other potentially infectious materials shall be performed in such a manner as to minimize splashing, spraying, and aerosolization of these substances, and shall comply with the Blood-Borne Pathogens Act.

B. Safety Equipment (Primary Barriers)

Safety equipment includes biological safety cabinets and a variety of enclosed containers. The biological safety cabinet is the principal device used to provide containment of infectious aerosols generated by many laboratory procedures. Open fronted Class I and Class II biological safety cabinets are partial containment cabinets which offer significant levels of protection to laboratory personnel and the environment when used with good microbiological techniques. The gas-tight Class III biological safety cabinet provides the highest attainable level of protection to personnel and the environment. Further references on proper and effective use of biological safety cabinets may be found in Section 5.3, "Effective Use of Biological Safety Cabinets."

An example of an enclosed container is the safety centrifuge cup, which is designed to prevent aerosols from being released during centrifugation.

Safety equipment also includes items for personal protection such as gloves, coats, gowns, shoe covers, boots, respirators, face shields, and safety glasses. These personal protective devices are often used in combination with biological safety cabinets and other devices which contain the agents, animals, or materials being examined. In some situations in which it is impractical to work in biological safety cabinets, personal protective devices may form the primary barrier between personnel and the infectious materials. Examples of such activities include production activities and processing.

C. Personal Protective Equipment

When there is a potential for occupational exposure, the employer shall provide and assure that the employee uses appropriate personal protective equipment such as, but not limited to, gloves, gowns, fluid-proof aprons, laboratory coats, head and foot coverings, face shields or masks, eye protection, mouthpieces, resuscitation bags, pocket masks, or other ventilation devices.

1. The employer shall assure that appropriate personal protective equipment in the appropriate sizes is readily accessible at the work site or issued to employees. Hypoallergenic gloves shall be readily accessible to those employees who are allergic to the gloves normally provided.
2. The employer shall provide for the cleaning, laundering or disposal of personal protective equipment.
3. The employer shall repair or replace required personal protective equipment as needed to maintain its effectiveness.
4. Gloves shall be worn when the employee has the potential for the hands to have the direct skin contact with blood, other potentially infectious materials, mucous membranes, non-intact skin, and when handling items or surfaces soiled with blood or other potentially infectious material.
 - a. Disposable (single-use) gloves such as surgical or examination gloves shall be replaced as soon as possible when visibly soiled, torn, punctured or when their ability to function as a barrier is compromised. They shall not be washed or disinfected for re-use.
 - b. Utility gloves may be disinfected for re-use if the integrity of the glove is not compromised, however, they must be discarded if they are cracked, peeling, discolored, torn, punctured, or exhibit other signs of deterioration.
5. Masks and eye protection or chin-length face shields shall be worn whenever splashes, spray, spatter, droplets, or aerosols of blood or other potentially infectious materials may be generated and there is a potential for eye, nose, or mouth contamination.

6. Appropriate protective clothing shall be worn when the employee has potential for occupational exposure. The type and characteristics will depend upon the task and degree of exposure anticipated.
 - a. Gowns, lab coats, aprons or similar clothing shall be worn if there is a potential for soiling of clothes with blood or other potentially infectious materials.
 - b. Fluid resistant clothing, surgical caps or hoods shall be worn if there is a potential for splashing or spraying of blood or other potentially infectious materials.
 - c. Fluid-proof shoe covers shall be worn if there is a potential for shoes to become contaminated and/or soaked with blood or other potentially infectious materials.

D. Housekeeping

The work site shall be maintained in a clean and sanitary condition. All equipment, environmental enclosures and working surfaces shall be properly cleaned and disinfected after contact with blood or other potentially infectious materials.

1. Work surfaces shall be decontaminated with an appropriate disinfectant after completion of procedures; when surfaces are overtly contaminated; immediately after the spill of blood or other potentially infectious materials; and at the end of the work shift.
2. Protective coverings such as plastic wrap, aluminum foil, or imperviously-backed absorbent paper may be used to cover equipment and environmental surfaces. These coverings shall be removed and replaced at the end of the work shift or when they become overtly contaminated.
3. Equipment which may become contaminated with blood or other potentially infectious materials shall be checked routinely and prior to servicing or shipping and shall be decontaminated as necessary.
4. All bins, pails, cans, and similar receptacles intended for re-use which have a potential for becoming contaminated with blood or other potentially infectious materials shall be inspected, cleaned, and disinfected on a regularly scheduled basis and cleaned and disinfected immediately or as soon as possible upon visible contamination.
5. Broken glassware which may be contaminated shall not be picked up directly with the hands. It shall be cleaned up using mechanical means such as a brush and dust pan, tongs, cotton swabs or forceps.
6. Specimens of blood or other potentially infectious materials shall be placed in a closable, leak-proof container labeled or color-coded bag prior to being stored or transported. If outside contamination of the primary container is likely, then a second leak-proof container that is labeled or color-coded shall be placed over the outside of the first container and closed to prevent leakage during handling, storage, or transport. If puncture of the primary container is likely, it shall be placed in a leak-proof puncture-resistant secondary container.
7. Reusable items contaminated with blood or other potentially infectious materials shall be decontaminated prior to washing and/or reprocessing.

E. Infectious Waste Disposal

All infectious waste destined for disposal shall be placed in closable, leak-proof containers or bags that are color-coded or labeled.

1. If outside contamination of the container or bag is likely to occur then a second leak-proof container or bag which is closable and labeled or color-coded shall be placed over the outside of the first and closed to prevent leakage during handling, storage, and transport.

2. Disposal of all infectious waste shall be in accordance with procedures found in Section 5.4, "Biohazard/Biomedical Waste."
3. Immediately after use, sharps, i.e., broken glass, needles, pipettes, etc., shall be placed in closable, labeled or color-coded leak-proof, puncture resistant, disposable containers.
4. These containers shall be easily accessible to personnel and located in the area of use.

F. Bio-safety Levels

Four bio-safety levels are described which consist of combinations of laboratory practices and techniques, safety equipment, and laboratory facilities appropriate for the operations performed and the hazard posed by the infectious agents and for the laboratory function or activity.

1. Bio-safety Level 1: Practices, safety equipment, and facilities are appropriate for facilities in which work is done with defined and characterized strains of viable microorganisms not known to cause disease in healthy adult humans. *Bacillus subtilis*, *Naegleria gruberi*, and infectious canine hepatitis virus are representative of those microorganisms meeting these criteria. Many agents not ordinarily associated with disease processes in humans are, however, opportunistic pathogens and may cause infection in the young, the aged, immunodeficient or immunosuppressed individuals. Vaccine strains which have undergone multiple in-vivo passages should not be considered avirulent simply because they are vaccine strains.
2. Bio-safety Level 2: Practices, equipment, and facilities are applicable to clinical facilities in which work is done with the broad spectrum of indigenous moderate-risk agents present in the community and associated with human disease of varying severity. With good microbiological techniques, these agents can be used safely in activities conducted on the open bench, provided the potential for producing aerosols is low. Hepatitis B virus, the *Salmonellae*, and *Toxoplasma* spp. are representative of microorganism assignment to this containment level. Primary hazards to personnel working with these agents may include accidental autoinoculation, ingestion, and skin or mucous membrane exposure to infectious materials. Procedures with high aerosol potential that may increase the risk of exposure to personnel, must be conducted in primary containment equipment or devices.
3. Bio-safety Level 3: Practices, safety equipment, and facilities are applicable to facilities in which work is done with indigenous or exotic agents where the potential for infection by aerosols is real and the disease may have serious or lethal consequences. Autoinoculation and ingestion also represent primary hazards to personnel working with these agents. Examples of such agents for which bio-safety Level 3 safeguards are generally recommended include *Mycobacterium tuberculosis*, St. Louis encephalitis virus and *Coxiella burnetti*.
4. Bio-safety Level 4: Practices, safety equipment, and facilities are applicable to work with dangerous and exotic agents which pose a high individual risk of life threatening disease. All manipulations of potentially infectious diagnostic materials, isolates, and naturally or experimentally infected animals pose a high risk of exposure and infection to laboratory personnel. Lassa Fever virus is representative of the microorganisms assigned to Level 4.

Work with known agents shall be conducted at the bio-safety level recommended by the Centers for Disease Control (CDC) or the National Institute of Health (NIH), unless specific information is available to suggest the virulence, pathogenicity, antibiotic resistance patterns, and the other factors are significantly altered to require more stringent or allow less stringent practices to be used.

At OSU, the area of biological safety is under the guidance of the Biological Safety Committee (BSC) and the Biological Safety Officer.

Research involving Biological Safety Levels II, III or IV shall contact the Biological Safety Committee for appropriate authorization, guidelines and inspections. For Biological Safety Level

I, researchers are strongly encouraged to work with the Committee for guidelines and inspections. All biological safety cabinets shall be certified and inspected by the Committee.

OSU adheres and subscribes to the procedures outlined in the Biosafety in Microbiological and Biomedical Laboratories, US. Department of Health and Human Services (Public Health Services, Centers for Disease Control and National Institute of Health), HHS Publication No. (CDC) 88-8395, Second Edition, May, 1988.

SECTION 4.3 - EFFECTIVE USE OF BIOLOGICAL SAFETY CABINETS

Exposure to airborne microorganisms can result in infection of laboratory workers or contamination of research materials. Biomedical engineering and technology have provided safeguards, but these safeguards do not prevent mistakes or human errors. Danger to personnel and to the success of scientific investigation from carelessly or improperly used equipment cannot be overly emphasized.

The Laminar Flow Biological Safety Cabinet, designed to prevent escape of pathogens into the workers' environment and to bar contaminants from the research work zone, is a key element to safe, successful experimentation with biological materials. Escape of pathogens into the workers' area is prevented by an air barrier at the front opening and the cleaning action of the exhaust air filter. Inward flow of room air into the front air intake grill creates the air barrier. The amount of air drawn into the air intake grill and the amount of air exhausted through the exhaust filter are equal. The exhaust filter removes airborne biological contaminants which may be released in the cabinet. It does not remove chemical or radiological contaminants.

Contamination of the work area inside the cabinet is prevented by the cleaning action of the supply filters. Air flows through the cabinet work area in a downward direction at a uniform velocity. The air continues to be recirculated by the fan through the air flow plenum. Airborne biological contaminants are removed by the filters as the air is returned to the cabinet work area.

Certification and advance planning are of prime importance to safe operation. Only qualified personnel using approved test methods and equipment should provide performance certification at initial installation, after maintenance, and on an annual basis thereafter. Certification is also necessary after the cabinet has been moved and after filters have been replaced. Many cabinets have gauges to indicate pressure differential across the supply filters. If the filters must be replaced, the cabinet MUST be decontaminated first. This is the responsibility of the researcher to do or have done by a qualified contractor. Procedures must follow those outlined in the National Sanitation Foundation Standard Number 49. After decontamination, only qualified Site Support personnel should replace filters. Fan speed must also be readjusted by qualified maintenance technicians.

Environmental Health & Safety maintains a list of firms specializing in the decontamination and certification of biological safety cabinets. It is the responsibility of individual researchers and/or departments to insure this process is accomplished at least annually. If your biological safety cabinet has not been certified, contact EHS for a list of names and phone numbers of certification agencies.

In a survey performed by a cabinet manufacturer, 65 of 100 cabinets failed to pass filtration system leak tests. The operators of these cabinets were unaware of the malfunction. Maximum safety and full use of the cabinet can be best achieved by adequate advanced planning. Ideally, advanced planning should follow a procedural check list to anticipate equipment, apparatus, media, order of events and the many other details necessary for the completion of the assignment.

When planning is completed, start-up procedures may be initiated. There are three start-up steps:

1. Turn on the lights
2. Check the air intake and exhaust grill to make sure they are unobstructed
3. Turn on the fan

Allow the fan to operate a minimum of five minutes before manipulations are begun in the cabinet. In addition, the following points should be considered:

1. Some cabinets are equipped with ultraviolet light. These must be turned off during the day while laboratory personnel are occupying the room.
2. Hands and arms should be washed well with germicidal soap before and after work in the cabinet.

3. Technicians are encouraged to wear long-sleeve gowns with knit cuffs and rubber gloves. This minimizes the shedding of skin flora into the work area and protects the hands and arms from contamination by viable agents.
4. Interior surfaces of the work area should be disinfected by wiping them thoroughly with 70% alcohol.
5. The cabinets should not be overloaded. Everything needed for the complete procedure should be placed in the cabinet before starting so that nothing passes in or out through the air barrier until the procedure is completed.
6. Do not place anything over the front intake or rear exhaust grill in units having a solid work surface. As a general rule, keep equipment at least four inches inside the cabinet window and perform transfer of viable materials as deeply into the cabinet as possible.
7. After all materials have been placed in the cabinet, wait 2-3 minutes before beginning work. This will allow sufficient time for the cabinet air to purge airborne contamination from the work area.
8. Hold the activity in the room to a minimum. Unnecessary activity may create disruptive air currents. The ideal location for a cabinet is in a quiet end of the laboratory, removed from doorways, air conditioning and heating vents. Opening and closing laboratory doors can cause disruptive drafts that allow microorganisms to penetrate the air barrier.
9. Schedule uninterrupted work periods. The movement of objects including hands and arms causes turbulent air currents which disrupt the air barrier and allow escape and entrance of airborne contaminants.
10. Air turbulence caused by rotating laboratory equipment, such as a small clinical centrifuge, disrupt air flow within the cabinet and at the work opening. This is sufficient for contaminated air to escape to the laboratory environment. If a centrifuge must be used in the cabinet, do not perform other research activities in the cabinet while the centrifuge is operating.
11. Normal laboratory contamination control procedures and aseptic techniques are still necessary while working in the biological safety cabinet.
12. Equipment in direct contact with the biological agent should not be removed from the cabinet until enclosed or until the surface is decontaminated. Trays of discarded pipettes and glassware must be covered before removal from the cabinets.
13. If an accident occurs which spills or splatters the biological agent in the work area, all surfaces in the cabinet must be surface decontaminated before being removed.
14. Do not use a Bunsen Burner in a biological safety cabinet. The flame causes turbulence in the air stream and the heat generated may damage the HEPA filter. If a procedure requires the use of a flame, a burner with a pilot light should be used. It should be placed to the rear of the work space where resulting air turbulence will have a minimal effect.
15. Do not mouth pipette.
16. Following completion of the work, the following steps must be performed:
 - A. Allow the cabinet to run 2-3 minutes with no activity. This will allow sufficient time for cabinet air flow to purge airborne contaminants from the work area;
 - B. Decontamination of the interior surfaces should be repeated after removal of all materials, cultures, apparatus, etc. A careful check of the work area should be made for spilled or splashed nutrients. They may support fungus growth and result in spore liberation that contaminates the protected work environment; and
 - C. Shut down by turning off the fan and lights. Use UV lights according to manufacturer's recommendations. Do not use the cabinet to store excess laboratory equipment.

Myths, Lies, and Gobbledygook*

"I've got to use a Bunsen Burner in my biohazard cabinet..."

Using a Bunsen Burner in a biohazard cabinet compromises the performance of the unit and may be dangerous. During operation, the flame of a burner is very disruptive to the air flow patterns of the cabinet, and may actually increase the dispersion of aerosols in the work area. In addition, if the flame of the burner is too large, the excessive heat may melt in adhesive holding the HEPA filter together or literally burn holes in the filter media. (Yes, it does happen on a regular basis.) Finally, a Bunsen Burner in a biological safety cabinet is just plain dangerous. An unattended burner may blow out. If in a Type A or A/B3 cabinet, the recirculating gas may reach explosive concentrations (that has also happened on several occasions). Labconco recommends using alternative methods such as electric incinerators, or disposable inoculating hoops, for instance. The practice of flaming bottle mouths is unnecessary, as the work area of a Biohazard Cabinet should be a sterile environment, if used properly.

"I can use a biological safety cabinet just as if it were a fume hood..."

No. The biohazard cabinet and the chemical fume hood are two distinctly different pieces of equipment and MUST be used differently. The fume hood is designed to remove noxious or toxic fumes and aerosols away from the operator. It should be constructed of materials that are inert to a wide variety of chemical agents. The biohazard cabinet's primary purpose is to protect the operator, environment, and often the product from biohazardous contaminants. The biohazard cabinet and its HEPA filters are constructed of materials that are inert to the chemicals used in connection with biological research, but may be damaged by some of the more corrosive chemicals commonly used in fume hoods. **Don't try to use a Biohazard Cabinet as a Fume Hood!**

"If I work in a biohazard cabinet, I don't have to be as careful with my technique..."

Wrong. The biohazard cabinet will provide personal and product protection only if used properly. Aseptic technique must be practiced at all times while working in a biohazard cabinet.

"I use the cabinet's UV light, so I don't need to decontaminate the work area..."

Wrong. The UV light is only good as an adjunct, to minimize contamination of the work area when the cabinet is not in use. Ultraviolet light has virtually no penetrating power, and as such, will not kill microbes protected by dust, dirt, or organic material. The best method to prevent contamination in the cabinet is regular decontamination of the work area surfaces, before and after the cabinet is used.

"Can I put a centrifuge in the biohazard cabinet?"

Large objects placed in the biohazard cabinet will impede the airflow in the work area, reducing the efficiency of the cabinet. Electrical appliances like centrifuges, blenders, etc., will often disrupt the airflow around them due to their cooling fans. It is better to use a primary barrier on the appliance (such as a sealed safety cup in the centrifuge) rather than a biohazard cabinet to provide containment.

"A total exhaust biohazard cabinet will give better protection than a Type A cabinet..."

If you're talking about protection from volatile toxic chemicals or radionuclides, you're right.

If you're referring to protection from biohazardous aerosols, you may not be.

Assuming that the units in question are both NSF listed, then both are subjected to the same biological challenge tests. Any claims for superior biological containment should be documented by additional biological challenge test data.

"There's nothing wrong with using the biohazard cabinet to store material when not in use."

Yes there is. Storing chemicals and materials in the biohazard cabinet make it more difficult to use when the need arises. If chemicals leak while stored in the cabinet, the work area of the cabinet could be damaged. **Don't use the biohazard cabinet as a storage area.**

"All biohazard cabinets should operate continuously, 24 hours-a-day."

Some applications of the biohazard cabinet require that the unit operate continuously. When used to prepare cytotoxic drugs, for example, the unit should operate continuously, to prevent toxic residue from migrating out of the cabinet ductwork and into the laboratory.

If the cabinet is not used in such an application, there is no need to leave it operating continuously. This will only reduce the life of the cabinet blower and HEPA filters.

"If I leave my Type A cabinet running continuously, it will clean all the air in the room to Class 100 conditions."

Not necessarily. Assuming you had an air-tight room, with no ventilation system, an air-tight door seal, and no activity in it, then a recirculating Type A cabinet might clean the room to Class 100 levels. This would also unfortunately shorten the operating life of the motor and HEPA filters (and heat up the room considerably). Regardless, as soon as the operator opens the room door to enter, particulate-laden air will contaminate the room, raising it far above Class 100 conditions.

* Adapted from Labconco Biological Safety Cabinet Training Program, Version 1.0, 3/91.

SECTION 4.4 - BIOHAZARD WASTE

The following information regarding biohazard waste is being provided to eliminate any misunderstandings about the requirements for proper disposal of biohazard wastes. A full copy of the Oregon State Department of Health regulations are available from the University Biological Safety Officer and will be provided upon request. If you do not currently have satisfactory arrangements for the proper disposal of your biohazard wastes, please contact the University Biological Safety Officer for assistance.

- A. Biohazard Wastes are discarded materials "that are biological agents or conditions (as an infectious organism or unsecure laboratory condition) that constitutes a hazard to man or his environment." This definition includes "any and all substances which contain materials to which organisms may cause injury or disease to man or his environment, but which are not regulated as controlled industrial waste".
- B. Infectious Wastes include the following categories:
- cultures and stocks of infectious agents and associated biologicals;
 - human blood and blood products,
 - pathological wastes,
 - contaminated sharps,
 - contaminated animal carcasses, body parts, and bedding,
 - wastes from surgery, necropsy and other medical procedures,
 - laboratory wastes,
 - isolation wastes, unless determined to be non-infectious by the infection control committee at the health care facility,
 - any other material and contaminated equipment which, in the determination of the facility infection control staff, presents a significant danger of infection because it is contaminated with, or may reasonably be expected to be contaminated with, etiologic agents.
- C. Chemical Wastes subject to the requirements of biohazard waste regulations include wastes from the following categories:
- pharmaceutical wastes,
 - laboratory reagents contaminated with infectious body fluids,
 - all the disposable materials which have come into contact with cytotoxic/antineoplastic agents during the preparation, handling, and administration of such agents, and
 - other chemicals that may be contaminated by infectious agents, as designated by experts at the point of generation of the waste.

- D. Treated Biohazard Wastes are all biohazard wastes that have been treated by one of the following methods and rendered harmless and biologically inert:
- incineration in an approved incinerator,
 - steam sterilization at sufficient time and temperature to destroy infectious agents in waste ("autoclaved"),
 - chemical disinfection where contact time, concentration, and quantity of the chemical disinfectant are sufficient to destroy infectious agents in the waste, and
 - any other method approved by the Oregon State Department of Health and is generally recognized as effective.
- E. Sharps are used in animal or human patient care or treatment or in medical research, or industrial laboratories, including: hypodermic needles, syringes, (with or without the attached needle), pasteur pipettes, scalpel blades, suture needles, blood vials, needles with attached tubing, and culture dishes (regardless of presence of infectious agents). Also included are other types of broken or unbroken glassware that were in contact with infectious agents, such as used slides and cover slips.
- F. The following guidelines should be followed for biohazard waste disposal:
1. If any infectious waste is also a chemical waste, call for assistance with disposal AFTER disinfection. All waste of this type must be non-human, non-infectious, and non-viable.
 2. Biohazard wastes that are also radioactive shall be treated according to requirements for both biohazard and radioactive waste.
 3. Untreated biohazard waste shall NEVER be disposed of in the municipal solid waste stream. All laboratories shall evaluate their waste stream to ensure that all biohazard wastes, including sharps and syringes, are treated in a manner as described earlier before disposal in the municipal waste stream.
 4. Prior to any treatment all biohazard wastes, including those to be incinerated, shall be enclosed in a puncture-proof, red BIOHAZARD BAG that is marked with the universal biological hazard symbol.
 5. All sharps intended for disposal, whether contaminated or not, shall be enclosed in a sharps container. Recapping needles is dangerous and shall be avoided. Treat syringes as you would a controlled substance. It is recommended that all unwanted syringes be destroyed after disinfection but before disposal in the solid waste stream. Destroying an infectious sharp or syringe before disinfection could spread contamination. Special consideration should also be given to the disposal of contaminated pipettes.
 6. After disinfection but before disposal in the municipal waste stream, all treated biohazard wastes shall be enclosed in an unmarked outer bag that is NOT red. Any biohazard waste that has been treated as described above, packaged such that it is clearly evident that the waste had been effectively treated AND contains no chemical or radioactive waste is NOT subject to regulation as biohazard waste and may be collected, transported, and disposed of as MUNICIPAL WASTE.

CHAPTER 5.0 - ADMINISTRATIVE

The intent of a laboratory safety program is to provide guidance and training to all laboratory workers who use hazardous substances or engage in potentially hazardous laboratory operations. Experience in industry has shown that the laboratory can be a safe workplace, however, this achievement was accomplished ONLY by the implementation of vigorous safety planning and training sessions.

Educational activities shall be provided for all persons who may be exposed to potential hazards in connection with laboratory operations including faculty members, students, lab supervisors, lab workers, maintenance workers, janitorial and storeroom personnel. If other non-lab related offices are nearby, consideration should be given to providing these workers with the necessary knowledge to protect them (which might be as simple as telling them which door to use in case of an emergency). This training process shall be a part of new employee indoctrination or reassignment.

Institutional safety education programs shall be a regular continuous activity and not once-a-year presentations provided for groups of new students or employees.

The following sections are intended as resource documents for administrative benefit.

SECTION 5.1 - TRAINING

Federal and State Legislation now require laboratories to provide health and safety training programs for their employees. Attendance at these training courses is mandatory and shall be documented.

While this section deals with only mandated Federal and State training, it is strongly advised that laboratories provide training to laboratory workers on chemical safety, glassware handling and general laboratory safety.

Employees shall also be instructed in how to respond to unsafe conditions or practices and communicate safety concerns to the appropriate individuals.

A formal session in a classroom setting is not necessary to impart information or to train a group of employees, though it is often desirable for this purpose. Informal group or individual discussions with a supervisor, posted notices, or handout booklets can be effective. Commercially prepared programs can also be effective, especially if supplemented with details that pertain specifically to local conditions.

OSHA does not mandate the details of the instructional method to be used. OSHA requires that, if asked by an OSHA inspector, the employees must be able to answer to the issues. Hence, whatever technique or combination of techniques are used to impart information and to train, the effectiveness of the instruction should be evaluated prior to an OSHA inspection.

The OSU Environmental Health Services Department will conduct regular training for the Departmental Chemical Hygiene Officers who are then, in turn, responsible for training their employees.

A. Hazard Communication Training

1. The individual Departmental Chemical Hygiene Officers are responsible for providing departmental laboratory employees with information and training to ensure that they are informed of the hazards of chemicals present in their work area.
2. Such information and training shall be provided at the time of an employee's initial assignment to a work area where hazardous chemicals are present and prior to assignments involving new exposure situations. Refresher information and training shall be provided on at least an annual basis.
3. Departmental Chemical Hygiene Officers shall document performance, content and attendance of their training programs.
4. Employee Information:
 - a. The contents and requirements of the OSHA Laboratory Standard.
 - b. The content, location, and availability of the laboratory's Chemical Hygiene Plan.
 - c. The PEL's, action levels, and other recommended exposure limits for hazardous chemical used in their laboratories.
 - d. Signs and symptoms associated with exposures to the hazardous chemicals used in their laboratories.
 - e. The location and availability of known reference material on the hazards, safe handling, storage and disposal of hazardous chemicals found in the laboratory including, but not limited to, Material Safety Data Sheets.
5. Employee training shall include:
 - a. The methods and observations that may be used to detect the presence or release of a hazardous chemical.

- b. The physical and health hazards of chemicals used in the work area.
- c. The measures employees can use to protect themselves from these hazards, including specific procedures such as appropriate work practices, personal protective equipment to be used, and emergency procedures.
- d. The OSU Laboratory Safety Manual.

B. First Aid/CPR Training

This training shall include the following items:

1. The availability and location of First Aid equipment.
2. The names of individuals in the area who are trained in first aid and/or CPR. It is desirable that several individuals in each area be trained in basic first aid and cardiopulmonary resuscitation. The American Red Cross offers courses in Standard First Aid and CPR.
3. How to access Emergency Medical Services (EMS). For medical emergencies on- and off-campus, call **911**.
4. Someone knowledgeable about the accident should always accompany the injured person to the medical facility with a copy of the appropriate MSDS.
5. Notify the Departmental Chemical Hygiene Officer and Environmental Health Services of any chemical accident requiring first aid.
6. Consult a licensed physician qualified to handle chemical emergencies to determine if further examination and treatment is necessary following any first aid or emergency medical treatment for chemical exposure..
7. Post the location and phone number of a licensed physician qualified to handle chemical emergency cases in an obvious place.

D. Fire Extinguisher Training

Training of employees in the use of fire extinguisher is required by OSHA 29 CFR 1910.157 (g) "where the employer has provided portable fire extinguisher for employee use in the work place." Such training shall be conducted at initial employment and annually thereafter.

E. Spill Response Training

All employees shall be trained in the proper methods for spill response. (See Section 1.1 - "Chemical Spills")

SECTION 5.2 - AUDITS

A. Safety Audits

The safety audit or safety review is an evaluation of a laboratory's total safety program and is to cover everything from management philosophy and attitude toward safety to the seemingly insignificant details of laboratory housekeeping. The purpose of the audit is to rate a safety program, identify its strengths and weaknesses, know where improvements are needed, and obtain commitments and target dates for correcting problems from the managers involved. The audit should not be regarded as fault-finding or placing-the-blame process, but a positive experience for everyone involved in the laboratory organization.

1. Benefits of an audit:
 - a. Provide management with a way to assess the effectiveness of their laboratory's safety program;
 - b. Provide recommendations for improvement;
 - c. Monitor changes on safety performance;
 - d. Build and maintain awareness of interest in the program by employees;
 - e. Indicate to the employee that management is serious about safety; and
 - f. Audit recommendations that are implemented can lead to lower accident and injury rates, which in turn, lowers cost of operations and increases morale.

2. Conducting the Audit

Audits shall be conducted on at least an annual basis.

The audit shall be conducted by either the Departmental Chemical Hygiene Officer (DCHO) or by a Safety Committee made up of the DCHO, employees, and supervisors. The audit is to make sure that each laboratory area or department conforms to the established Laboratory Chemical Safety Policy. When the audit is performed, detailed notes of the observations shall be made. One way to do this is for the leader to record the observations and then later have them transcribed for review. This also eliminates the need for the committee team to wait around while notes are being taken.

Once the audit is complete, it shall be written up and copies sent to the supervisor or department head responsible for the areas that were audited. The report should be discussed with the supervisor, and time set aside to correct any problem that might have been uncovered during the audit. A completion date shall be set for correcting each problem that was found and a person shall be assigned the responsibility for correcting each problem uncovered. If nothing is done, review the situation with the next University administrative level of management.

3. An audit should answer questions such as:

- a. Is there a safety committee that is achieving results?
- b. Are there safety monitors in each major job area of the laboratory?
- c. Are productive safety meetings being held at regular intervals?
- d. Are the safety rules being enforced?
- e. Disaster plan, fire escape plan, etc.?

- f. Hazardous waste and proper disposal program?
- g. Is an effort being made to comply with OSHA regulations affecting health, safety, and training of laboratory personnel?
- h. Are accidents reported and investigated? Do investigations include recommendations to avoid or prevent future occurrences?
- i. Does supervisory staff receive training in safety, HazCom, HazMat, first aid, CPR, fire extinguisher, chemical disposal, etc.?
- j. Do all employees receive hazard communication training?
- k. Is there a safety bulletin board?
- l. Are the fire protection measures uncompromised?
 - 1. Are sprinkler heads clear of stored materials?
 - 2. Are fire extinguishers readily accessible and not obstructed?
 - 3. Is the location of the nearest fire alarm pull-box known?
- m. Is there adequate personal protective equipment available? Do supervisors ensure that employees wear personal protective equipment when needed?
- n. Is there adequate lighting in the work area?
- o. Is housekeeping satisfactory? Is it emphasized?
 - 1. Is the area kept as clean as work allows?
 - 2. Is the floor clean and dry?
 - 3. Is the floor free from litter and obstructions?
- p. Is there any loose or protruding shelving or edging that could cause a safety problem?
- q. Is glassware that is chipped or broken in use?
- r. Are compressed gas cylinders handled properly?
 - 1. Are valve caps in place on all gas cylinders that are not in use?
 - 2. Are all cylinder movements made with a dolly?
- s. Is there a program that addresses the concerns of the employee regarding health and safety in the laboratory?
- t. Do Standard Operating Procedures address proper storage and handling of chemicals?
- u. Is the Laboratory Safety Manual available, current, and reviewed regularly?

B. Safety Surveys

Safety surveys are similar to safety audits except they do not evaluate management, attitudes, nor do they ensure that safety programs are in place.

Safety surveys should be considered as walk-throughs of the physical areas of the laboratory and related areas, with the goal of identifying safety hazards and concerns. The surveys shall be conducted on a monthly basis by the laboratory supervisor. These personnel should concentrate on working conditions, working practices, housekeeping, process controls, hazard exposure, and other similar concerns.

Please see Appendix I for a copy of the Safety Survey conducted on an annual basis by the OSU Environmental Health & Safety Department.

SECTION 5.3 - FACILITY DESIGN

While Safety procedures recommended for use to protect building occupants from specific hazardous materials are presented elsewhere in this manual, there are a number of general environmental and procedural factors often overlooked in the design and operation of laboratory facilities. These factors can have a considerable effect on the safety of the work area. This section discusses several factors relevant to the laboratory and recommends certain procedures related to each.

Appropriate design and traffic flow of the laboratory facility is critical in assuring a safe work environment for laboratory employees. In the following section, several considerations for facility design are discussed with regard to their contribution in helping to reduce the potential of accidental chemical exposure and accidental injury in the laboratory. This information is of use to those designing a new laboratory or to those renovating or updating an existing one.

A. Lighting

Adequate, glare-free lighting is necessary throughout the laboratory facility. Unshielded lighting, the presence of harsh shadows and annoying reflections, and insufficient illumination are to be avoided in the design of the laboratory. Shielded fluorescent lights are particularly effective in providing sufficient lighting without direct glare. Placement of work stations facing windows or reflective walls tend to produce visual fatigue.

The Illuminating Engineering Society recommends illumination levels for different types of work. For regular office work, (including chemist or lab technician offices) plus most typical lab work, 70-100 foot candles of illumination is recommended. For more intensive visual applications such as drafting, designing, and some accounting activities, 150-200 foot-candles is recommended.

B. Emergency Lighting

Each laboratory facility shall anticipate the need for emergency lighting. The use of a backup generator or similar system is often necessary to provide safe occupant exit and to provide lighting for any emergency repairs or procedures. It is especially important that the exit doors be clearly marked in accordance with NFPA 101. The Manager of OSU Environmental Health & Safety is the authority having jurisdiction over all formal interpretations of NFPA Codes.

C. Floors, Stairways, and Aisles

The following specifics are recommended for ensuring a floor plan that is efficient, convenient and safe:

1. Should be durable and maintenance free as possible.
2. Finishes shall be anti-slip.
3. Carpeting is not recommended for lab areas.
4. Stairs and passageways shall be sufficiently illuminated.
5. All open sides of stairwells shall have railings, as a minimum. Stairs less than 44 inches wide shall have railings on at least one side, with wider stairs having railings on both sides. Stairs over 88 inches wide shall have a center railing as well.
6. Passageways/aisles shall be a minimum of six feet wide.
7. File drawers or other storage doors shall not open into narrow aisles.
8. Doors should not open directly into passageways.

D. Egress

The following procedures are required either by OSHA, NFPA 101, BOCA, and/or other building codes:

1. Both regular exits and emergency exits shall be clearly marked.
2. Locations of emergency exits should be identified in each work area, such as in a posted floor plan.
3. Fire doors shall be unobstructed, and swing in the direction of the escape.
4. Non-exit doors and storage rooms shall be marked as such to avoid confusion with exits in the event of an emergency.
5. If possible, there should be two exits for each laboratory area.

E. Electrical

The typical laboratory requires a large quantity of electrical power. Consequently, the likelihood of electrically related problems and hazards is increased. One must address both the electrical shock hazard to the facility occupants and the fire hazard potential. The following requirements are basic to a sound electrical safety program in the laboratory.

1. Electrical standards shall be as set forth in NFPA 70 - NATIONAL ELECTRICAL CODE.
2. All electrical equipment shall be U.L. listed or F.M. approved.

F. Ventilation, Indoor Air Quality, Heating, and Cooling

While specific sources of laboratory related emissions are generally controlled, with fume hoods and local exhaust ventilation, general room and building ventilation has a considerable effect on the air quality in the laboratory and its associated offices. A facility ventilation system which provides even circulation and sufficient indoor/outdoor air exchange serves the comfort and safety of the occupants by reducing indoor air contaminant levels. Variable volume air systems should be avoided so that air contaminant levels may be precisely controlled.

The American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE) Standard 62-1999 "Ventilation for Acceptable Indoor Air Quality" addresses ventilation rates of buildings by offering recommendations for maximum indoor air contaminant concentrations as well as volumes of fresh air expected to provide air test results lower than those concentrations.

In design of the ventilation system, air intakes and exhausts should be located so as to avoid re-entrainment of contaminated air. Also, additional general ventilation may be required for stockroom and storerooms in the facility.

Closely related to the ventilation requirements is the need for proper heating and cooling of room air in the laboratory. ASHRAE Standard 55-1981 "Thermal Environmental Conditions for Human Occupancy" addresses this subject.

Separate systems may be required for the specific requirements of certain types of analytical equipment and computer operations.

G. Ventilation Hoods

1. Laboratory Hoods

An efficient hood system is a requirement for all laboratories. Work that involves hazardous and/or noxious materials which are toxic, irritating, volatile or harmful shall be conducted within a laboratory hood.

The primary purpose of a laboratory hood is to keep toxic or irritating vapors and fumes out of the general laboratory working area. A secondary purpose is to serve as a shield between the worker and equipment being used, when there is the possibility of an explosive reaction.

- a. Hood air velocity and velocity profile evaluations should be made at least annually and when ventilation changes, construction, maintenance, or normal wear and tear causes a change in the system. Contact OSU Environmental Health Services to perform this service.
- b. Hood ventilation systems are best designed to have an airflow of not less than 60 ft/min (linear) across the face of the hood, 100 ft/min (linear) for slightly hazardous materials, and 125 ft/min (linear) if toxic materials are involved. Flow rates of higher than 125 ft/min can cause turbulence problems and are not recommended. A mark or label shall be placed on the hood so the sash can be drawn to a point where 100 ft/min can be achieved. Guidelines for designing fume hood systems may be found in Industrial Ventilation, a Manual of Recommended Practice published by the American Conference of Governmental Industrial Hygienists.
- c. Avoid creation of strong cross drafts (100 fpm) caused by open doors and windows, air conditioning/heating vents, or personnel movement. Drafts will pull contaminants from the hood into the laboratory.

100 FPM is generally not perceptible (100 fpm is approximately 3 mph, a normal walking pace). Air conditioning and heating vents plus personnel traffic all create airflows in excess of 200 FPM, often much higher. Therefore, care should be taken in fume hood placement and laboratory traffic pattern design to minimize activity near the hood in use.
- d. Tempered makeup air should be supplied to rooms and/or to hoods to replace the quantity of air exhausted through the hoods.
- e. Incompatible exhausts should be ventilated separately with the exhaust being terminated a safe distance from the building.
- f. Exhaust fans should be spark-proof if exhausting flammable vapors and corrosive resistant if handling corrosive fumes.
- g. Controls for all services should be located at the front of the hood and should be operable when the hood door is closed.
- h. All laboratory rooms should have the air changed at a rate depending on the materials being handled and consistent with ASHRAE standards.
- ij. Fresh outdoor air shall be supplied as outlined in ASHRAE standard 62-1999.

2. Biological Safety Cabinets

Biological Safety cabinets are among the most effective, as well as the most commonly used, primary containment devices in laboratories working with bio-hazardous agents. The National Sanitation Foundation has developed standards for the design, construction and performance of vertical laminar flow biological safety cabinets (Class II). Utilization of this standard and list should be the first step in selection and procurement of a biological safety cabinet.

Class I and II biological safety cabinets, when used in conjunction with good microbiological techniques, provide an effective partial containment system for safe manipulation of moderate and high-risk microorganisms. Both Class I and II biological safety cabinets have comparable inward face velocities (75 linear fpm) and provide comparable levels of containment in protecting the laboratory worker and the immediate laboratory environment from infectious aerosols generated within the cabinet. However, it has been recently shown that this 75 fpm face velocity may not adequately provide protection where laboratory activity and ventilation disturbance may significantly affect cabinet performance. Therefore, a minimum inward face velocity of 100 fpm is highly recommended.

It is imperative that Class I and II biological safety cabinets are tested and certified in situ at the time of installation within the laboratory, at any time the cabinet is moved, and at least annually thereafter. Certification at locations other than the final site may attest to the performance capability of the individual cabinet or model but does not supersede the critical certification prior to use in the laboratory.

HHS Publication No. (NIH) 99-8395, titled "BIOSAFETY IN MICROBIOLOGICAL AND BIOMEDICAL LABORATORIES", published by the Centers for Disease Control and National Institutes of Health, shall be consulted for classification, specifications, and laboratory design of biological safety cabinets and Microbiological and Biomedical laboratories.

3. Specialized Local Ventilation

Some instruments such as atomic absorption spectrophotometers (AA's) or inductively coupled argon spectrometers (ICP's) emit small quantities of hazardous substances during use. To prevent excessive accumulations of these materials, each of these instruments should be provided with an individual ventilation duct placed directly over the exhaust of the instrument. Manufacturer's recommendations should be consulted for cubic foot per minute requirements for each instrument.

H. Chemical Storage

The storage of chemicals within laboratories and storage areas must incorporate a number of considerations, including the following:

1. OSHA requirements (Federal and State)
2. NFPA, State, and University Fire Code Requirements
3. Facility layout and limitations
4. Chemical use patterns and locations (location and quantities in which specific chemicals are used)

It is anticipated that laboratories may use relatively large quantities (bulk drums) of certain solvents or acids (which are stored in storage areas) with a majority of chemicals being stored and used in four liter or smaller containers.

The principle concerns in achieving proper storage is to maximize employee safety with regard to chemical compatibility, spill control, fire/explosion control, to provide security and identification and to provide a "user friendly" system with respect to point-of-use.

Certain storage guidelines apply to central storage locations:

- Storage must be physically secure.
- Adequate containment for spills and accidental releases must be provided.
- Flammable chemicals shall be stored in accordance with NFPA, OSHA, and University fire codes. Metal drums used for storage and dispensing require grounding.
- NFPA labeling must appear on cabinet and room doors at approximately waist level or lower to allow adequate visualization in dense smoke conditions.
- Chemicals shall be stored in accordance with compatibility and hazard classes. Generally, these chemicals will be segregated as flammables, acids, bases, reactives, oxidizers, and toxins.

Storage rooms or cages must be equipped with spill control/containment typically adequate for 10% of the storage capacity or the volume of the largest container. Cabinets designed for flammable or corrosive chemical storage provide a specific design capacity for containment.

Storage must conform to compatibility restrictions as described in Appendix B. Typically, solvents, acids, bases, reactives, oxidizers, and toxins will be stored separately. Separation basically refers to physical separation of containers and isolation of potential spills and releases with the goal of preventing chemical reactions. Ideally, separate cabinets or isolated areas within a central storage area should be utilized for segregated storage of incompatibles.

Small quantities of chemicals can be held at individual work stations if this quantity is to be promptly used in a test or set of tests and does not compromise acceptable ambient organic vapor levels or procedures for spill control and fire safety.

Chemicals should be stored as close as feasible to the point of use in order to minimize transport distance. Chemical storage should be limited only to areas in which the particular chemical is used. Storage locations must be identified on an emergency floor plan posted in each work area and must be equipped with a fire extinguisher, spill kit, eye wash, first aid kit, and telephone.

I. Biohazard Facility Design

The facility design is important as it not only provides barrier protection to those working within the laboratory, but also provides protection for those outside the laboratory. Three facility designs are described below, in ascending order by level of containment:

1. ***The basic laboratory.*** This laboratory provides general space in which work is done with viable agents which are not associated with disease in healthy adults. Basic laboratories include those described in Bio-safety Levels 1 and 2 facilities.

This laboratory is also appropriate for work with infectious agents or potentially infectious materials when the hazard levels are low and laboratory personnel can be adequately protected by standard laboratory practice. While work is commonly conducted on the open bench, certain operations are confined to biological safety cabinets. Conventional laboratory designs are adequate. Areas known to be sources of general contamination such as animal rooms and waste staging areas, should not be adjacent to patient care activities. Public areas and general offices to which non-laboratory staff require frequent access should be separated from spaces which primarily support laboratory functions.

2. ***The containment laboratory.*** This laboratory has special engineering features that make it possible for laboratory workers to handle hazardous substances without endangering themselves, the community, or the environment. The containment laboratory is described as a Bio-Safety Level 3 facility. The unique features that distinguish this laboratory from the basic laboratory are the provisions for access control and a specialized ventilation system. The containment laboratory may be an entire building or a single module or complex of modules within a building. In all cases, the laboratory is separated by a controlled access zone from areas open to the public.

3. ***The maximum containment laboratory:*** This laboratory has special engineering and containment features that allow activities to be conducted safely that involve infectious agents which are extremely hazardous to the laboratory worker or may cause outbreaks of serious epidemic disease. Although the maximum containment laboratory is generally a separate building, it can be constructed as an isolated area within a building. The laboratory's distinguishing characteristic is that it has secondary barriers to prevent hazardous materials or infectious agents from escaping into the environment. Such barriers include sealed openings into the laboratory, air locks or liquid disinfectant barriers, a clothing change and shower room contiguous to the laboratory, a double-door autoclave, a bio-waste treatment system, a separate ventilation system, and a treatment system to decontaminate exhaust dust.

J. Safety Showers and Eyewash Fountains

Safety Showers and Eyewash fountains **Error! Bookmark not defined.** shall be installed, maintained and tested in accordance with ANSI Standard for Emergency Eyewash and Safety Shower Equipment (Z358.1-1990).

K. Sinks

The water supply for laboratory sinks should be separate from that used for toilets, drinking water and emergency showers or eye washes. This is necessary to prevent possible contamination of the potable water supply. Back siphoning or back pressure can suck sink water into the potable water system through hoses or other apparatus. Building codes require a check valve system that must be tested periodically. It is advantageous to separate laboratory sink drainage from the sanitary drainage (see Appendix "D").

L. Sanitation Facilities, Lunch and Break Areas

Due to the use of various hazardous materials in laboratories, it is especially critical that sanitation facilities, such as rest rooms, as well as lunch or break rooms be distinctly separate from the main laboratory areas. This is best accomplished by isolation of these areas from the laboratory sections. Any lab coats, respirators, or other protective gear must be left in the lab areas upon leaving, and therefore should be provided with a designated storage area by the laboratory exit. Employees are, as a matter of routine, responsible for washing, cleaning, and any other decontamination required when passing between the lab and the other areas. Therefore, it may be advantageous to provide the necessary decontamination facilities by the laboratory exit.

M. Telephones

An emergency telephone or unrestricted access telephone capable of dialing 911 shall be readily available near any laboratory area. Emergency telephone numbers or instructions shall be posted by each such telephone.

N. Fire Protection

Oregon State University policy and Oregon state law require that all new construction and major remodeling projects provide certain levels of fire protection. All laboratories shall meet the requirements of NFPA - 45 "Standard on Fire Protection for Laboratories Using Chemicals." Contact the OSU Environmental Health Services Department for other specific requirements.

O. Operations

In planning the location of various laboratory operations, one should evaluate the various chemicals, equipment, storage, and potential accidents related to the operation. For example:

1. Are flammable materials used or stored?
2. Are compressed gases used or stored?
3. Is there an open flame used in the operation?
4. Are special air quality, heating, or air conditioning requirements needed for equipment used?
5. Will the presence of untrained persons in the area constitute a potential hazard, i.e., office or administration?
6. If flammable liquids are utilized, is proper vented storage available? (Consult NFPA 45 for quantities of flammable liquids allowed in a laboratory area.)

SECTION 5.4 - FACILITY TESTING AND MAINTENANCE

A. Chemical Fume Hoods

Fume Hoods shall be tested annually by Physical Plant Environmental Health Services in accordance with the requirements of NFPA 45 and OSHA 1910.1450 (Lab Standard). The results of these tests shall be available to the respective Departmental Chemical Hygiene Officers for their files. In addition a copy of each test result for each fume hood shall be posted on that hood.

B. Electrical Equipment

All electrical testing and maintenance shall be performed by the OSU Physical Plant Electrical Department in accordance with NFPA 70 - National Electrical Code.

C. Eyewash Fountains

Eyewash fountains shall be tested annually for proper operation. The results of these tests shall be submitted to the respective Departmental Chemical Hygiene Officers for their files. Eyewash fountains shall be maintained and tested in accordance with ANSI Standard for Emergency Eyewash and Safety Shower Equipment (Z358.1-1990).

D. Fire Protection Equipment

Fire protection equipment shall be tested and maintained by the OSU Environmental Health Services Department in accordance with the applicable National Fire Protection Association (NFPA) Standards.

E. First Aid Kits

The Departmental Chemical Hygiene Officer shall be responsible for monitoring and maintaining the first aid kits in the Department. The location of first aid kits should also be plainly marked.

F. Safety Showers

Safety showers shall be tested annually for proper operation. The results of these tests shall be submitted to the respective Departmental Chemical Hygiene Officers for their files. Safety Showers are maintained and tested in accordance with ANSI Standard for Emergency Eyewash and Safety Shower Equipment (Z358.1-1990).

CHAPTER 6.0 - STANDARD AND SPECIAL OPERATING PROCEDURES

While other chapters of this manual cover general safety requirements for a laboratory, it is recognized that each research laboratory may have unique requirements. It is the purpose of this chapter to provide a place in the Laboratory Safety Manual for the inclusion of requirements specific to an individual laboratory.

Section 6.1 supplies a place to detail procedures for those operations in a laboratory which are considered routine for that laboratory.

Section 6.2 supplies a place to detail procedures for those operations which require special prior approval or which represent severe hazards to workers.

Section 6.3 supplies a place to insert details of procedures for dealing with substances for which OSHA has substance-specific standards.

SECTION 6.3 - SUBSTANCE-SPECIFIC SAFETY PROCEDURES

The following is a list of the OSHA substance-specific standards from 29 CFR 1910:

- 1001 - Asbestos, Tremolite, Anthophyllite, and Actinolite
- 1003 - 4-Nitrobiphenyl
- 1004 - alpha-Naphthylamine
- 1006 - Methyl Chloromethyl Ether
- 1007 - 3,3'-Dichlorobenzidine (and its salts)
- 1008 - Bis-Chloromethyl Ether
- 1009 - beta-Naphthylamine
- 1010 - Benzidine
- 1011 - 4-Aminodiphenyl
- 1012 - Ethyleneimine
- 1013 - beta-Propiolactone
- 1014 - 2-Acetylaminofluorene
- 1015 - 4-Dimethylaminoazobenzene
- 1016 - N-Nitrosodimethylamine
- 1017 - Vinyl Chloride
- 1018 - Inorganic Arsenic
- 1025 - Lead
- 1028 - Benzene
- 1029 - Coke Oven Emissions
- 1043 - Cotton Dust
- 1044 - 1,2-Dibromo-3-chloropropane
- 1045 - Acrylonitrile
- 1046 - Ethylene Oxide
- 1048 - Formaldehyde

If your laboratory requires any substance-specific safety procedures they will be inserted here.

CHAPTER 7.0 - FACILITY DATA

This chapter is for the storage of facility information specific to a particular laboratory unit.

Section 7.1 supplies a place to install a detailed description of your laboratory facility.

Section 7.2 supplies a place to store your laboratories Chemical Inventory List

Section 7.3 explains Material Safety Data Sheets (MSDS) and supplies a place to store MSDS for your laboratory.

Section 7.4 supplies a place to store any Air Monitoring Data for your laboratory.

SECTION 7.1 - FACILITY DESCRIPTION

Each individual Laboratory Safety Manual should include a description of the facility, including a detailed floor plan. (Contact the OSU Physical Plant for assistance in meeting these requirements.) THE FLOOR PLAN SHOULD BE POSTED PROMINENTLY. This floor plan consists of the following items:

- A. Physical layout of rooms, with halls and passageways noted;
- B. Dimensions of the above items;
- C. Locations of fire exits, major fire and safety equipment on the premises;
- D. Locations of major pieces of equipment, including fume hoods as well as analytical items;
- E. Locations of heating, cooling and ventilation units and outlets;
- F. Location of emergency equipment -- lighting, fire extinguishers, first aid kits, eye washes, oxygen, spill control materials, emergency showers, telephones, etc.; and
- G. Location of chemical storage.

A narrative description of the various building systems should be included in this section of the safety manual as well. This will include items such as the ventilation, cooling, heating, and humidifier equipment. Also, this should include descriptions of the electrical, fuel, water, and sewer systems. Descriptions should consist of a summary of the present system as well as the locations of shutoffs (water, electrical power, gas) and emergency maintenance areas.

The description of lab facilities shall identify the activities conducted in each lab, the types of chemicals and other potential hazards in each laboratory. Emergency notification forms are also available from the OSU Environmental Health Services Department for application outside of each lab entrance.

Within each area, there should be posted a floor plan indicating exits, evacuation routes, the location of emergency equipment and the location of chemical storage areas. The posting shall also include phone numbers (work and home) of personnel to be notified in the event of an emergency.

SECTION 7.2 - CHEMICAL INVENTORY LIST

Please place your laboratory's Chemical Inventory List in this section. If your laboratory's Chemical Inventory List is not placed in this section, give complete instructions so that it may be located.

SECTION 7.3 - MATERIAL SAFETY DATA SHEETS (MSDSs)

Material Safety Data Sheets generally have nine parts associated with them. These parts will not necessarily appear in the following order.

1. Basic information on the manufacturer or distributor and identification of the chemical. This includes trade name, chemical name, any synonyms or other names associated with the chemical, chemical family, CAS name, CAS registry number, and the manufacturer.
2. The product's hazardous ingredients; whether it is an OSHA-regulated chemical, the degree of toxicity, and the statement of a Permissible Exposure Level (PEL) or Threshold Limit Value (TLV).
3. Information in the MSDS on the physical data of the pure chemical and/or mixture includes boiling point, specific gravity, vapor density, volatility, general appearance, pH, melting point, vapor pressure, solubility in water, evaporation point, color, and odor.
4. Included in the fire and explosion data are flash point, auto-ignition temperature, explosion/flammable limits (LEL, UEL), fire and explosion hazards, extinguishing media, and other special instructions.
5. The potential reactivity of the product includes instability or incompatibility, potential decomposition products, and/or polymerization data.
6. Health hazard information: Lethal concentration doses, potential problems of eye and skin contact, inhalation, ingestion, and other modes of entry.
7. Protection information: Is a fume hood or other personal protective equipment, i.e., respirator, gloves, goggles, aprons, boots, etc., required?
8. What to do in case of a spill or leak including disposal procedures. (Always check local requirements.)
9. Additional information not covered by the above.

Each worker must read each MSDS for chemicals in their work place. The workers shall then print their names in the space provided on the MSDS Training Log Sheet for that MSDS, sign in the space provided, and date their signature.

Please place your laboratory's MSDSs at the end of this section.

APPENDIX A
POTENTIAL PEROXIDE-FORMING CHEMICALS¹

Acetal	Ether (Glyme)
Cyclohexene	Ethylene Glycol Dimethyl Ether
Decahydronaphthalene	Tetrahydronaphthalene
Diacetylene	Methyl Acetylene
Dicyclopentadiene	Isopropyl Ether
Diethyl Ether	Tetrahydrofuran
Diethylene Glycol	Sodium Amide
Dimethyl Ether	Vinyl Ethers
para-Dioxane	Vinylidene Chloride
Divinyl Acetylene	

¹ From Manufacturing Chemists' Association, Guide for Safety in the Chemical Laboratory, pages 215-217.

APPENDIX B

INCOMPATIBLE CHEMICALS¹

<u>Chemical</u>	<u>Keep out of Contact With:</u>
Acetic Acid	Nitric acid, hydroxyl compounds, ethylene glycol, perchloric acid, peroxides, permanganates
Acetylene	Chlorine, bromine, copper, fluorine, silver, mercury
Alkali Metals	Water, carbon tetrachloride or other chlorinated hydrocarbons, carbon dioxide, the halogens
Ammonia, Anhydrous	Mercury, chlorine, calcium hypochlorite, iodine, bromine, hydrofluoric acid
Ammonium nitrate	Acids, metal powders, flammable liquids, chlorates, nitrites, sulfur, finely divided organic or combustible materials
Aniline	Nitric acid, hydrogen peroxide
Bromine	Same as chlorine: ammonia, acetylene, butadiene, butane, methane, propane (or other petroleum gases), hydrogen, sodium carbide, turpentine, benzene, finely divided metals
Butyl lithium	Water.
Carbon, activated	Calcium hypochlorite, all oxidizing agents
Chlorates	Ammonium salts, acids, metal powders, sulfur, finely divided organic or combustible materials
Chromic Acid	Naphthalene, camphor, glycerin, turpentine, alcohol, flammable liquids in general
Chlorine	Same as bromine: ammonia, acetylene, butadiene, butane, methane, propane (or other petroleum gases), hydrogen, sodium carbide, turpentine, benzene, finely divided metals
Chlorine dioxide	Ammonia, methane, phosphine, hydrogen sulfide
Copper	Acetylene, hydrogen peroxide
Cumene hydroperoxide	Acids, organic or inorganic
Cyanides (Na, K)	Acids
Flammable liquids	Ammonium nitrate, chromic acid, hydrogen peroxide, nitric acid, sodium peroxide, halogens, other oxidizing agents

¹

From Manufacturing Chemists' Association, Guide for Safety in the Chemical Laboratory, pages 215-217.

Hydrocarbons	Fluorine, chlorine, bromine, chromic acid, sodium peroxide
Hydrocyanic acid	Nitric acid, alkalis
Hydrofluoric acid	Ammonia, aqueous or anhydrous
Hydrogen peroxide	Copper, chromium, iron, most metals or their salts, alcohols, acetone, organic materials, aniline, nitromethane, flammable liquids, oxidizing gases
Hydrogen sulfide	Fuming nitric acid, oxidizing gases
Iodine	Acetylene, ammonia (aqueous or anhydrous), hydrogen
Mercury	Acetylene, fulminic acid, ammonia
Nitric Acid	Acetic acid, aniline, chromic acid, hydrocyanic acid, hydrogen sulfide, flammable liquids, flammable gases
Oxalic acid	Silver, mercury
Perchloric acid	Acetic anhydride, bismuth and its alloys, alcohol, paper, wood, sulfuric acid, organics
Potassium	Carbon tetrachloride, carbon dioxide, water
Potassium permanganate	Glycerin, ethylene glycol, benzaldehyde, sulfuric acid
Silver	Acetylene, oxalic acid, tartaric acid, ammonium compounds
Sodium	Carbon tetrachloride, carbon dioxide, water
Sodium peroxide	Ethyl or methyl alcohol, glacial acetic acid, acetic anhydride, benzaldehyde, carbon disulfide, glycerin, ethylene glycol, ethyl acetate, methyl acetate, furfural
Sulfuric acid	Potassium chlorate, potassium perchlorate, potassium permanganate (or compounds with similar light metals, such as sodium, lithium, etc.)

APPENDIX C

POTENTIAL SHOCK-SENSITIVE CHEMICALS¹

Acetylides of heavy metals	Fulminate of silver
Aluminum ophorite explosive	Fulminating gold
Amatol explosive (sodium amatol)	Fulminating mercury
Ammonal	Fulminating silver
Ammonium nitrate	Fulminating platinum
Ammonium perchlorate	Gelatinized nitrocellulose
Ammonium picrate	Guanyl nitrosamino guanyl tetrazene
Ammonium salt lattice	Guanyl nitrosamino guanylide hydrazine
Calcium nitrate	Heavy metal azides
Copper Acetylide	Hexanite
Cyanuric triazide	Hexanitrodiphenylamine
Cyclotrimethylenetrinitramine	Hexanitrostilbene
Cyclotetramethylenetrinitramine	Hexogen (Cyclotrimethylenetrinitramine)
Dinitroethyleneurea	Hydrazoic acid
Dinitroglycerine	Lead azide
Dinitrophenol	Lead mannite
Dinitrophenolates	Lead picrate
Dinitrophenyl hydrazine	Lead salts
Dinitroresorcinol	Lead styphnate
Dinitrotoluene	Magnesium ophorite
Dipicryl sulfone	Mannitol hexanitrate
Dipicrylamine	Mercury oxalate
Erythritol tetranitrate	Mercury tartrate
Fulminate of mercury	Mononitrotoluene
Nitrated carbohydrate	Silver styphnate
Nitrated glucoside	Silver tetrazene

¹ From Manufacturing Chemists' Association, Guide for Safety in the Chemical Laboratory, pages 215-217.

Nitrated polyhydric alcohol	Sodatol
Nitrogen trichloride	Sodium amatol
Nitrogen triiodide	Sodium dinitro-ortho-cresolate
Nitroglycerin	Sodium nitrate-potassium nitrate explosive mixtures
Nitroglycol	Sodium picramate
Nitroguanidine	Styphnic acid
Nitroparaffins	Tetrazene (guanyl nitrosamino guanyl tetrazene)
Nitromethane	Tetranitrocarbazole
Nitronium perchlorate	Tetrytol
Nitrourea	Trimethylolethane
Organic amine nitrates	Trimonite
Organic nitramines	Trinitroanisole
Organic peroxides	Trinitrobenzene
Picramic acid	Trinitrobenzoic acid
Picramide	Trinitrocresol
Picratol explosive (ammonium picrate)	Trinitro-meta-cresol
Picric acid	Trinitronaphthalene
Picryl chloride	Trinitrophenol
Picryl fluoride	Trinitrophloroglucinol
Polynitro aliphatic compounds	Trinitroresorcinol
Potassium nitroaminotetrazole	Tritronal
Silver acetylide	Urea nitrate
Silver azide	

APPENDIX D

NEUTRALIZATION OF SPENT ACIDS AND BASES

Spent mineral acids, straight-chain fatty acids, and bases (hydroxides) comprise a large portion of the unwanted chemicals being stored in campus laboratories. As a part of regular laboratory procedures, campus labs should neutralize spent inorganic acids, acetic acid, straight-chain fatty acids, and bases (hydroxides) that do not contain metal or organic contaminants. These chemicals will be managed in an "elementary neutralization unit" and, therefore, are not considered a part of the hazardous waste stream for the campus. An "elementary neutralization unit" is a container used for neutralizing corrosive wastes.

Neutralization is a relatively simple procedure that is best done by and in the laboratory that uses inorganic acids, acetic acid, straight-chain fatty acids, and bases (hydroxides) on a regular basis. The laboratory that generates spent corrosives usually has the facilities and expertise to neutralize them, and therefore will be responsible for doing so. The following procedures (see A - D) describe the proper technique for neutralization of spent inorganic acids, acetic acid, straight-chain fatty acids, and bases (hydroxides) as a part of regular laboratory procedures. At the end of this appendix are lists of corrosives to be managed in-house by campus laboratories. Aqueous corrosive wastes shall NOT contain sulfides, cyanides, metals, or other materials that can give off hazardous fumes upon reaction with the acid or base.

Do **NOT** use these procedures for:

- INORGANIC ACIDS THAT CONTAIN HEAVY METALS (e.g., Atomic Absorption Standards, arsenic, cadmium, chromium, lead, mercury, nickel, selenium, silver, thallium. Solutions containing sodium, potassium, magnesium, iron can be neutralized as long as the anion is also non-hazardous.)
- ESTERS OF INORGANIC ACIDS
- CHROMIC ACID
- PERCHLORIC ACID
- HYDROFLUORIC ACID
- ORGANIC ACIDS EXCEPT ACETIC ACID AND STRAIGHT-CHAIN FATTY ACIDS
- LARGE QUANTITIES OF NITRIC ACID

Chemicals shall not be disposed in the sanitary sewer for two reasons. First, Stillwater does not allow the disposal of most chemicals in the wastewater flow. Second, strong reactions can take place if the chemical carries unknown contaminants or contacts an incompatible chemical in the wastewater.

A. Equipment Needed for Neutralizing Acids and Bases

1. Sodium carbonate (Soda ash), baking soda, or diluted inorganic base (hydroxide) for neutralization of an acid, or a diluted inorganic acid for neutralization of a base.
2. Polyethylene bucket - 1 or 2 gallon size, as personal preference dictates. Remember that 1 gallon weighs approximately 8 pounds or greater.
3. Protective equipment (goggles, apron, gloves).
4. 500 ml beakers.
5. pH Indicator Strips, or other pH test method.

B. Personal Protective Equipment

Read the Material Data Safety Sheet (MSDS) for detailed information. Call the Environmental Health Services Department Hazard Communications Section if an MSDS is not available. The **MINIMUM** recommended personal protection needed when performing the neutralization procedure is:

Ventilation Work in a fume hood

Gloves Use neoprene, natural rubber, butyl, polyethylene, nitrile butadiene, or polyvinyl chloride depending on the MSDS information

Clothing Apron (rubber is preferred), lab coat (or protective suit or coveralls), and closed-toe shoes.

Eye Protection Splash-proof or dust-proof goggles **AND** a face-shield (8 inch minimum)

Hands shall always be washed after working with these chemicals. An eyewash station and quick-drench facility shall be located in the area. All employees shall locate these emergency facilities *before starting to work*.

WARNING: REMEMBER THAT EXTREME HEAT CAN BE PRODUCED BY THIS PROCEDURE UNLESS IT IS DONE VERY SLOWLY AND WELL-DILUTED. CLOSELY MONITOR THE AMOUNT OF HEAT PRODUCED BY TOUCHING THE OUTSIDE OF THE NEUTRALIZATION CONTAINER. USE ICE BATH IF NECESSARY.

C. Neutralization Procedure for Acid

1. Make a saturated solution of sodium carbonate (soda ash) in a beaker or use an inorganic base diluted in water (1:10 ratio) - set aside.
2. Put tap water into 1 or 2 gallon polyethylene bucket.
3. Dilute acid at least 1:10 (1 part acid to 9 parts of water) by slowly pouring and *stirring the acid into the water*².
4. Slowly add soda ash or other basic solution into diluted acid with stirring, or save diluted acid to neutralize bases as described below.
5. Monitor pH with pH meter, pH indicator strips, or other pH test method.
6. When pH is between 6 and 9, dispose in a drain followed with excess water. A pH near 7 is preferred to reduce the possibility of plumbing damage.

HELPFUL HINT: When neutralizing an acid, the pH can be tested quickly by the following method. Make a saturated solution of sodium bicarbonate in water. A small amount of sodium bicarbonate solution poured into the acid will make a "fizz", which is a release of carbon dioxide. Since carbon dioxide evolves from these procedures, insure adequate ventilation is available. This "fizz" will indicate that the solution is still acidic, and needs more base to be added. Always stir the mixture and do a final check of the pH before pouring the neutralized acid down the drain.

D. Base Neutralization

1. Put tap water into 1 or 2 gallon polyethylene bucket.

² For concentrated acids and bases, neutralization must be done slowly and with vigorous stirring. If there are any questions, or if you are hesitant about attempting this procedure with any spent acid or alkali waste, please call Environmental Health Services, Hazardous Materials Section, at extension 47241. The recommended time for the neutralization procedure is when the wastewater flow is at a peak, e.g., 9:00 a.m.

2. Dilute alkali wastes at least 1:10 (1 part alkali to 9 parts water) by slowly pouring and *stirring the base into the water*³.
3. Neutralize the diluted alkali solution with a previously diluted inorganic acid.
4. Monitor pH with pH meter, pH indicator strips, or other pH test method.
5. When pH is between 6 and 9, dispose in a drain followed with excess water. A pH near 7 is preferred to reduce the possibility of plumbing damage.

³ For concentrated acids and bases, neutralization must be done slowly and with vigorous stirring. If there are any questions, or if you are hesitant about attempting this procedure with any spent acid or alkali waste, please call Environmental Health Services, Hazardous Materials Section, at extension 47241. The recommended time for the neutralization procedure is when the wastewater flow is at a peak, e.g., 9:00 a.m.

INORGANIC ACIDS

NAME/MOLECULAR WT.

Sulfuric Acid
M.W. - 98.08

Boric Acid
M.W. - 61.84
Nitric Acid
M.W. - 63.02

Hyponitrous Acid
Hydrochloric Acid
M.W. - 36.46

Aqua Regia

Phosphoric Acid
M.W. - 98.00

FORMULA

H_2SO_4

BH_3O_3

HNO_3

$H_2N_2O_2$
 HCl

HCl/HNO_3
(3:1 mixture)
 H_3PO_4

SYNONYMS

Dipping Acid
Oil of Vitrol
Sulphuric Acid
Nordhausen Acid
Boracic Acid
Orthoboric Acid
Aqua Fortis
Azotic Acid
Hydrogen Nitrate

Chlorohydric Acid
Hydrochloride
Muriatic Acid
Nitrohydrochloric Acid
Nitromuriatic Acid
Orthophosphoric Acid

INORGANIC BASES

<u>NAME/MOLECULAR WT.</u>	<u>FORMULA</u>	<u>SYNONYMS</u>
Aluminum Hydroxide M.W. - 78.01	$\text{Al}(\text{OH})_3$	Alumigel Alumina Hydrate Alumina Trihydrate Aluminum Hydrate Aluminum(III) Ammonia Aqueous
Ammonium Hydroxide Hydroxide	NH_4OH	Aluminum Oxide-3H ₂ O Aluminum Trihydroxide Precipitated Chalk Chalk Dolomite Limestone/Marble Slaked Lime Lime Water Hydrated Lime Calcium Hydrate Lime Burnt Lime Calcia Calx Lime, Unslaked Quicklime
Calcium Carbonate M.W. - 100.09	CaCO_3	Carbonate Magnesium Magnesia Alba Magnesium Carbonate- (Precipitated)
Calcium Hydroxide M.W. - 74.10	$\text{Ca}(\text{OH})_2$	Magnesia Magma Magnesium Hydrate Milk of Magnesia Caustic Potash Lye Potassium Hydrate Baking Soda Bicarbonate of Soda Sodium Acid Carbonate Soda Ash Crystal Carbonate Carbonic Acid - Disodium Salt
Calcium Oxide M.W. - 56.08	CaO	Lye Caustic Soda Soda Lye Sodium Hydrate
Magnesium Carbonate M.W. - 84.32	MgCO_3	
Magnesium Hydroxide M.W. - 58.33	$\text{Mg}(\text{OH})_2$	
Potassium Hydroxide M.W. - 56.11	KOH	
Sodium Bicarbonate M.W. - 85.01	NaHCO_3	
Sodium Carbonate M.W. - 105.99	Na_2CO_3	
Sodium Hydroxide M.W. - 40.00	NaOH	

APPENDIX E

CLEANING SOLUTION FOR LABORATORY GLASSWARE

Laboratories using chromic acid for cleaning laboratory glassware should begin to abandon the practice as soon as possible for two reasons. First, the City of Stillwater has placed limitations on the concentration of chromium in wastewater discharge (1 mg/l hexavalent chromium; 5 mg/l total chromium). Second, the costs for proper treatment and disposal of the spent cleaning product can be expensive and shall be avoided, if possible. Spent (waste) cleaning products which contain potassium/sodium dichromate in sulfuric acid or the product Chromerge shall not be discharged into the wastewater treatment system; these materials shall be collected, marked & labeled, and disposed of as a hazardous waste. Therefore, due to the difficulties involved in treatment and disposal and management of spent cleaning solutions, the OSU Environmental Health Services Department Hazardous Materials Section recommends the following:

Laboratories should seek alternative glassware cleaning solutions for products to meet their needs. Glassware cleaning products which do not contain chromium such as Nochromix are readily available and are recommended. Nochromix mixed with sulfuric acid is as effective as Chromerge in removing trace metals and enzyme residues, but it eliminates the need for special handling caused by the toxicity of Chromerge. In fact, spent solutions of Nochromix can be safely disposed of (after elementary neutralization) via the sanitary sewer if not contaminated with other metals or toxic substances. The cost of Nochromix is approximately one-third of that for Chromerge. Similar substitutes might also be available from other manufacturers. Purchasers of reagents and chemicals for the affected laboratories should determine if their suppliers can provide such environmentally suitable glassware cleaning agents.

As an alternative to a sulfuric acid bath, a 95% Ethanol/Hydrochloric Acid bath or 95% Ethanol/Potassium Hydroxide bath can be used effectively against organic residues. (Caution: This procedure may etch glassware.)

In cases where it is imperative that glassware must be cleaned using a cleaning solution containing chromium, the spent cleaning reagent is classified as a hazardous waste. This procedure will also be considered a special procedure (see Section 8.2 - "Special Procedures").

Please convey this information to persons in your area who may utilize chromic acid cleaning solutions. Your cooperation in this matter is solicited to help minimize the costs of disposal for regulated wastes. Please contact Environmental Health Services, Hazardous Materials Section, if you have any questions.

APPENDIX F

Decontamination and Destruction of Ethidium Bromide (EB)

Ethidium Bromide is also known as:

2,7-DIAMINO-10-ETHYL-PHENYLPHENANTHRIDINIUM BROMIDE
3,8-DIAMINO-5-ETHYL-6-PHENYLPHENANTHRIDINIUM BROMIDE
2,7-DIAMINO-9-PHENYL-10-ETHYLPHENANTHRIDINIUM BROMIDE
2,7-DIAMINO-9-PHENYLPHENANTHRIDINE ETHOBROMIDE
DROMILAC
HOMIDIUM BROMIDE
RD 1572
NOVIDIUM BROMIDE
BABIDIUM BROMIDE

A. Principles of Decontamination and Destruction

Ethidium Bromide is a powerful mutagen which is widely used in laboratories for visualizing nucleic acids. It may be harmful by inhalation, ingestion, and skin absorption and should be handled only when wearing rubber gloves and non-vented chemical goggles with work being done in a chemical fume hood. It is also irritating to the mucous membranes and respiratory tract.

Several methods have been published for the chemical destruction of EB involving treatment with bleach, hypophosphorus acid and sodium nitrate, and potassium nitrate. Decontamination products from these procedures, however, can also be mutagenic. For example, the projects of bleach decontamination show 20% mutagenic activity of the original EB, products of the $H_3PO_4/NaNO_2$ procedure show 0.6% mutagenic activity, and $KMnO_4$ procedure shows 0.03%. This information clearly demonstrates that the commonly used technique of bleach decontamination is not the best choice. Because potassium nitrate will stain most materials it contacts, the best choice for destruction or decontamination is the sodium nitrate procedure. The reagents (sodium nitrate and a dilute solution of hypophosphorus acid) are inexpensive and relatively non-toxic.

In the laboratory, EB might be encountered in a variety of solvents including EB dissolved in water, TBE buffer, MOPS buffer, and cesium chloride solution. The method to destroy EB in these solvents is based on a decontamination procedure that was previously published. Lunn and Sansone (1989) conclude that the recommended procedure removes the amino groups from the EB and it may cleave the N-containing ring. The only problem encountered was the failure to add enough hypophosphorus acid to reduce the pH sufficiently ($pH < 3$, approximately) which caused the reaction to fail. Although the procedure was tested only for the solvents listed above, Lunn and Sansone did not see a reason why the method should not work for other buffers, provided that sufficient hypophosphorus acid is added. Validation of the destruction, however, by lack of fluorescence and, preferably, lack of mutagenic activity is, of course, essential.

Hypophosphorus acid is corrosive and should be handled carefully. If your laboratory uses any of these chemicals, call Environmental Health Services (EHS) for copies of the Material Safety Data Sheets if you do not have them.

Any towels, gloves, or other materials that are used during the handling of EB should be disposed of carefully as solid waste. Empty containers which once held EB are also considered to be solid waste when empty. Only paper towels or other materials that are grossly contaminated, such as from a spill clean-up, should be decontaminated. The decontamination should be validated through the use of a fluorescent lamp. It should be noted that the fluorescent lamp procedure only determines fluorescent compounds (such as EB) but that the EB is readily changed into non-fluorescent but still toxic compounds. Accordingly, Lunn and Sansone recommend periodic testing of reactions for mutagenicity, if possible. If a source is located either to test the mutagenicity of the decontaminated solutions, or to further validate decontamination procedures, EHS will notify laboratories.

EB can also be determined by thin-layer chromatography using silica gel plates eluted with 1-butanol:acetic acid:H₂O (4:1:1).

B. Safety Considerations

The decontamination mixture gives off a small amount of nitrogen dioxide when initially mixed, and should be used in a chemical fume hood. A full description of the recommended procedures for destruction and decontamination of EB follows. Please call EHS at extension 4-7241 with questions regarding these procedures.

The following descriptions are designed to give a sufficiently complete guide to the destruction methods available in order to allow one to implement them successfully. The user may wish to consult other sources cited in the literature to determine the exact reaction conditions, limitations, and hazards. In some cases, more than one procedure is listed. In these instances, all the procedures should be regarded as equally valid unless restrictions on applicability are noted.

C. Destruction and Decontamination Procedures

The following information is largely taken from Destruction of Hazardous Chemicals in the Laboratory:

1. Destruction of EB in Aqueous Solution

- a. Dilute the solution, if necessary, so that the concentration of EB does not exceed 0.5 mg/mL. For each 100 mL of EB in H₂O, MOPS buffer (see below), or 1 g/mL cesium chloride solution, add 20 mL of 5% hypophosphorus acid solution and 12 mL of 0.5 M sodium nitrite solution. Stir briefly and allow to stand for 20 hours. Neutralize with sodium bicarbonate (NaCO₃), check for completeness of destruction, and discard the solution.
- b. The hypophosphorus acid solution is prepared by adding 10 ml of the commercially available 50% solution to 90 ml of water and stirring briefly. It is advisable to prepare the hypophosphorus acid solution and the sodium nitrite solution (34.5 g/liter) fresh each day. Even if less concentrated solutions are to be decontaminated, it is best to add the same volume of hypophosphorus acid and sodium nitrite solutions to ensure the completeness of destruction. For more concentrated solutions, the volumes should be increased pro rata.
- c. Caution! Ozone is an irritant. This reaction should be carried out in a properly functioning chemical fume hood. Dilute the solution, if necessary, so that the concentration of EB in H₂O, Tris buffer, MOPS buffer, or cesium chloride solution does not exceed 0.4 mg/mL. Add hydrogen peroxide (H₂O₂) solution so that the concentration of H₂O₂ in the solution to be decontaminated is 1%. Pass air containing 300-400 ppm of ozone (from an ozone generator) through the solution at a rate of 2L/min. The red solution will turn light yellow. The destruction process typically takes 1 hour. Check the reaction mixture for completeness of destruction and discard it. Degrade residual ozone by making the reaction 1 M in sodium hydroxide.

2. Decontamination of EB in Aqueous Solution

Dilute the solution, if necessary, so that the concentration of EB does not exceed 0.1 mg/mL. For each 100 mL of EB in H₂O, TBE buffer (see below), MOPS buffer (see below), or cesium chloride solution add 2.9 g of Amberlite XAD-16 resin. Stir for 20 hours, then filter the mixture. Place the beads, which do not contain EB, with the hazardous solid waste. Check the liquid for completeness of decontamination and discard it. An alternative procedure for solutions that are more concentrated than 0.1 mg/mL is to increase the relative amount of resin. This procedure should be fully validated before employing it on a routine basis.

3. Decontamination of Equipment Contaminated with EB

- a. Wash the equipment once with a paper towel soaked in a decontamination solution consisting of 4.2 g of sodium nitrite and 20 mL of hypophosphorus acid (50%) in 300 mL of H₂O. Then wash five times with wet paper towels using a fresh towel each time. Soak all the towels in decontamination solution for 1 hour. Check for completeness of decontamination and discard it. Make up the decontamination solution just prior to use.
- b. If the decontamination solution (pH 1.8) is felt to be too corrosive for the surface to be decontaminated, then use six H₂O washes. Again, soak all towels in decontamination solution for 1 hour before disposal. Glass, stainless steel, Formica, floor tile, and the filters of transilluminators have been successfully decontaminated using this technique.
- c. No change in the optical properties of the transilluminator filter could be detected even after a number of decontamination cycles using the decontamination solution.

4. Decontamination of EB in Isopropanol Saturated with Cesium Chloride

Dilute the solution, if necessary, so that the concentration of EB in the isopropanol saturated with cesium chloride does not exceed 1 mg/mL. For each volume of EB solution, add 4 volumes of a decontamination solution consisting of 4.2 g of sodium nitrite and 20 mL of hypophosphorus acid (50%) in 300 mL of H₂O and stir the mixture for 20 hours. Neutralize with NaCO₃, test for completeness of destruction, and discard it.

5. Decontamination of EB in Isoamyl Alcohol and 1-Butanol

- a. Dilute the solution, if necessary, so that the concentration of EB in the alcohol does not exceed 1 mg/mL. For each volume of EB solution, add four volumes of a decontamination solution consisting of 4.2 g of sodium nitrite and 20 mL of hypophosphorus acid (50%) in 300 mL of H₂O and stir the two-phase mixture rapidly for 72 hours. For each 100 mL of total reaction volume, add 2 g of activated charcoal and stir for another 30 minutes. Filter the reaction mixture, neutralize with NaCO₃, and separate the layers. More alcohol may tend to separate from the aqueous layer on standing. Test the layers for completeness of destruction and discard them. It should be noted that the aqueous layer contains 4.6% of 1-butanol or 2.3% of isoamyl alcohol. Discard the activated charcoal with the solid waste.
- b. This procedure has been tested in three separate experiments for both isoamyl alcohol and 1-butanol. In one experiment, one plate (TA 1530 with S9 activation) indicated significant mutagenic activity. The number of revertants was 2.6 times background. All the other plates for this experiment and all the other experiments showed no significant mutagenicity. For comparison, untreated EB solutions were between 39 and 122 times background, depending on the solvent and tester strain.

6. Decontamination of Ethidium Bromide Spills

Given the wide usage of EB in laboratories, spills may be expected to occur, e.g., on benches, in fume hoods, or on the floor. Another problem that may occur is the build-up of EB residues on the surfaces of equipment such as centrifuges. Transilluminators are used to view the gels which contain DNA stained with EB, and residues of EB may build up on the large UV filter which forms the top surface of these units. Any decontamination method should not, of course, damage the optical surface. The decontamination solution described below is less corrosive than potassium permanganate in hydrochloric acid and does not appear to damage surfaces of transilluminator filters and Formica. Another method using activated charcoal and ethanol may leave activated charcoal on optical surfaces. The method described here does not appear to leave residues on nonporous surfaces.

Although low levels of mutagenic activity were found when high (10 mg/ml) concentrations of EB in solution were degraded, the sodium nitrite/hypophosphorus acid method does not produce significantly mutagenic solutions when the EB concentration does not exceed 0.5 mg/ml.

- a. De-energize all electrical equipment before decontamination and wear appropriate protective equipment, including rubber gloves, lab coat, and chemical goggles. A small amount of nitrogen dioxide is given off when the decontamination solution is mixed. This procedure would be best if carried out in the fume hood.
- b. Scrub the contaminated surface or equipment with a paper towel soaked in a freshly prepared decontamination solution (prepared by adding 20 ml of 50% hypophosphorus acid to a solution of 4.2 g of sodium nitrite in 300 ml of water). Scrub another five times with wet paper towels, using a fresh towel each time.
- c. Place all towels in a large container and soak them in fresh decontamination solution for at least 1 hour before disposing of them.
- d. Test the used decontamination solution and squeezings from the towels used for some of the later washes for fluorescence and/or mutagenicity.
- e. Dry off the decontaminated surface or equipment and place it in service again. Neutralize the used decontamination solution with sodium bicarbonate and discard as aqueous waste.

APPENDIX G

How to Run a Regularly Scheduled Health and Safety Meeting

1. Planning is essential. Start early, prepare an agenda, choose a place that is well ventilated, quiet, and comfortable.
2. Contact all who need to attend. Make sure that they have enough advance warning. For this reason regularly scheduled meetings are preferable unless there is a need for a "special" meeting.
3. Contact individuals who have "special" expertise well in advance to arrange for their attendance.
4. Prepare the agenda and stick to it. Start by determining your objectives; what needs to be accomplished? If it is a regularly scheduled meeting, you will want to follow-up on previously discussed items to check on their resolution.

Conduct of the Meeting

1. Call to Order.
2. Attendance is taken.
3. Review unfinished business.
4. Review any "action" items that were not taken up at the last meeting.
5. Discuss any accidents that took place since the last meeting. Develop written loss control recommendations.
6. Discuss "near" accidents which have taken place since the last meeting.
7. Discuss "unsafe acts or practices and regulatory compliance issues" that have been observed during regular or special inspections.
8. Discuss new business, i.e., Personal Protective Equipment recommendations for new procedures, training schedule for Hazard Communication compliance.
9. Ask those attending to review any special safety problems or concerns they may have or problems brought up by their constituency.
10. Explore special interest items such as a safety film or posters or any other safety/health related items.
11. Be sure that assignments are made to individuals if there is not enough information available to make loss control recommendations.
12. Keep detailed minutes of the meetings.
13. After the meeting, distribute copies of the minutes for posting and discussion.
14. After the meeting, evaluate the meeting to determine if you met your objectives.

APPENDIX H

SAFETY SURVEY LIST

Working Areas

- _____ 1. Adequate lighting in the work area?
- _____ 2. Laboratory work areas reasonably clean and tidy?
- _____ 3. Area kept as clean as work allows?
- _____ 4. Guards on fan blades that are located within 7 ft. of the floor?
- _____ 5. Ladders and step-stools in good condition and used in the manner for which they were designed?
- _____ 6. Two and four-wheeled carts and hand trucks in good condition?
- _____ 7. List of emergency numbers, First Aid, and CPR certified employees clearly displayed?
- _____ 8. No foods, beverages, tobacco, or cosmetics in laboratory?
- _____ 9. Eating, drinking, use of tobacco, and use of cosmetics prohibited in the laboratory?
- _____ 10. No chipped or broken glassware in use?

Means of Egress

- _____ 11. Sidewalks kept free of snow and ice?
- _____ 12. Stairs well lit?
- _____ 13. Stairs of sturdy design?
- _____ 14. Railings provided on all open sides of exposed stairways?
- _____ 15. Anti-skid walking surfaces on the stairs?
- _____ 16. Stairs clean?
- _____ 17. All non-exit doors and passages which could be mistaken for an exit marked as such?
- _____ 18. All exits clearly designated?
- _____ 19. All exits unobstructed?
- _____ 20. All exit signs illuminated? (They must be illuminated by general room lighting or internal lighting.)
- _____ 21. Emergency lighting provided for fire escape routes?
- _____ 22. All fire doors unobstructed and free of locks and devices that could prevent free egress?
- _____ 23. Designated fire doors closed and operable?
- _____ 24. All fire doors side hinged and swing in the direction of the escape?
- _____ 25. Floors free from protrusions and large holes?
- _____ 26. Floors free from litter and obstructions?
- _____ 27. Floors clean and dry?
- _____ 28. Drainage provided for continuously wet floors?
- _____ 29. Mats and carpeting in good condition?
- _____ 30. Aisles and passageways well lit?
- _____ 31. Aisles and passageways kept clear to provide safe movement of materials handling equipment or employees?
- _____ 32. No loose or protruding shelving or edging that could cause a safety problem?
- _____ 33. Covers or guard rails provided for open pits, vats, etc.?
- _____ 34. Guard rails provided for platforms greater than 4 feet above the adjacent floor?

Materials Handling and Storage

- _____ 35. Area free of the accumulation of materials that could cause tripping, fires, explosions, or pest harboring?
- _____ 36. Sprinklers clear of stored materials (18 inch clearance)?
- _____ 37. NFPA 704 labeling appears on doors and cabinets?
- _____ 38. Materials stored to prevent sliding, falling, or collapse?
- _____ 39. Storage shelving secure, in good condition, and not over-loaded or crowded?
- _____ 40. Storage shelving provided with a lip on forward edge?
- _____ 41. Hazardous chemicals not stored on floor?
- _____ 42. Sufficient waste containers provided?
- _____ 43. A closable metal container provided for oily rags (if necessary)?
- _____ 44. Reagents used at the bench properly labeled to prevent accidental use of the wrong reagent or wash bottle?
- _____ 45. Containers labeled with the identity of contents and general hazard(s) of contents?
- _____ 46. Containers properly capped or sealed?
- _____ 47. Flammable liquids in quantities greater than one liter stored in safety cans designed for flammable liquid storage?
- _____ 48. Flammable and combustible liquids stored in containers labeled as such?
- _____ 49. Flammable and combustible liquids stored in approved cabinets marked "Flammable"?
- _____ 50. Cabinets properly ventilated?
- _____ 51. If flammable liquids are used in large volumes, is the mechanical ventilation adequate to remove vapors before they reach hazardous concentrations?
- _____ 52. Stored combustibles and flammables separated from any heat source by at least 20 feet?
- _____ 53. Areas where flammables are used or stored designated "NO SMOKING - NO OPEN FLAMES"?
- _____ 54. Metal drums used for storage and dispensing of flammable liquids properly grounded?
- _____ 55. Materials stored only with other compatible materials? (e.g., solvents, acids, bases, reactives, oxidizers, and toxins stored separately)

Compressed Gases

- _____ 56. Each compressed gas cylinder marked with the identity of its contents?
- _____ 57. Compressed gas cylinders inspected visually for safe operating condition?
- _____ 58. Gas cylinders secured so they will not tip over or fall?
- _____ 59. Valve caps in place on all gas cylinders that are not in use?
- _____ 60. All gas lines leading from compressed gas supplies labeled as to identity of gas, laboratory served, and emergency telephone numbers?
- _____ 61. Gas cylinder storage areas properly ventilated?
- _____ 62. Areas where flammable compressed gases are stored posted "NO SMOKING - NO OPEN FLAMES"?
- _____ 63. Oxygen cylinders not stored in the same vicinity of greasy or oily rags?
- _____ 64. Oxygen cylinders stored a minimum of 50 feet from flammable gas cylinders or a minimum five feet high fire wall with a 0.5 hour fire rating separates them?

Electrical

- _____ 65. All electrical equipment properly grounded? (Double insulated tools are exempt.)
- _____ 66. All electrical equipment U.L. listed and/or F.M. approved?
- _____ 67. Breaker boxes that may need maintenance while live have a minimum of 30" width clearance in front of them?
- _____ 68. All circuit breakers and fused circuits labeled to indicate whether they are in the open (off) or closed (on) position?
- _____ 69. Properly rated fuses used?
- _____ 70. All electrically live parts guarded? Electrical boxes and panels covered with face-plates to prevent exposure to live wires?
- _____ 71. Tool, appliance, instrument, and extension cords in good repair?
- _____ 72. Has permanent wiring been installed to alleviate the use of extension cords?
- _____ 73. Electrical cords or other lines not suspended unsupported across rooms or passageways?
- _____ 74. Cords not routed over metal objects?
- _____ 75. Cords not run through holes in walls or ceilings or through doorways or windows?
- _____ 76. Cords not placed under carpet, rugs, or heavy objects?
- _____ 77. Cords not placed in pathways or other areas where repeated abuse can cause deterioration of insulation?
- _____ 78. Octopus (multi-outlet) plugs not used? Approved multiple outlets with circuit breakers used instead?

General Safety Equipment

- _____ 79. Fire extinguishers located where flammable or combustible liquids are used?
- _____ 80. A fire extinguisher located between 10 feet and 25 feet of a door opening to rooms used for storage?
- _____ 81. Other extinguishers ready and accessible?
- _____ 82. Extinguishers mounted so that the top is not more than 5 feet above the floor, and not more than 3 feet if it weighs more than 40 lbs?
- _____ 83. Extinguishers suitable for the class of fire anticipated in each area?
- _____ 84. Extinguishers inspected and labeled as inspected on a yearly basis?
- _____ 85. Employees instructed in the proper use of fire extinguishers on an annual basis?
- _____ 86. Fire alarm boxes readily accessibly and within normal path distance of 200 feet.
- _____ 87. Fire alarm system tested on an annual basis?
- _____ 88. Eyewash and safety showers installed within 25 feet of laboratory work areas where corrosive chemicals are used?
- _____ 89. Safety showers and eyewash fountains easily accessible?
- _____ 90. Employees familiar with operation of safety showers and eyewash fountains?
- _____ 91. Safety showers and eyewash fountains tested at least annually?
- _____ 92. First aid kits available, in good condition, and plainly marked?
- _____ 93. Explosion-proof refrigerators not used for storage of food?
- _____ 94. Fume hoods in proper operating condition?
- _____ 95. Function of fume hoods periodically checked and results recorded and posted?
- _____ 96. Equipment properly placed in fume hoods? (i.e., nothing within 6 inches of sash and all instruments elevated a minimum of 2 inches from hood floor.)
- _____ 97. Fume hoods not used for storage?

Personal Protection

- 98. Eye protection provided and used by all personnel when in the laboratory area?
- 99. Eye protection provided for all guests that enter the laboratory?
- 100. Proper laboratory clothing provided and used by all personnel when in the laboratory area?
- 101. Laboratory clothing clean and in good repair?
- 102. Gloves provided and used when needed?
- 103. Proper gloves provided for each different solvent type?
- 104. Employees who are required to wear steel toe shoes comply?
- 105. Area provided outside the laboratory for eating and drinking; lab coats and protective clothing prohibited in this area?
- 106. Change rooms provided for each sex where it is necessary to change clothes?
- 107. Change rooms provided with separate storage facilities for street clothes and protective clothing?
- 108. Personal hygiene facilities provided and kept in sanitary condition?

Other

- 109. Noise levels checked and protection provided when needed?

APPENDIX I

LABORATORY ENVIRONMENTAL AUDIT FORM

Department:	Faculty Member:	Date:
Building:	Room #:	Phone #:
Fire Protection (Yes/No)	Electrical (Yes/No)	Biological Safety (Yes/No)
<input type="checkbox"/> Easy extinguisher access? <input type="checkbox"/> Inspection current? How many of each? Dry Chem ___ Halon ___ CO2 ___ APW ___	<input type="checkbox"/> Absence of overloaded circuits? <input type="checkbox"/> Electrical cords in good condition? <input type="checkbox"/> Proper grounding? <input type="checkbox"/> Absence of extension cords?	<input type="checkbox"/> Absence of live animals? <input type="checkbox"/> Are the workers trained? <input type="checkbox"/> Is PPE adequate? <input type="checkbox"/> Are there BioSafety cabinets?
First Aid (Yes/No)	Eye Wash Stations (Yes/No)	Safety Showers (Yes/No)
<input type="checkbox"/> Is the stock adequate? <input type="checkbox"/> Labeled? <input type="checkbox"/> Easy access? <input type="checkbox"/> Are the procedures posted?	<input type="checkbox"/> Proper location? <input type="checkbox"/> Inspected and tested? <input type="checkbox"/> Plumbed system? <input type="checkbox"/> Labeled?	<input type="checkbox"/> Proper location? <input type="checkbox"/> Tested and sealed? <input type="checkbox"/> Workable? <input type="checkbox"/> Labeled?
Staff Summary (+/-)	Hazard Communications (Yes/No)	Refrigerators (Yes/No)
<input type="checkbox"/> Safety practices <input type="checkbox"/> Haz-Com <input type="checkbox"/> PPE / spill training <input type="checkbox"/> Chemical hygiene plan	<input type="checkbox"/> Lab sign-in? <input type="checkbox"/> Safety rules posted? <input type="checkbox"/> Emergency procedures? <input type="checkbox"/> Containers labeled? <input type="checkbox"/> Emergency labels on entrance?	<input type="checkbox"/> Absence of food storage? <input type="checkbox"/> "Explosion-proof?" <input type="checkbox"/> Properly installed? <input type="checkbox"/> Marked for flammables? <input type="checkbox"/> Absence of domestic refrigerator?
General Use (Yes/No)	Housekeeping (Yes/No)	General Storage (Yes/No)
<input type="checkbox"/> Absence of hazardous materials? <input type="checkbox"/> Absence of explosives? <input type="checkbox"/> Absence of cryogenics? <input type="checkbox"/> Absence of laser hazard? <input type="checkbox"/> Absence of corrosives?	<input type="checkbox"/> Aisles clear? <input type="checkbox"/> Exits clear? <input type="checkbox"/> Haz-Waste collection? <input type="checkbox"/> Absence of eat/drink/smoke? <input type="checkbox"/> Absence of previous spills?	<input type="checkbox"/> Absence of leaking containers? <input type="checkbox"/> Glass containers all less than 4 liters? <input type="checkbox"/> Segregation of chemicals? <input type="checkbox"/> Absence of corroded containers? <input type="checkbox"/> Containers capped? <input type="checkbox"/> Glass shatter-proof?

Equipment Summary (count)		Ventilation (Yes/No)
Fume Hoods _____ Perc Hoods _____ Cano Hoods _____ BioSafety Hoods _____ Cylinder Dolly _____ Spill Kit _____	Explos. Frig. _____ Eye Wash _____ Exits _____ Safety Shower _____ Flam. Cab. _____ Spill PPE _____	<input type="checkbox"/> Adequate ventilation? <input type="checkbox"/> Absence of storage in hood? <input type="checkbox"/> Fume hoods adequate? <input type="checkbox"/> Velocity tested? <input type="checkbox"/> Lab neg. to other rooms? <input type="checkbox"/> Haz. exhaust labeled?
PPE (Yes/No)	Flammables (Yes/No)	Security (Yes/No)
<input type="checkbox"/> Goggles/shields? <input type="checkbox"/> Gloves? <input type="checkbox"/> Aprons? <input type="checkbox"/> Respirators? <input type="checkbox"/> Eye protection worn? <input type="checkbox"/> Other necessary equip.?	<input type="checkbox"/> Adequate cabinets? <input type="checkbox"/> Absence of excess storage? <input type="checkbox"/> Spill plan? <input type="checkbox"/> Safety cans? <input type="checkbox"/> Bonded/grounded? <input type="checkbox"/> Less than 300 gallons? <input type="checkbox"/> Absence of storage by exits?	<input type="checkbox"/> Intrusion alarms? <input type="checkbox"/> Security procedures? <input type="checkbox"/> Absence of past vandalism? <input type="checkbox"/> Key control? <input type="checkbox"/> Absence of custodial serv.? <input type="checkbox"/> Dead bolt? <input type="checkbox"/> If 2nd exit, emergency lights?
Gas Cylinders (Yes/No)		
<input type="checkbox"/> Cylinders secured? <input type="checkbox"/> Contents identified? <input type="checkbox"/> Caps on tightly? <input type="checkbox"/> If NFPA rating >2, 2nd exit?	<input type="checkbox"/> Two gauges? <input type="checkbox"/> Less than 3 cyl. in use? <input type="checkbox"/> Less than 9 cyl. in lab? <input type="checkbox"/> Shutoffs?	
Personal Protective Equipment		
Type:	Material Used On:	Condition:
Cylinders		
Number:	Contents:	Size:

Fume Hoods	
Hood #1	Hood #2
Type of work performed:	Type of work performed:
Location of hood in lab:	Location of hood in lab:
If next to exit, is there a 2nd exit? (yes/no) Emergency shut-off within 50 feet? (yes/no)	If next to exit, is there a 2nd exit? (yes/no) Emergency shut-off within 50 feet? (yes/no)
Type of hood (check)	Type of hood (check)
<input type="checkbox"/> Chemical <input type="checkbox"/> Perchloric Acid <input type="checkbox"/> Washdown? <input type="checkbox"/> Removable baffles? <input type="checkbox"/> Canopy <input type="checkbox"/> Biological <input type="checkbox"/> Radioactive	<input type="checkbox"/> Chemical <input type="checkbox"/> Perchloric Acid <input type="checkbox"/> Washdown? <input type="checkbox"/> Removable baffles? <input type="checkbox"/> Canopy <input type="checkbox"/> Biological <input type="checkbox"/> Radioactive
Last inspection date: _____ Avg. face velocity (ft./min.) _____ Location of fan that serves the hood: _____	Last inspection date: _____ Avg. face velocity (ft./min.) _____ Location of fan that serves the hood: _____
Inspector's name:	Inspector's name:
Alarms: (check)	Alarms: (check)
<input type="checkbox"/> Pressure <input type="checkbox"/> Face Velocity <input type="checkbox"/> Other:	<input type="checkbox"/> Pressure <input type="checkbox"/> Face Velocity <input type="checkbox"/> Other:
Filters: (check)	Filters: (check)
<input type="checkbox"/> HEPA <input type="checkbox"/> Charcoal <input type="checkbox"/> Scrubber <input type="checkbox"/> Other:	<input type="checkbox"/> HEPA <input type="checkbox"/> Charcoal <input type="checkbox"/> Scrubber <input type="checkbox"/> Other:
Ducts: (Yes/No)	Ducts: (Yes/No)
Negative pressure? _____ Absence of manifold? _____ if no, in shaft? _____ Outlet 10 ft. above roof? _____ (If Perchloric Acid...) Absence of manifold? _____ Straight path to roof? _____	Negative pressure? _____ Absence of manifold? _____ if no, in shaft? _____ Outlet 10 ft. above roof? _____ (If Perchloric Acid...) Absence of manifold? _____ Straight path to roof? _____
Comments:	
Inspector's Name	Inspector's Signature:

APPENDIX J – FORMS

1. REPORT OF ACCIDENT/ILLNESS FORM INSTRUCTIONS

A. [HTTP://OREGONSTATE.EDU/ADMIN/HR/BENEFITS/ROA.PD
F](http://oregonstate.edu/admin/hr/benefits/roa.pdf)

2. REPORT OF ACCIDENT/ILLNESS FORM

A. [HTTP://OREGONSTATE.EDU/ADMIN/HR/BENEFITS/ROA.PD
F](http://oregonstate.edu/admin/hr/benefits/roa.pdf)

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GLOSSARY

AA	Atomic absorption spectrophotometers
Action level	A concentration for a specific substance, calculated as an eight (8) hour time-weighted average, which initiates certain required activities such as exposure monitoring and medical surveillance. Typically it is one-half that of the PEL for that substance.
ACGIH	The American Conference of Governmental Industrial Hygienists is a voluntary organization of professional industrial hygiene personnel in government or educational institutions. The ACGIH develops and publishes recommended occupational exposure limits each year called Threshold Limit Values (TLVs) for hundreds of chemicals, physical agents, and biological exposure indices.
Acute Exposure	Single exposure episodes which occur over a short time period.
ANSI	The American National Standards Institute is a voluntary membership organization (run with private funding) that develops consensus standards nationally for a wide variety of devices and procedures.
ASHRAE	American Society of Heating, Refrigeration and Air Conditioning Engineers
Asphyxiant	A chemical (gas or vapor) that can cause death or unconsciousness by suffocation. Simple asphyxiants such as nitrogen, either use up or displace oxygen in the air. They become especially dangerous in confined or enclosed spaces. Chemical asphyxiants, such as carbon monoxide and hydrogen sulfide, interfere with the body's ability to absorb or transport oxygen to the tissues.
Biohazard Wastes	Discarded materials "that are biological agents or conditions (as an infectious organism or unsecure laboratory condition) that constitutes a hazard to man or his environment." This definition includes "any and all substances which contain materials to which organisms may cause injury or disease to man or his environment, but which are not regulated as controlled industrial waste."
BSC	Biological Safety Committee
BSO	Biological Safety Officer
"C" or Ceiling	A description usually seen in connection with a published exposure limit. It refers to the concentration that should not be exceeded, even for an instant. It may be written as TLV-C or Threshold Limit Value--Ceiling. (See also Threshold Limit Value).
Carcinogen	Any substance that causes the development of cancerous growths in living tissue, either those that are known to induce cancer in man or animals or experimental carcinogens that have been found to cause cancer in animals under experimental conditions.
C.A.S. Number	Identifies a particular chemical by the Chemical Abstracts Service, a service of the American Chemical Society that indexes and compiles abstracts of worldwide chemical literature called "Chemical Abstracts". These numbers are always contained in brackets.
CDC	Centers for Disease Control
CFR	Code of Federal Regulations

Chemical Hygiene Plan	A written program developed and implemented by the employer which sets forth procedures, equipment, personal protective equipment and work practices that are capable of protecting employees from the health hazards presented by hazardous chemicals used in that particular work place and meets the requirements of 29 CFR 1910.1450(e).
CHP	See Chemical Hygiene Plan
Chemical Reaction	A change in the arrangement of atoms or molecules to yield substances of different composition and properties. (See Reactivity).
Chronic Exposure	A series of exposures occurring over a longer period of time.
Combustible	A combustible liquid or an "Ordinary Combustible" such as wood, paper, etc.
Combustible Liquid	Any liquid having a flashpoint at or above 100 °F (37.8 °C), but below 200 °F (93.3 °C), except any mixture having components with flashpoints of 200 °F (93.3 °C), or higher, the total volume of which make up 99 percent or more of the total volume of the mixture.
Corrosive	Any gas, liquid, or solid that causes destruction of human tissue or a liquid that has a severe corrosion rate on steel. Generally, a substance that has a very low or a very high pH.
Cutaneous	Pertain to or affecting the skin.
Decomposition	The breakdown of a chemical or substance into different parts or simpler compounds. Decomposition can occur due to heat, chemical reaction, decay, etc.
Dermal	Pertaining to or affecting the skin.
Dermatitis	An inflammation of the skin.
Designated Area	An area which may be used for work with "select carcinogens, reproductive toxins, or substances which have a high degree of acute toxicity." A designated area may be the entire laboratory, an area of a laboratory, or a device such as a laboratory hood. A designated area shall be placarded to reflect the designated hazard.
Dose	The concentration of a substance and the time period during which the exposure occurs. The dose received links hazard and toxicity.
DOT	The United States Department of Transportation is the federal agency that regulates the labeling and transportation of hazardous materials.
Dyspnea	Shortness of breath; difficult or labored breathing.
Emergency Spills	Accidental chemical discharges that present an immediate danger to personnel and/or the environment. Under these circumstances, leave the spill site immediately and send for help. Management of these spills is the responsibility of specially trained and equipped personnel. Contact the campus police at 911 for response. They will notify the appropriate persons/departments. (See Section 1.1 - "Chemical Spills")
Employee	An individual employed in a laboratory work place who may be exposed to hazardous materials in the course of his or her assignments.

EPA	The Environmental Protection Agency is the governmental agency responsible for administration of laws to control and/or reduce pollution of air, water, and land systems.
EPA Number	The number assigned to chemicals regulated by the Environmental Protection Agency (EPA).
Erythema	A reddening of the skin.
Fires	
Class A	Fires in ordinary combustible materials such as wood, cloth, paper, rubber, and many plastics.
Class B	Fires in flammable liquids, oils, greases, tars, oil-base paints, lacquers and flammable gases.
Class C	Fires that involve energized electrical equipment where the electrical conductivity of the extinguishing medium is of importance; when electrical equipment is de-energized, extinguishers for class A or B fires may be safely used.
Class D	Fires in combustible metals such as potassium, sodium, lithium, magnesium, titanium, zirconium.
Flammable	Any substance which may be classified as a flammable aerosol, flammable gas, flammable liquid or flammable solid.
Flammable Aerosol	An aerosol that, when tested by the method described in 16 CFR 1500.45, yields a flame protection exceeding 18 inches at full valve opening, or a flashback (a flame extending back to the valve) at any degree of valve opening.
Flammable Gas	A gas that, at ambient temperature and pressure, forms a flammable mixture with air at a concentration of 13 percent by volume or less; or a gas that, at ambient temperature and pressure, forms a range of flammable mixtures with air wider than 12 percent by volume, regardless of the lower limit.
Flammable Liquid	Any liquid having a flashpoint below 100°F (37.8°C), except any mixture having components with flashpoints of 100°F (37.8°C), or higher, the total volume of which make up 99 percent or more of the total volume of the mixture.
Flammable Solid	A solid, other than a blasting agent or explosive, that is liable to cause fires through friction, absorption of moisture, spontaneous chemical change, retained heat from processing, or which can be ignited readily, and when ignited burns so vigorously and persistently as to create a serious hazard. A chemical shall be considered a flammable solid if, when tested by the method described in 16 CFR 1500.44, it ignites and burns with a self-sustained flame at a rate greater than one-tenth of an inch per second along its major axis.
Hazard	The possibility that exposure to a substance will cause injury when a specific quantity is used under certain conditions.
Health Hazard	A substance for which there is statistically significant evidence based on at least one study conducted in accordance with established scientific principles that acute or chronic health effects may occur in exposed employees. This term includes carcinogens, toxic or highly toxic agents, reproductive toxins, irritants, corrosives, sensitizers, hepatotoxins, nephrotoxins, neurotoxins, agents which act on the hematopoietic systems, and agents which damage the lungs, skin, eyes, or mucous membranes.
ICP	Inductively-coupled argon spectrometers

IDLH	Immediately dangerous to life or health concentrations represent the maximum concentration from which one could escape within 30 minutes without a respirator and without experiencing any escape-impairing (e.g., severe eye irritation) or irreversible health effects.
Ignitable	A solid, liquid, or compressed gas that has a flashpoint of less 140°F. Ignitable material may be regulated by the EPA as a hazardous waste, as well.
Incompatible	The term applied to two substances to indicate that one material cannot be mixed with the other without the possibility of a dangerous reaction.
Ingestion	Taking a substance into the body through the mouth as food, drink, medicine, or unknowingly as on contaminated hands or cigarettes, etc.
Inhalation	The breathing in of an airborne substance that may be in the form of gases, fumes, mists, vapors, dusts, or aerosols.
Inhibitor	A substance that is added to another to prevent or slow down an unwanted reaction or change.
Irritant	A substance that produces an irritating effect when it contacts skin, eyes, nose, or respiratory system.
LC₅₀	See Lethal Concentration ₅₀ .
LD₅₀	See Lethal Dose ₅₀ .
LEL	See Lower Explosive Limit.
Lethal Concentration₅₀	The concentration of an air contaminant that will kill 50 percent of the test animals in a group during a single exposure.
Lethal Dose₅₀	The dose of a substance or chemical that will kill 50 percent of the test animals in a group within the first 30 days following exposure.
LFL	See Lower Explosive Limit.
Lower Explosive Limit	(Also known as Lower Flammable Limit.) The lowest concentration of a substance that will produce a fire or flash when an ignition source (flame, spark, etc.) is present. It is expressed in percent of vapor or gas in the air by volume. Below the LEL or LFL, the air/contaminant mixture is theoretically too "lean" to burn. (See also UEL.)
Minor Spills	Small chemical leaks that usually are detected early and present no immediate danger to personnel or the environment. These are spills that can be safely corrected with the advice of knowledgeable laboratory or supervisory personnel.
MSDS	Material Safety Data Sheet (See Section 9.3)
Mutagen	Anything that can cause a change (or mutation) in the genetic material of a living cell.
Narcosis	Stupor or unconsciousness caused by exposure to a chemical.

NFPA	The National Fire Protection Association is a voluntary membership organization whose aims are to promote and improve fire protection and prevention. NFPA has published several volumes of codes known as the National Fire Codes.
NIH	National Institute of Health
NIOSH	The National Institute for Occupational Safety and Health is a federal agency that among its various responsibilities trains occupational health and safety professionals, conducts research on health and safety concerns, and test and certifies respirators for work place use.
Odor Threshold	The minimum concentration of a substance in the air at which a majority of test subjects can detect and identify the substance's characteristic odor.
OSHA	The Occupational and Safety Health Administration is a federal or state agency under the Department of Labor that publishes and enforces safety and health regulations for most businesses and industries in the United States.
OSU HAZCOMM	OSU Environmental Health Services Department Hazard Communications Section
OSU HAZMAT	OSU Environmental Health Services Department Hazardous Materials Section
Oxidizer	A substance such as chlorate, permanganate, inorganic peroxide, nitrocarbonitrate, or a nitrate that yields oxygen readily to stimulate the combustion of organic matter.
Oxygen Deficiency	An atmosphere having less than the normal percentage of oxygen found in normal air. Normal air contains approximately 21% oxygen at sea level.
PEL	See Permissible Exposure Limit.
Permissible Exposure Limit	An exposure limit that is published and enforced by OSHA as a legal standard. PEL may be either a time-weighted-average (TWA) exposure limit (8 hour), a 15-minute short term exposure limit (STEL), or a ceiling (C). The PELs are found in Tables Z-1, Z-2, or Z-3 of 29 CFR 1910.100. This level of exposure is deemed to be the maximum safe concentration and is generally the same value as the threshold limit value (TLV).
Personal Protective Equipment	Any devices or clothing worn by the worker to protect against hazards in the environment. Examples are respirators, gloves, and chemical splash goggles.
Physical Hazard	A substance which is a compressed gas, explosive, flammable, organic peroxide, oxidizer, pyrophoric, unstable or water reactive.
Polymerization	A chemical reaction in which two or more small molecules combine to form larger molecules that contain repeating structural units of the original molecules. A hazardous polymerization is the above reaction with an uncontrolled release of energy.
Reactivity	A substance's susceptibility to undergoing a chemical reaction or change that may result in dangerous side effects, such as explosion, burning, and corrosive or toxic emissions. The conditions that cause the reaction, such as heat, other chemicals, and dropping, will usually be specified as "Conditions to Avoid" when a chemical's reactivity is discussed on a MSDS.

Respirator	A device which is designed to protect the wearer from inhaling harmful contaminants.
Respiratory Hazard	A particular concentration of an airborne contaminant that, when it enters the body by way of the respiratory system or by being breathed into the lungs, results in some bodily function impairment.
Sensitizer	A substance that may cause no reaction in a person during initial exposures, but afterwards, further exposures will cause an allergic response to the substance.
Sharps	Hypodermic needles, syringes, (with or without the attached needle), pasteur pipettes, scalpel blades, suture needles, blood vials, needles with attached tubing, and culture dishes (regardless of presence of infectious agents). Also included are other types of broken or unbroken glassware that were in contact with infectious agents, such as used slides and cover slips.
Short Term Exposure Limit	Represented as STEL or TLV-STEL, this is the maximum concentration to which workers can be exposed for a short period of time (15 minutes) for only four times throughout the day with at least one hour between exposures.
"SKIN"	This designation sometimes appears alongside a TLV or PEL. It refers to the possibility of absorption of the particular chemical through the skin and eyes. Thus, protection of large surface areas of skin should be considered to prevent skin absorption so that the TLV is not invalidated.
STEL	See Short Term Exposure Limit
Synonym	Another name by which the same chemical may be known.
Systemic	Spread throughout the body; affecting many or all body systems or organs; not localized in one spot or area.
Teratogen	An agent or substance that may cause physical defects in the developing embryo or fetus when a pregnant female is exposed to that substance.
Threshold Limit Value	Airborne concentrations of substances devised by the ACGIH that represents conditions under which it is believed that nearly all workers may be exposed day after day with no adverse effect. TLVs are advisory exposure guidelines, not legal standards, that are based on evidence from industrial experience, animal studies, or human studies when they exist. There are three different types of TLV's: Time Weighted Average (TLV-TWA), Short Term Exposure Limit (TLV-STEL) and Ceiling (TLV-C). (See also PEL.)
Time Weighted Average	(TLV-TWA, Threshold Limit Value-Time Weighted Average) The time weighted average airborne chemical concentration for a normal eight hour work day and a 40 hour work week to which nearly all workers may be repeatedly exposed, day after day, without adverse effect.
TLV	See Threshold Limit Value.
Toxic	Substances such as carcinogens, irritants, or poisonous gases, liquids, and solids which are irritating to or affect the health of humans.
Toxicity	The potential of a substance to exert a harmful effect on humans or animals and a description of the effect and the conditions or concentrations under which the effect takes place.

Trade Name	The commercial name or trademark by which a chemical is known. One chemical may have a variety of trade names depending on the manufacturers or distributors involved.
TWA	See Time Weighted Average.
UEL	See Upper Explosive Limit.
UFL	See Upper Explosive Limit.
Unstable Liquid	A liquid that, in its pure state or as commercially produced, will react vigorously in some hazardous way under shock conditions (i.e., dropping), certain temperatures, or pressures.
Upper Explosive Limit	Also known as Upper Flammable Limit. Is the highest concentration (expressed in percent of vapor or gas in the air by volume) of a substance that will burn or explode when an ignition source is present. Theoretically above this limit the mixture is said to be too "rich" to support combustion. The difference between the LEL and the UEL constitutes the flammable range or explosive range of a substance. (See also LEL.)
Vapor	The gaseous form of substances which are normally in the liquid or solid state (at normal room temperature and pressure).
Water Reactive	Substances that react violently when in contact with water. They can be either be flammable solids or corrosives