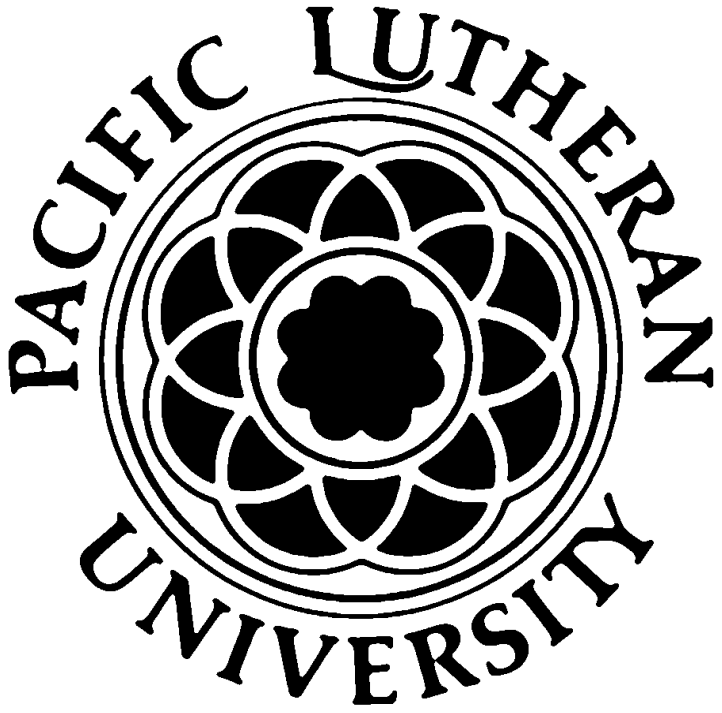
DIVISION OF NATURAL SCIENCES



CHEMICAL HYGIENE PLAN

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Emergency reference numbers:
Police, Fire, or Ambulance 9-911
Campus Safety x7911

Acknowledgement
Pacific Lutheran University would like to acknowledge the University of Illinois at Urbana-Champaign, Davidson College, and Saint Olaf College, from whom we have adopted portions of this Chemical Hygiene Plan.

Revision Date: December 2011

Pacific Lutheran University
Chemical Hygiene Plan

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1. Introduction

It is the goal of Pacific Lutheran University (PLU) to provide a workplace free from recognized hazards likely to cause physical harm to its employees and students. PLU is committed to ensuring that the procedures, engineering controls, safety and emergency equipment, personal protective equipment, and work practices outlined herein are capable of protecting faculty, students, staff and visitors from the health hazards presented by hazardous chemicals in laboratories and support areas.

PLU's Chemical Hygiene Plan (CHP) is written in accordance with the requirements of OHSA's Laboratory Standard *Occupational Exposure to Hazardous Chemicals in Laboratories*, 29 CFR 1910.1450, (attached as Appendix A) and is applicable to all laboratory employees. Laboratory employees include faculty, staff, teaching assistants, paid research students, and stockroom assistants. The departments covered under this CHP include Chemistry, Biology, Geosciences, and Physics as well as the Environmental Studies Program.

The CHP does not specifically cover students enrolled at PLU, but it is strongly suggested that the faculty in each department discuss the elements of the CHP with each student working in a laboratory. Further, it is the intention that this CHP complies with all federal, state, and local laws and regulations that pertain to the health and safety of these individuals. The standard operating procedures (laboratory practices and engineering controls) recommended in this CHP identify the safeguards that should be taken when working with hazardous chemicals. While these safeguards should protect laboratory workers from unsafe conditions in most situations, there is no substitute for personal knowledge and vigilance when working with hazardous chemicals.

1.1 Chemical Hygiene Plan Roles and Responsibilities

PLU has the responsibility to provide a safe workplace that is in full compliance with all laws and regulations at the local, state, and federal levels. A fully implemented CHP and a concerned employer, in full legal and regulatory compliance, cannot assure a workplace without any hazards. All employees have a responsibility to themselves and their co-workers to observe the training and procedures of the CHP and other sources in order to make the laboratories of the Rieke Science Center a safe place to work and learn.

The authority and responsibility for implementation of chemical hygiene policies at the operating level are delegated by PLU's Chemical Hygiene Officer (CHO) to the Division of Natural Sciences. To fully implement chemical hygiene policies, the assistance and cooperation of all laboratory staff is necessary. The following descriptions outline key roles and responsibilities of all PLU employees involved in implementation of this plan.

Identification of Current Assigned Roles

Loren J. Anderson – *President*

The ultimate responsibility for all University activities rests with the President.

Steven P. Starkovich – *Provost*

The responsibility for the activities of all academic units of the University, including the Division of Natural Sciences, rests with this officer as delegated by the President.

Matthew J. Smith – *Dean, Division of Natural Sciences*

The responsibility for the activities of the Division of Natural Sciences, which operates the laboratories of the Rieke Science Center, rests with this Dean as delegated by the President through the Provost.

Terrence D. Nicksic – *Chemical Hygiene Officer, Division of Natural Sciences*

The direct responsibility for the development, implementation, and revision of the Chemical Hygiene Plan rests with this employee as delegated by the Dean of the Division of Natural Sciences.

Ann J. Auman – *Chair, Department of Biology*

Craig B. Fryhle – *Chair, Department of Chemistry*

Jill M. Whitman – *Chair, Department of Geosciences*

Richard N. Louie – *Chair, Department of Physics*

The ultimate responsibility for implementation of the Chemical Hygiene Plan on the departmental level rests with the Department Chairs as delegated by the Dean of the Division of Natural Sciences.

1.1.1 Deans/Chairs and Higher Administration

PLU President: Responsibility for chemical hygiene rests at all levels, including the President, who has ultimate responsibility for promoting the importance of safety in all activities and chemical hygiene within the institution and must, with other administrators, provide continuing support for institutional chemical hygiene (29 CFR 1910.1450 Appendix A, Sect. B.1).

Academic Provost and Dean: Responsible for providing for the health and safety of their faculty, staff, students, and visitors. Promote the importance of safety in all activities and establishing environmental, safety, and regulatory compliance as a priority so that work activities do not violate health and environmental standards. Support a broad-based laboratory safety/chemical hygiene program that will protect laboratory workers from health effects associated with hazardous chemicals, biological, or physical agents. Ensure that Department Chairs provide adequate time and resources for employees who are given laboratory safety responsibilities. Ensure a Divisional member is elected to the PLU Safety Committee.

Chairs: Provide supervision of the department and have the primary responsibility for chemical hygiene in that department (29 CFR 1910.1450 Appendix A, Sect. B.2).

- Promote the importance of safety in all activities.
- Ensure that faculty, staff, and undergraduate research/teaching assistants adhere to the CHP and to accepted safety practices, and promote the importance of safety in all activities.
- Ensure that each laboratory has designated someone as supervisor who is familiar with the CHP and is responsible for the overall safety of the laboratory. This is especially important for labs that have many users, such as teaching labs or joint research labs. Chemistry and Biology have these positions built into their organizations. In the case of research labs, the principal investigator will take on this role.

- Support a broad-based laboratory safety/chemical hygiene program that will protect laboratory workers from health effects associated with hazardous chemicals, biological, or physical agents.
- Ensure that laboratory supervisors, Faculty, and Principal Investigators are provided adequate time and resources to complete all laboratory safety responsibilities.
- Work with faculty and staff to adapt the CHP to include department- or lab-specific guidelines.
- Exercise authority to stop a laboratory activity due to observing conditions/practices that could result in unsafe health & safety work conditions. Chair has the explicit authority to suspend the practice/policy and refuse to allow employees to work in the particular location or perform a particular procedure until the problem is corrected.

1.1.2 Faculty/Principal Investigator (PI)

Faculty/PIs have specific responsibilities toward providing a work environment free from environmental, health and safety hazards for those supervised. Each faculty member/PI's responsibilities include:

- Provide information about relevant environmental, health, and safety rules, regulations, standards, or practices.
- Assure that required safety-related equipment and personal protective devices are provided, maintained, and used.
- Observe safety procedures and see that they are followed by your students, student assistants, and student researchers.
- Set an example by wearing the appropriate PPE and by following proper laboratory procedures to promote safe work habits; ensure that students are wearing the appropriate PPE.
- Carefully review laboratory experiments for possible safety problems before the experiments are assigned to students.
- Take prompt action when unsafe acts or hazardous conditions are reported or noted.
- Be sure students are familiar with emergency procedures and equipment.
- Provide or arrange for environmental, health, and safety training and education as needed.
- Require that visitors and students follow the same safety procedures as laboratory workers. If they refuse to follow the procedures, politely instruct them to leave the room; if they refuse then immediately contact the department chair and the CHO.
- Make sure Material Data Safety Sheets and additional sources of hazard information are readily available to all students; encourage their use.
- Inform the CHO of *any* accidents involving exposure to hazardous chemicals, fire, significant property damage; or call an external agency (police, fire, OSHA). Report hazardous conditions to the CHO.
- Develop written standard operating procedures (SOPs), such as lab manuals, for ongoing activities in teaching labs. Review and update (if necessary) procedure-specific SOPs at least annually or whenever conditions in the lab change.
- Promptly investigate and report all on-the-job accidents and/or job-related health problems and request medical treatment, if needed.
- Take prompt action to prevent and clean up spills to the environment. Encourage and train employees to use recommended best management practices to prevent and reduce pollution on campus.
- Request the assistance of the next higher level of supervision regarding budget requests for environmental, health, and safety improvements.

1.1.3 Chemical Hygiene Officer

The CHO is responsible for providing technical guidance in the development of the provisions of the CHP and works with the science faculty, laboratory managers and staff to develop and implement appropriate chemical hygiene policies and practices and to continually seek to improve the chemical hygiene program. In emergency situations or cases where there is a clear and present danger existing in a laboratory, the CHO has the authority to cease a particular laboratory procedure or all laboratory operations.

The CHO is also required to:

- Inspect laboratory facilities periodically to ensure compliance with the provisions of the CHP.
- Monitor health and safety conditions at laboratory facilities and investigate accidents/exposures.
- Maintain training records.
- Review and update the Chemical Hygiene Plan annually or as circumstances deem necessary.
- Ensure that safety devices (i.e. safety showers, eye washes, fire extinguishers and fume hoods) are working properly and serviced as required.
- Remain abreast of regulatory and legal requirements associated with use of hazardous chemicals.
- Ensure that workers/students know and follow chemical hygiene policies and practices

1.1.4 Laboratory Workers (Student Assistants & Paid Research Assistants)

Laboratory Workers are expected to be familiar with PLU's CHP. Laboratory employees are also required to:

- Plan and conduct each laboratory operation in accordance with a standard written lab protocol.
- Become familiar with good standard practices with procedures and chemicals they are involved with by reviewing current literature, available Material Safety Data Sheets and applicable PLU safety policies.
- Wear the personal protective equipment required for each task to which they are assigned.
- Use engineering controls and safety equipment properly and according to the requirements outlined in this CHP.
- Develop good personal chemical hygiene habits.
- Participate in all required training programs.
- Report to the responsible faculty, who will in turn report to the CHO all facts pertaining to accidents resulting in exposure to hazardous chemicals, and any action or condition that may cause an accident and/or exposure to hazardous chemical.

1.1.5 Facilities Management

In order to ensure the safety of new and renovated laboratories, specific design and construction features are required by state and federal codes. All design, construction, and/or major modifications of laboratory facilities where hazardous chemicals are used or stored must be reviewed and approved by: Division of Natural Sciences – Dean; Director of Facilities Management; Environmental Health & Safety Manager; and Chemical Hygiene Officer.

It is recognized that Facilities Management constantly receives requests & work orders for a tremendous variety of projects. To ensure the health & safety of all employees, students, and visitors certain safety-related requests must take priority over non-safety requests, and in many cases must have an immediate response (fume hood and ventilation problems; safety shower and eyewash station problems; electrical problems/exposed wiring, etc.). In the event of an untimely equipment

failure, Facilities Management must be notified and the problem addressed immediately. Equipment not operating properly must be tagged “Out Of Service” until repairs and confirmation testing has been completed.

Facilities personnel often enter rooms that potentially contain hazardous chemicals, and some individuals (i.e. custodians and technicians) use chemicals on a daily or regular basis. PLU staff is required to read, and follow all aspects of the PLU’s Hazard Communication Program (http://www.plu.edu/safety/documents-forms/home.php).

1.1.6 General Safety

The following general responsibilities apply to all individuals who work with, or in areas containing, hazardous chemicals:

- The responsibility for chemical hygiene and safety rests at all administrative and academic levels.
- All PLU faculty, staff, and employed students who work with chemicals are responsible for keeping safe all work areas where chemicals are used/stored.
- Each person working with or around chemicals, and having been trained, is responsible for remaining aware of the hazards of those materials and handling those chemicals in a safe manner. All Permissible Exposure Limits (PELs) and Action Levels must be followed.
- Each laboratory worker is responsible for knowing how to handle a hazardous chemical safely according to its types of hazards.
- Everyone shares the responsibility to ensure that all containers of chemicals are properly labeled with the identity of the chemical and its hazards.
- If you are unsure of a hazard or safety procedure, ASK!
- Reporting an Unsafe Situation – ALL PERSONS!

If you notice anything that you feel might represent an unsafe condition, please report immediately these conditions/concerns to the CHO.

1.2 OSHA Laboratory Standard: Purpose/Scope/Application

The Laboratory Standard applies to employers and employees who are involved with the laboratory use of hazardous chemicals. A hazardous chemical is defined as “a chemical 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.”

A laboratory is defined as “a facility where the laboratory use of hazardous chemicals occurs, and relatively small quantities of hazardous chemicals are used on a non-production basis.” Laboratory use of hazardous chemicals means the handling or use of such chemicals in which all of the following conditions are met:

- The handling or use of chemicals occurs on a 'laboratory scale', that is, the containers used for reactions, transfers, and other handling of substances are designed to be easily and safely manipulated by one person.
- Multiple chemical procedures or chemical substances are used.
- The procedures involved are not part of a production process, nor in any way simulate a production process.
- Protective laboratory practices and equipment are available and in common use to minimize the potential for employee exposures to hazardous chemicals.

At a minimum, these regulations apply to PLU employees and visiting researchers who use chemicals in teaching, research, or in stockrooms. These individuals are required to follow all relevant policies, procedures, and guidelines presented in this CHP.

In consultation with individual academic departments, certain non-traditional settings, such as the Desserts & Demos or Mole Day Celebration put on by the Chemistry department, where laboratory-like activities occur may be included under this CHP.

It is the policy of PLU that laboratory students, while not legally covered under this standard, will be given training commensurate with the level of hazard associated with their laboratory work. The Laboratory Standard does not apply to:

- Laboratory use of chemicals that provide no potential for employee exposure.
- Facilities Management staff are covered by (and must follow) PLU's Occupational Health, Safety and Accident Prevention Manual.
- School of Art and Communication faculty/staff are covered by (and must follow) PLU's Occupational Health, Safety and Accident Prevention Manual.

As defined in the OSHA Laboratory Standard, PLU developed and implemented this written CHP setting 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 laboratory
- Keeping chemical exposures below PELs as specified in 29 CFR 1910, subpart Z (attached as Appendix B)
- Indicating specific measures that PLU will take to ensure laboratory employee protection
- Being readily available to employees, employee representatives and OSHA Assistant Secretary of Labor. PLU's CHP on-line Division of Natural Sciences Web Page (http://www.chem.plu.edu/chem_hygiene_plan) and a hard copy in the Chemical Hygiene Officer's (CHO) office.

1.3 Additional Regulatory Information

As previously written, the Laboratory Standard is the primary OSHA regulation concerning work with chemicals in academic laboratories, and supersedes the requirements of all other health standards in 29 CFR 1910 Subpart Z except for the requirement of limiting exposure levels to below the PELs. While the Laboratory Standard supersedes the remaining sections of Subpart Z, other standards not specifically addressed remain applicable. For example, Subpart H of 29 CFR 1910 addresses physical hazards such as compressed gases, flammable liquids, combustible liquids, explosives, and anhydrous ammonia. Subpart I of 29 CFR 1910 addresses personal protective equipment and Subpart G addresses ionizing and non-ionizing radiation.

OSHA's Hazard Communication Standard (29 CFR 1910.1200) requires that employers develop, implement, and maintain a written Hazard Communication Program that provides information to their employees about the hazardous chemicals to which they are exposed, and is designed to ensure the safety of employees from exposure to hazardous chemicals by including information on:

- Labels and other forms of warning
- Material safety data sheets
- Information and training
- How the employer will implement the Program
- A list of the hazardous chemicals known to be present
- Methods the employer will use to inform employees of the hazards of non-routine tasks
- Methods the employer will use to inform employees of chemicals contained in unlabeled pipes in their workstation

Besides OSHA standards, the Washington State Department of Ecology governs the management of hazardous wastes. Protection from radiation hazards is regulated by both OSHA and the Nuclear Regulatory Commission. In addition, components of the Toxic Substances Control Act apply to academic laboratories.

Also applicable is the General Duty Clause [29 USC, Section 5(a) and (b)] which is to assure that the workplace is free from recognized hazards that are causing or likely to cause serious physical

harm to employees. Any serious hazard not covered by a specific provision of OSHA may be subject to a citation under the General Duty Clause when:

- Employees were exposed to a hazard.
- The employer failed to keep the workplace free of the hazard or should have recognized the hazard based on industry standards or national consensus standards.
- The hazard is likely to cause death or serious physical harm.
- A feasible method is available to correct the hazard.

OSHA has allowed individual states to develop their own set of safety standards, provided that the standards are at least as encompassing as 29 CFR 1910. The Washington State Legislature enacted the Worker and Community Right-to-Know Act in 1984 to help people understand the potential dangers of the hazardous chemicals they work with and live near. The law's purpose is to protect the safety and health of people at work and at home.

The Washington State Department of Labor & Industries administers the Worker Right-to-Know portion of the law through the Employer Chemical Hazard Communication rule, WAC 296-800-170. The rule requires employers to inform and train their employees about the hazards of chemicals they may be exposed to during normal working conditions, or in foreseeable emergencies.

Subpart I of 29 CFR 1910 ensures that employees are provided with and have appropriate training in the use of personal protective equipment including eye protection, face protection and respiratory tract protection. Also applicable are associated American National Standard Institute (ANSI) Standards.

Protection from the hazards associated with radiation including ionizing radiation, non-ionizing radiation and radioactive materials is required by WAC 246-221.

The Department of Ecology oversees the proper management of hazardous waste and has a series of regulations (http://www.ecy.wa.gov/waste.html). Included are manifesting rules, storage rules, record-keeping requirements, training requirements and emergency response requirements. Also applicable are 49 CFR 100 to 199 (Department of Transportation Rules). PLU's Hazardous Waste Management program can be found @ (http://www.plu.edu/safety/documents-forms/home.php).

The purpose of the Toxic Substances Control Act (TSCA) (http://www.epa.gov/lawsregs/laws/tsca.html) is to control new or existing chemicals that may present unreasonable health risks. The part of TSCA that directly affects research laboratories is Part 8c, which includes record keeping requirements for significant adverse reaction allegations.

The purchase, use, storage, and disposal of controlled substances is regulated by the U.S. Drug Enforcement Agency (21 CFR, Part 1300 to end), and Washington State Department of Ecology (http://www.ecy.wa.gov/programs/hwtr/pharmaceuticals/pages/controlsub.html).

Fire protection and fire safety are addressed in the OSHA standards 29 CFR 1910.157 and 1910.138. OSHA requires that personnel be trained in basic fire safety and that available firefighting equipment is maintained. Also applicable are the Uniform Fire Code and the National Fire Protection Association (NFPA) Standards.

2. Standard Operating Procedures

This document represents a minimum set of guidelines for the handling of toxic chemicals on campus. Individual departments and faculty are expected to develop more detailed procedures as their situations warrant. CHO, faculty, and lab managers are responsible for complying with and/or enforcing appropriate safety and hygiene measures in the work areas they supervise. The CHO and EHS Manager are available for assistance to develop safe procedures for situations not covered in this guide.

Rules or standard operating procedures which apply to the Division of Natural Sciences include the following:

2.1 General Procedures

Respect and understand the safety and health hazards associated with the chemicals and equipment you use, and practice the following general safety guidelines at ALL times:

2.1.1 Accident Response (See Also Section 5.4)

If an injury requiring emergency medical assistance has occurred, call 9-911. The emergency

response number should be posted in all offices, labs and work areas. Chemical spills: If a toxic/hazardous chemical has made contact with the skin, start flushing the area immediately. If emergency assistance is required, call 9-911.

2.1.1.1 Chemical Spills (See Also Section 5.6)

Spills of toxic substances or hazardous chemicals should be resolved immediately. Laboratory personnel should be aware of the volume of material that could be released; its chemical, physical and hazardous properties by checking the MSDS and any recommended unusual spill cleanup procedures. All spills will be handled by trained cleanup personnel and the CHO will be notified.

Simple spills

- If a spill is flammable, attempt to turn off ignition and heat sources.
- All cleanup material should be labeled and assessed for disposal as hazardous waste.
- Report all spill incidents to the EHS Manager x7233

Complicated spills

- clear the area immediately
- pull the fire alarm
- evacuate the lab
- call 9-911 from a safe location and notify Campus Safety x7911

If a spill has taken place, confine the spill by pouring an inert absorbent material around the edge of the spill. Reactive chemicals should be neutralized. Add the neutralizer in small amounts to avoid a violent reaction until enough has been added to completely neutralize the entire spill. Once the spill has been absorbed and neutralized it can be removed. The resultant material should be disposed of properly as chemical waste.

2.1.2 Animal Research

PLU abides by the NIH Animal Care guidelines. If working with or planning on working with animals at PLU, you must communicate with the PLU Institutional Animal Care and Use Committee (IACUC) Chair.

2.1.3 Children and Unauthorized Persons

Children and other unauthorized persons generally should not be in laboratories where hazardous materials or hazardous equipment are being used. Exceptions might be granted for non-traditional uses of laboratories in consultation with the CHO.

2.1.4 Disposal of Chemicals

Disposal of chemicals should be coordinated through the lab manager in either Chemistry or Biology and scheduled by the PLU's EHS Manager.

No chemicals should be disposed of in sinks or in containers designated for non-chemical waste. Chemicals that are to be discarded should be placed in containers clearly labeled with the identity of the contents and their hazards. A log of discarded chemicals will be maintained.

2.1.5 Electrical

Access to electrical equipment (e.g., plugs, switches and electrical panels) should be maintained free from obstructions to allow immediate access in an emergency. Extension cords should not be used as substitution for fixed receptacle outlets. When utilized, all electrical extension cords used should be visible and should not run in aisles or corridors where they might be damaged or create a tripping hazard. Cords should not be run through doors, walls or partitions, under rugs, or above dropped ceilings.

2.1.6 Emergency Eye Wash/Safety Showers Inspection (See Also Section 5.3.2)

Emergency showers are designed to provide first aid treatment to prevent permanent eye and skin damage from chemical burns or foreign substances. Be certain safety showers/emergency eyewashes are properly located and maintained. These units should be located in areas, which will be immediately accessible (reachable within 10 seconds). There should be no obstructions that might inhibit the use of this equipment. Some labs are equipped with emergency eyewash and shower stations.

Eye washes and safety showers should be flushed on a weekly basis to verify that the units are working and to clear the lines of stale water and debris. Whenever these emergency units are checked for proper functioning, written documentation showing the date and person's initials performing the check should be maintained.

2.1.7 Equipment

Use proper equipment that is in good condition. For example, never use chipped or cracked glassware. Shield pressurized or vacuum apparatus and safeguard against bumping or overheating.

2.1.8 Fire Extinguishers (See Also Section 5.3.3)

Fire extinguishers must be available, charged, and hung in a location, which is immediately accessible. There should be no obstructions that might inhibit the use of this equipment. Make sure that all extinguishers are checked annually. Each extinguisher should have a tag indicating the date it was last checked.

2.1.9 Food, Drink, Cosmetics, and Smoking

Eating, drinking and the application of cosmetics are forbidden in areas where hazardous chemicals are used. If you have been using chemicals, be sure to wash your hands before eating/drinking/applying cosmetics.

Separate refrigerators, ovens, and microwave ovens are required for preparation and/or storage of food from those used for chemicals, biohazards or radioactive materials. Food must never be stored or prepared in a laboratory appliance.

No smoking in laboratories. If you have been using chemicals, be sure to wash your hands before smoking.

2.1.10 Horseplay

Practical jokes or other behavior that might confuse, startle, or distract another worker is forbidden when hazardous chemicals are present.

2.1.11 Housekeeping

Exits, aisles and safety equipment must NOT be obstructed in any way with equipment, furniture, or other items. Aisles within the laboratory should be 36 inches in clear width. Work areas and floors are not to be used for excessive storage. Doors which are not in use but which are accessible from a corridor or adjacent room should be appropriately labeled if they are blocked on the interior of the room. Hallways are not to be used as storage areas.

Only glassware and chemicals for the experiment at hand should be out. The work surface must be kept free of anything not needed for the experiment. All chemicals, glassware and non-permanent set-ups from earlier experiments should be removed. Glassware should be cleaned immediately after an experiment is completed. Chemical spills, no matter how small, must be cleaned up immediately. Keep drawers and cabinet doors closed when working.

There should be separate containers for trash and broken glass. Chemical and waste containers should be labeled at all times. Do not store chemicals or equipment in laboratory fume hoods.

2.1.12 Do not use mouth suction to pipet any materials or to start a siphon.

2.1.13 Signs (See Also Section 5.1)

An emergency contact card is recommended on each laboratory entrance. This card should contain emergency phone numbers for the primary contact persons who are familiar and/or responsible for the oversight of the laboratory.

OSHA recommends the use of signs to alert employees to hazards. Danger signs indicate immediate specific hazards and which special precautions are necessary. Caution signs are used to warn against potential hazards or to caution against unsafe practices. Safety signs are used to provide general instructions and suggestions about safety measures.

2.1.14 Hazard Awareness (See Also Section 5.6.2)

Prior to working with a chemical, you should be familiar with its hazards and properties. Always check the MSDS beforehand for special precautions, wear the proper personal protective equipment, and assess potential spill hazards. Each laboratory worker should be familiar with general spill response procedures. Written protocols should be developed when extremely hazardous or large quantities of chemicals are used. Have readily available all necessary spill cleanup materials.

2.1.15 Unattended Experiments

If operations involving hazardous substances are carried out with no one present, it is the responsibility of the principal investigator to design procedures to prevent the release of hazardous substances in the event of interruptions in utility services such as electricity, cooling water, and inert gas. Room lights should be left on, an Experiment in Progress Form should be posted on the door and near the experimental set-up, identifying the nature of the operation and the hazardous substances in use, your name, who to contact and what actions to take in the event of an emergency. If appropriate, arrangements should be made for other persons to periodically inspect the operation.

2.1.16 Working Alone

NEVER carry out hazardous work alone in a laboratory or chemical storage area. Make sure someone is in visible or audible range to help you if something goes wrong. Regardless of the work function, there should be a check procedure established at some regular interval to determine the physical state of any person working alone. Keep aware of your neighbors. Make sure there is an unlocked entrance to any room in which you are working.

If an individual department allows students to work outside of normal building access hours, they must work in pairs when handling hazardous materials or dangerous equipment.

2.2 Pollution Prevention and Waste Minimization (ACS's 12 Principles of Green Chemistry)

Waste minimization strategies usually have the dual benefits of improving safety and reducing chemical purchase and disposal costs. It is recommended that each unit evaluate its procedures periodically to consider the possible usage of less hazardous or smaller quantities of chemicals. This evaluation may include the following issues:

- Is there a working chemical inventory?
- Is there good housekeeping where chemicals are used and stored?
- Are all containers properly labeled?
- Do the chemicals in use present significant hazards to those working with them? (e.g. highly reactive, highly toxic, carcinogenic, and/or corrosive chemicals should be discouraged). When applicable design, develop and implement process and products to reduce or eliminate the use/generation of substances hazardous to human health and the environment. If applicable, consider substitutes for all uses of mercury, chromium, lead, and cadmium.

- Environmentally-friendly cleaning solutions

2.3 Handling and Storage of Chemicals

Hazards associated with various chemicals and gases vary widely. Understanding the hazards associated with a compound and minimizing the quantity used and stored in the lab will decrease chance of injury.

The proper storage of chemicals is complicated by the diverse individual physical properties of the numerous chemicals that may be present in the laboratory. Some general procedures for chemical storage are listed below. However, these procedures are not intended to be all-inclusive but rather to serve to supplement more specific procedures adopted for particular laboratory situations. Specific instructions on chemical storage may be obtained from the MSDS, container label, and by contacting the CHO.

- Ensure that all containers are in good condition and properly labeled.
- Stored chemicals should be examined periodically (at least annually) for replacement, inactive status, deterioration, and container integrity.
- Unneeded items shall be properly discarded in accordance with existing local, state, and federal regulations.
- Storage on bench tops, hoods, and sinks should be avoided.
- Ensure that all storage locations are dry and adequately ventilated.
- Use spill trays, spill and shatterproof containers, secondary containers, and proper receptacles as needed.
- Large bottles of chemicals (> 500 mL), especially corrosives and solvents, should not be stored on shelves higher than 5 feet.
- Chemicals should be segregated by hazard classification. Once segregated by hazard class, chemicals may be stored alphabetically. Basic segregations should keep oxidizers away from organics; air/water reactives away from air and water; and caustics, cyanides, and sulfides away from acids.
- Volatile chemicals should be stored in cabinets designed for that chemical property.
- When volatiles must be stored in a cooled atmosphere, flammable material refrigerators, explosion-proof refrigerators or cold rooms designed for this purpose must be used.

When hazardous chemicals are hand carried, they should be placed in protective containers to protect against breakage and spillage. When a chemical is being transferred from one container to another, one should be sure the new container is compatible with the chemical and is labeled with the identity of the chemical and the hazards it poses. All chemical containers must be capped and sealed when not in use.

Whenever chemicals are transported outside the laboratory, the primary container should be placed in a secondary, non-breakable carrier. Before moving containers, check and tighten caps, taps, or other enclosures

2.3.1 Compressed Gases

Use appropriate handcarts to move compressed gas cylinders. Compressed gas cylinders should never be rolled or dragged. Gas cylinders should be capped and secured to a cart during transport. Highly toxic gases should not be moved through the corridors, particularly during business hours. Always consider cylinders as full and handle them with corresponding care.

Gas cylinders should be stored in well-ventilated areas with their protective caps on. Gas cylinders should be secured (e.g., strapped or chained in place) to reduce the chance of being knocked over. Do not store cylinders near heat or high traffic areas. Do not store flammables and oxidizers together. Do not store empty and full cylinders together. Storage of large quantities of cylinders should be in an approved gas cylinder storage area.

All cylinders should have a three-part tag attached to the body of the cylinder indicating whether the cylinder is "Full," "Partly Full," or "Empty." These tags may be requested from the CHO.

Before a regulator is removed from a cylinder, the cylinder valve should be closed and the regulator relieved of gas pressure.

2.3.1.1 Leaking Cylinder

Should a compressed gas cylinder show major signs of leakage, the following steps should be taken:

- Notify the CHO, the Environmental Health & Safety Office and Campus Safety immediately as this is a chemical release, only trained personnel may respond.
- For toxic gases, evacuate the area immediately.
- For flammable gases, turn off ignition sources and evacuate immediately.
- Place an appropriate sign at the entrance of the laboratory or storage area warning others of the hazard present.
- Afterwards, notify the gas supplier, and follow instructions as to the return or disposition of the cylinder.

2.3.1.2 Cryogenic Liquids

These items present the potential hazards of fire or explosion, pressure buildup, embrittlement of structural materials, frostbite, and asphyxiation. Work areas must be well ventilated. Cryogenic liquids must be stored, shipped, and handled in containers that are designed specifically for this purpose. Because of the extreme cold and splash hazards, skin protection and eye protection - preferably a face shield - should be worn when handling cryogenic liquids. First time users of cryogenic liquids should have direct supervision and instruction from an experienced user when attempting transfers from one container to another.

2.3.1.3 Peroxide Formers

Peroxidizable chemicals and other chemicals that may become unstable over time should be dated when received and also when the container is opened. Test and/or dispose of them when appropriate. Common examples of chemicals that form peroxides upon aging are: ethyl ether, isopropyl ether, tetrahydrofuran, dioxane, and cycloalkenes.

2.4 Container Labeling

Make sure all labels are legible. Label all containers with the chemical name and appropriate health hazard warning(s). Hazard labels should be easily visible and not obscure essential information on the label. The PLU Division of Natural Sciences requires that secondary containers that will not be emptied immediately should have the chemical identification of the material and the hazards posed by the material on the chemical container. In this way a temporary container that inadvertently becomes a more permanent container will be properly identified.

2.5 Chemical Fume Hoods and Other Engineering Controls

A chemical fume hood is a ventilated enclosure where hazardous materials can be handled safely. The hood is designed to contain contaminants by preventing their escape into the laboratory. Inhalation and contact by the user is minimized by drawing the contaminants within the work area away from the user. To protect the user of airborne chemical hazards, fume hood velocities should be between 80 -100 cubic feet per minute (CFM) and sash should not be raised higher than 18 inches.

The performance of a fume hood is affected by several factors including conditions in the room in which it is located. Cross drafts caused by movement of personnel or air currents from open doors or windows can even cause contaminants to be drawn from the hood into the room. The

amount of equipment in a hood and the location can influence hood performance by creating air turbulence. For this reason hoods should not be used for storage and should be kept as empty as possible.

Chemical fume hoods are inspected annually by a qualified person with a written report of the results maintained by the unit in charge of the laboratory.

2.6 Ordering Hazardous Materials

The responsibility for approval of the acquisition and use of toxic chemicals rests with the laboratory supervisor or lab manager. Certain materials such as radioactive materials require prior internal (Radiation Safety Officer) or external approval. Prior to arrival information on the proper handling, storage and disposal must be available to those who will receive, handle, distribute or store the chemical. No container should be accepted without an adequate identifying label and appropriate hazard marking. An MSDS for the chemical should be received and filed in a timely fashion.

2.7 Medical Attention and Medical Surveillance

In addition to reporting any physical injury sustained while working in laboratory, chemical exposures should be reported immediately, and may require medical attention. OSHA sets enforceable permissible exposure limits (PELs) to protect workers against the health effects of exposure to hazardous substances. PELs are regulatory limits on the amount or concentration of a substance in the air. Medical surveillance should begin when it is suspected that exposure has exceeded the PEL or action level for a hazardous substance.

2.7.1 Medical Attention

When a chemical exposure occurs, medical consultations and medical examinations will be made available to laboratory workers who work with hazardous chemicals as required. All work related medical examinations and consultations will be performed by or under the direct supervision of a licensed physician and will be provided at no cost to the employee without loss of pay, and at a reasonable time. The opportunity to receive medical attention, including any follow up examinations, will be provided to employees who work with hazardous chemicals under the following circumstances:

- Whenever an employee develops signs or symptoms associated with a hazardous chemical to which the employee may have been exposed in the laboratory.
- Where airborne exposure monitoring reveals an exposure level routinely above the action level (or in the absence of an action level, the Permissible Exposure Limit) for an OSHA regulated substance for which there are exposure monitoring and medical surveillance requirements.
- Whenever an event such as a spill, leak, explosion or other occurrence takes place and results in the likelihood of a hazardous exposure. Upon such an event, the affected employee shall be provided an opportunity for a medical consultation. The consultation shall be for the purpose of determining the need for a medical examination.

2.7.1.1 Information Provided to the Physician

The physician shall be provided with the following information:

- The identity and risks associated with the hazardous chemical(s) to which the employee may have been exposed. Such information can be found in the Material Safety Data Sheet (MSDS) for the chemical(s).
- A description of the conditions under which the exposure occurred including quantitative exposure data, if available
- A description of the signs and symptoms of exposure that the employee is experiencing, if any

2.7.1.2 The Physician's Written Opinion

The physician's written opinion for the consultation or examination shall include:

- The results of the medical examination and any associated tests
- Any medical condition that may be revealed in the course of the examination, which may place the employee at increased risk as a result of exposure to a hazardous workplace
- A statement that the employee has been informed by the physician of the results of the consultation or medical examination and any medical condition that may require further examination or treatment
- The written opinion shall not reveal specific findings of diagnoses unrelated to the occupational exposure

All records of medical consultations, examinations, tests, or written opinions shall be maintained in accordance with 29 CFR 1910.1020 Access to employee exposure and medical records.

2.8 Special Provisions for Select Carcinogens, Reproductive Toxins and Acutely Toxic Chemicals (California Proposition 65 List of Chemicals)

In addition to the general safety guidelines mentioned above, special precautions are needed when handling particularly toxic chemicals such as select carcinogens, reproductive toxins, and chemicals with a high degree of acute toxicity. The laboratory supervisor should ensure that these and other precautions designed to minimize risk of exposure to these substances are taken. The following are minimum guidelines:

- Quantities of these chemicals used and stored in the laboratory should be minimized, as should their concentrations in solution or mixtures. Work with carcinogens, reproductive toxins and acutely toxic chemicals should be performed within a functioning fume hood, ventilated glove box, sealed system, or other system designed to minimize exposure to these substances. (The exhaust air from the ventilation systems may require scrubbing before being released into the atmosphere.) In all cases, work with these types of chemicals should be done in such a manner that the OSHA's permissible exposure limits or similar standards are not exceeded.
- Compressed gas cylinders that contain acutely toxic chemicals, such as arsine and nitrogen dioxide, should be kept in ventilated gas cabinets.
- The ventilation efficiency of the designated chemical fume hood, glove box, or gas cabinet, and the operational effectiveness of mechanical and electrical equipment used to contain or manipulate these special substances should be evaluated periodically by the laboratory personnel at intervals determined by the laboratory supervisor. The interval of evaluating systems may vary from weekly to biannually depending upon the frequency of usage, quantities employed and level of hazard.
- Each laboratory utilizing these substances must designate an area for this purpose and sign or mark this area with an appropriate hazard warning. The designated area may be an entire laboratory, an area of the laboratory, or a device such as a fume hood or glove box. The designated area should be marked with a sign stating "DANGER, *specific agent,* AUTHORIZED PERSONNEL ONLY" or comparable warning sign.
- All laboratory workers who work in a laboratory, which has an area designated for use with carcinogens, reproductive toxins and/or acutely toxic chemicals, must be trained about the deleterious effects of these substances plus signs and symptoms regarding exposure to these substances. This training is required even for those who do not actually work with the substances. Training to ensure the safe handling and storage of these substances is required for those who use these materials. This training is the responsibility of the laboratory supervisor and must be done prior to the use of any of these materials.
- Laboratory workers using these chemicals must have access to appropriate personal

protective equipment (available at no expense to the workers) and must be trained on how to properly utilize this equipment.

- Detection equipment may be required in laboratories where highly toxic chemicals (especially poisonous gases) are used.
- All wastes contaminated with these substances should be collected and disposed of promptly. Treatment of waste products to lessen or eliminate their toxicity as part of the experimental protocol is encouraged as a way of minimizing health hazards and the amount of waste, only if such treatment can be performed safely.
- The designated working area shall be thoroughly decontaminated and cleaned at regular intervals determined by the laboratory supervisor. The interval may be as short as one day or as long as six months depending upon the frequency of usage and level of hazard.
- Special precautions to avoid release and exposure to carcinogens, highly toxic chemicals and reproductive toxins must be utilized. For instance, volatile substances should be kept cool and contained. Gas cylinders should have properly functioning valves, check valves, regulators, containment which can withstand pressure buildup, and appropriate piping; and dispersive solids should be kept in closed containers, used in places with minimal air currents, and appropriate contact materials should be used to avoid static charging.
- Emergency response planning for releases or spills should be prepared by the laboratory supervisor and included in the training of the laboratory workers and others who may be affected in the building. CHO and EHS should be involved in this planning.

3. Personal Protective Equipment (PPE)

Proper personal protective equipment (PPE) drastically diminishes the chance of injury and reduces the severity of an injury if an accident does occur. PPE should not be used as a substitute for other, more effective hazard controls. It should be used in concert with engineering and other controls to guarantee worker health and safety.

3.1 Laboratory Responsibilities for PPE

PPE must be made available to laboratory employees to reduce exposures to hazardous chemicals in the lab. Proper PPE includes items such as gloves, eye protection, lab coats, face shields, aprons, boots, hearing protection, etc. PPE must be readily available and most equipment is provided at no cost to the employee.

PLU's Chemical Hygiene Officer (CHO) must assess the laboratory workspace to determine if hazards are present, or are likely to be present, and which necessitate the use of personal protective equipment. When deciding on the appropriate PPE to wear when performing any operations or experiments, a number of factors must be taken into consideration such as:

- The chemicals being used, including concentration and quantity
- The hazards the chemicals pose
- The routes of exposure for the chemicals
- The composition of the PPE
- The permeation and degradation rate specific chemicals will have on the material
- The length of time the PPE will be in contact with the chemicals

The CHO must verify this assessment in writing. If such hazards are found the CHO must select the types of PPE that will protect against the identified hazards. The CHO must also make sure that the affected employees use them. The PPE must fit each affected employee properly. Damaged or defective equipment must not be used. PLU must also establish and certify a training program for employees/students on the proper use of PPE in each specified area. These requirements are spelled out in 29 CFR 1910.132-138.

Principal Investigators, laboratory supervisors, departments, and the CHO shall set policies that establish minimum PPE requirements for personnel working in and entering their laboratories.

3.1.1 Training for Personal Protective Equipment

Laboratory personnel must be trained in the selection, proper use, limitations, care, and maintenance of PPE. Training requirements can be met in a variety of ways including videos, group training sessions, and handouts. Retraining should be offered to both the employees and supervisors as appropriate. Examples of topics to be covered during the training include:

- When PPE must be worn
- PPE is necessary to carry out a procedure or experiment
- How to properly put on, take off, adjust, and wear PPE
- The proper cleaning, care, maintenance, useful life, limitations, and disposal of the PPE

As with any training sessions, PPE training must be documented, including a description of the information covered during the training session and a copy of the sign-in sheet. Written records must be kept of the names of the persons trained, the type of training provided, and the dates when training occurred.

It is the responsibility of the Principal Investigator or laboratory supervisor to ensure laboratory staff have received the appropriate training on the selection and use of proper PPE, that proper PPE is available and in good condition, and laboratory personnel use proper PPE when working in laboratories under their supervision.

3.2 Eye/Face Protection

Eye and face protection is of great importance. All safety eyewear must meet or exceed the requirements of the ANSI Z87.1-1968 “USA Standard Practice for Occupational and Educational Eye and Face Protection”, if they were purchased before July 5, 1994. If purchased after that date, they must conform to ANSI Z87.1-1989, American National Standard Practice for Occupational and Educational Eye and Face Protection.

All laboratory employees, students, and visitors should wear protective eyewear while in laboratories where chemicals are being handled or stored, at all times, even when not working directly with chemicals. Protective eyewear must be worn when working with corrosive or irritating volatile or liquid reagents (WAC 296-800-160).

3.2.1 Selection of Eye/Face Protection

The employee has the responsibility to correctly wear the protective eyewear provided, to regularly clean and maintain the equipment provided and to inform superiors when the eyewear needs to be replaced or repaired. Any employee who requires prescription eyewear must incorporate it within a safety eyewear design or additional protection must be worn over the prescription eyewear. After much debate, the wearing of contact lenses in the laboratory is no longer discouraged, but chemical splash goggles must be worn.

There are three main categories of eye hazards: impact, light radiation, and liquid splash. Protection against light radiation will be dealt with in the Standard Operating Procedures section. The four most common types of eye protection are: 1) safety glasses, 2) safety goggles, 3) face shields, and 4) fixed shields. In general, safety glasses provide the least protection of the four types, safety goggles significantly more, and face and protective shields the most, when used in combination with safety goggles.

3.2.1.1 Safety Glasses

Safety glasses are the least effective of the protective eyewear mentioned above. They are to be used only by visitors or workers who will not be in close proximity to hazardous chemicals or impact hazards.

3.2.1.2 Safety Goggles

Safety goggles with perforated venting are most useful for impact prevention and may be used only in areas where hazardous chemicals are not present and where glassware is not under either positive or negative pressure and there is no know danger of explosion. An example of an area where this type of goggle may be properly worn is the Division of Natural Science shops.

In areas where hazardous chemicals are being used, indirect venting chemical splash goggles must be worn. These can be purchased from the Chemistry department.

3.2.1.3 Face Shields

ANSI specifies that face shields should only be worn over primary eye protection. Face shields should not be used in place of chemical splash goggles because at certain angles of attack the eyes are totally unprotected. Face shields should be used in conjunction with chemical splash goggles when certain hazardous conditions are present. These conditions include:

- Working with chemicals so corrosive or toxic that slight contact can result in injury
- Situations where there is the possibility that glassware, chemicals or other materials may be dispersed with explosive force as the result of a too vigorous chemical reaction
- Situations where there is the possibility that glassware, chemicals or other materials may be dispersed with explosive force as the result of excessive positive pressure (such as that exerted by a compressed gas) or excessive negative pressure (such as that exerted under a vacuum)
- When working in front of ultraviolet rays, such as when viewing nucleic acid gels
- When handling cryogenic liquids

3.2.1.4 Fixed Shielding

Thicker shielding of either strengthened glass or plastic should be used where additional protection is desirable because of the danger when one is working at very high pressures or where a violent chemical reaction is possible. Fume hood windows function as fixed shielding if properly adjusted. Chemical splash goggles must also be worn in conjunction with this type of shielding since it is in a fixed position and only protects at certain angles.

3.3 Hand Protection (Gloves)

After the face and eyes, the hands are the most vulnerable parts of the body, and are most likely to be affected by spills, cuts, and contact with temperature extremes. There are a wide variety of gloves and hand protectors available for use in the chemical laboratory.

Gloves serve to protect the hand from contact with hazardous chemicals, from temperature extremes, from cuts by glass or sharp-edged materials, as well as provide a more secure grip under certain conditions. However, gloves should not be worn near moving equipment or machinery parts. The glove could get caught and pull a hand or fingers into the machinery.

Gloves must be worn whenever significant potential hazards from chemicals, cuts, lacerations, abrasions, punctures, burns, biohazards, or harmful temperature extremes are present. The proper use of hand protection can help protect from potential chemical and physical hazards. Gloves must be worn when using chemicals that are easily absorbed through the skin and/or particularly hazardous substances (such as —select carcinogens, reproductive toxins, and substances with a high degree of acute toxicity).

3.3.1 Selection of Proper Gloves

The CHO and responsible personnel should base the selection of the appropriate hand protection on an evaluation of the performance characteristics of the hand protection relative to the tasks to be performed, conditions present, the duration of use, and the hazards identified.

Gloves are constructed from a variety of materials. Among these are natural rubber latex, nitrile, neoprene, PVC, and leather. Materials vary in their resistance to certain classes of chemicals. No one material is most effective against every chemical that might be encountered. Which type of glove should be worn will depend on the nature of the chemical being handled.

3.3.2 Types of Gloves

Types of hand and forearm protection used in the Division of Natural Sciences include: 1) chemical resistant gloves, 2) general purpose gloves, and 3) special purpose gloves. Within these categories there is further differentiation by the material from which they are constructed. In addition, there are a number of glove designs, several cuff types and sizes, lined or unlined, and different grip designs. Other types of hand protection may include mitts and hot hand protectors.

3.3.2.1 Chemical Resistant Gloves

These gloves are primarily designed to protect against a wide range of chemicals. The material that the glove is made of is of prime importance since this will determine which chemicals it is resistant to. Glove manufacturers provide tables that indicate the resistance of certain types of gloves against a wide range of chemicals. This information can be used to select gloves that, if not resistant to all the chemicals being used, are at least highly resistant to the most hazardous of the chemicals in use.

3.3.2.2 General Purpose Gloves

These gloves protect against cuts, snags, punctures and abrasion. They are unsuitable for use in chemical operations but can be used for other tasks. Again the materials will determine what type of glove is used. The choices range from the standard leather and canvas work glove, to Kevlar or chainmail-cut protection gloves, to insulated gloves for working with cryogenic liquids.

3.3.2.3 Hand Protectors

These are usually used to protect the hands when handling hot objects. There are also mitts made of various materials to protect against heat.

3.3.2.4 Double Gloving

When working in certain situations such as with radioactive material, it may be advisable to double glove with two sets of gloves. If the outer glove becomes contaminated, starts to degrade, or tears open, the inner glove continues to offer protection until the gloves are removed and replaced.

3.4 Protective Clothing

A variety of protective clothing is available to protect the torso, including vests, coats, aprons, coveralls, and full body suits. The prime threat in the Division of Natural Sciences is a chemical splash or spill. Lab coats and aprons protect against gross contamination in case of a chemical splash or spill. They also serve to protect clothing. Coveralls or even full body suits may be necessary depending on the work situation and the toxicity of the chemicals involved.

PLU strongly encourages Principal Investigators and laboratory supervisors to require long pants and clothing which effectively covers the torso for all laboratory personnel, including visitors, working in or entering laboratories and laboratory support areas under their supervision.

Protective clothing should be easily removable and free from rips, tears, and other defects. It should be worn only in the lab and never brought into areas where food is consumed. Always wash lab clothes separately from personal laundry.

The CHO and responsible personnel have the responsibility to select and provide the proper chemical protective clothing for the hazards expected in the workplace. A number of factors go into that selection. The most important of these are the determination of what chemicals are likely to be

encountered, the hazards these chemicals pose to the workers, and the likely route of exposure to the chemicals. Other factors are what other personal protective equipment needs to be worn, how long the workers will be wearing the clothing, what the work environment is like, and finally how comfortable the PPE is. The laboratory supervisor must also train the employee in the proper use of the protective clothing and ensure that the employee uses it when appropriate.

The employee has the responsibility to wear the protective clothing when there are hazards present. The employee also has the responsibility to maintain the clothing and to notify the supervisor when the personal protective clothing has been damaged or begun to deteriorate.

3.5 Respirators

The use of all types of respiratory protection at PLU is governed by OSHA standards. There are four types of respiratory hazards faced by laboratory workers: particulates, vapors, gases, and fumes. In 29 CFR Part 1910.134 OSHA addresses the subject of protection against these hazards. These regulations permit respirators to be used when it is not feasible to control workplace air contamination by means of accepted engineering control measures.

Respiratory protection includes air purifying disposable respirators (i.e. N-95 particulate filtering face piece respirators and dust masks). Respirators are generally not required for laboratory workers. In most laboratory environments engineering controls (i.e. fume hoods) capture and remove vapors, fumes, and gases from the breathing zone of the user.

Filtering face piece respirators can provide an additional level of comfort and protection. The Washington Industrial Safety & Health Act (WISHA) office recommends voluntary use of respirators when exposure to substances is below WISHA permissible exposure limits (PELs). If an employee chooses to wear a filtering face piece respirator, they should contact the Principal Investigator, laboratory supervisor, or CHO.

Due to the hazards of using a respirator (fit testing, respiratory medical evaluation) employees may not utilize a respirator, even a filtering face piece respirator, without reading and signing the "Voluntary Respirator Use" form (Appendix C). Contact PLU Environmental, Health and Safety at x7233 for more information.

3.6 Hearing Protection

Hearing protective devices includes earplugs, earmuffs, or similar devices designed to protect your hearing. In situations where occupational noise exposures exceed permissible levels (≥ 85 decibels) and cannot be reduced through engineering or other controls, hearing protective devices must be worn. Noise is often defined as unwanted sound. High levels of noise can lead to temporary or even permanent hearing loss. Noise has also been linked with stress, high blood pressure, ulcers, headaches, and sleep disorders.

The only areas of the Division of Natural Sciences where noise is expected to be a continuing problem are the Division shops, some Geosciences labs, and certain Chemistry demonstrations. The rock and metal shops contain saws and other noise producing equipment. Earmuff-style hearing protection devices are provided in the rock and metal shops and will be worn by those working with noisy equipment. Regulations governing the allowable levels of noise and hearing protection requirements have been issued by WA State Dept. of Labor & Industries: WAC 296-817-200**.**

3.7 Head Protection

Prevention of head injuries is an important factor in every safety program. Head injuries are caused by falling or flying objects, or by bumping the head against a fixed object. The threat of head injuries is not considered to be very high during ordinary operations in the Division of Natural Sciences. Therefore, the specifics of head protection will not be considered in depth here. Head protection for specific jobs will be considered in the Standard Operating Procedures section. If there

is a real threat of head injury, the proper head protection must be worn and it must conform to WA State Dept. of Labor & Industries: WAC 296-800-16055.

3.8 Foot Protection

Protective footwear requirements are addressed by the WA State Dept. of Labor & Industries: WAC 296-800-16060. This regulation deals mostly with foot injuries caused by falling objects or objects piercing the sole of the shoe. These injuries are unlikely to happen in the Division of Natural Sciences. The most common hazard in these laboratories is chemical spills. Prevention of foot injuries from chemical spills has been addressed in the laboratory rules where the use of proper footwear is specified. For work in cleaning up hazardous material spills, chemical resistant boots must be provided to the clean-up personnel. Other threats to foot safety will be addressed if they are revealed during hazard assessment.

Laboratory personnel must wear closed-toe non-perforated shoes whenever working with or around hazardous chemicals. This is due to the potential exposure to toxic chemicals and the potential associated with physical hazards such as dropping pieces of equipment or broken glass being present. PLU requires the Principal Investigators and responsible personnel to enforce the use of closed-toe shoes for all laboratory personnel, including visitors, working in or entering laboratories and laboratory support areas under their supervision. Exceptions might be granted for non-traditional uses of laboratories in consultation with the CHO.

In general, shoes should be comfortable, and leather shoes are preferable to cloth shoes due to the better chemical resistance of leather compared to cloth. Leather shoes also tend to absorb fewer chemicals than cloth shoes. However, leather shoes are not designed for long-term exposure to direct contact with chemicals. In such instances, chemically resistant rubber boots are necessary.

4. Hazard Awareness

This chapter provides an introduction to the types of hazards, labeling systems and common sources of hazards information in research labs on campus. This information will help you to identify hazards in your laboratory and will provide resources to increase your understanding of those hazards. Additionally, this chapter provides information to researchers to assist in labeling in-house chemical containers and equipment to identify their unique hazards.

4.1 Types of Hazards

According to the OSHA Lab Standard, "Hazardous chemical" means a chemical 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.

4.1.1 Health Hazards

The term "health hazard" includes chemicals that are carcinogens, toxic or highly toxic agents, reproductive toxins, irritants, corrosives, sensitizers, hepatotoxins, nephrotoxins, and neurotoxins, agents that act on the hematopoietic system, and agents which damage the lungs, skin, eyes, or mucous membranes.

Working with chemicals in a research laboratory can expose researchers to health hazards through inhalation, ingestion, skin, eye, or mucous membrane contact or absorption, or injection of chemicals. Chemical exposures may be acute (short term), intermittent, or chronic (long term), they may be reversible or irreversible, and may have local or systemic effects.

The following are brief descriptions of the classes of health hazards included in the Lab Standard of “health hazard” above. Complete definitions are found in the OSHA Lab Standard (29 CFR 1910.1450).

- **Carcinogen**: A chemical which causes or potentially causes cancer according to the International Research on Cancer, or is listed as such in the National Toxicology Program Annual Report on Carcinogens; http://ehis.niehs.nih.gov/roc/.
- **Corrosive**: A chemical that causes visible destruction of, or irreversible alterations in, living tissue by chemical action at the site of contact.
- **Irritant**: A chemical, which is not corrosive, but which causes a reversible inflammatory effect on living tissue by chemical action at the site of contact.
- **Mutagen**: A chemical that damages chromosomes.
- **Sensitizer**: A chemical that causes a substantial proportion of exposed people or animals to develop an allergic reaction in normal tissue after repeated exposure to the chemical.
- **Target Organ Effects**:
  - *Hepatotoxins* damage the liver.
  - *Nephrotoxins* damage the kidneys.

- *Neurotoxins* adversely affect the nervous system.
- *Hematopoietic Agents* decrease hemoglobin function and deprive the body tissues of oxygen.
- *Agents that damage the lung* irritate or damage pulmonary tissue.
- *Reproductive toxins* affect reproductive capabilities including chromosomal damage (mutations) and effects on fetuses (teratogenesis).
- *Cutaneous hazards* affect the skin, or dermal layer, of the body.
- *Eye hazards* affect the eye or visual capacity.

- **Teratogen**: A chemical that causes birth defects.
- **Toxic**: A chemical falling within any of the following categories:
  - A chemical that has a median lethal does (LD_{50}) of more than 50mg/kg but not more than 500mg/kg when administered orally to albino rats weighing between 200 and 300 grams each.
  - A chemical that has a median lethal dose (LD_{50}) of more than 200mg/kg but not more than 1,000mg/kg when administered by continuous contact for 24 hours (or less if death occurs within 24 hours) with the bare skin of albino rabbits weighing between two and three kilograms each.
  - A chemical that has a median lethal concentration (LC_{50}) in air of more than 200 parts per million (ppm) but not more than 2,000 ppm by volume of gas or vapor, or more than 2,000mg/m^3 but nor more than 20,000mg/m^3 of mist, fume, or dust, when administered by continuous inhalation for one hour (or less if death occurs within one hour) to albino rats weighing between 200 and 300 grams each.
- **Highly Toxic**: A chemical falling within any of the following categories:
  - A chemical that has a median lethal dose (LD_{50}) of not more than 50mg/kg when administered orally to albino rats weighing between 200 and 300 grams each.
  - A chemical that has a medial lethal dose (LD_{50}) of not more than 200mg/kg when administered by continuous contact for 24 hours (or less if death occurs within 24 hours) with the bare skin of albino rabbits weighing between two and three kilograms each.
  - A chemical that has a median lethal concentration (LC_{50}) in air of 200 ppm by volume or less of gas or vapor, or 2,000mg/m^3 or less of mist, fume, or dust, when administered by continuous inhalation for one hour (or less if death occurs within one hour) to albino rats weighing between 200 and 300 grams each.

	LD_{50} (oral, rat)	**LD_{50} (skin, rabbit)**	**LC_{50} (rat)**	
	(mg/kg)	(mg/kg)	(ppm for 1 hour)	(mg/m^3 for 1 hour)
Highly Toxic	≤50	≤200	≤200	≤2,000
Toxic	50 to 500	200 to 1000	200 to 2,000	2,000 to 20,000

4.1.1.1 Toxicity

Any substance could be harmful to living things. But complex relationships exist between a substance and its physiological effect in humans. The major factors include the dose (the amount of a substance to which one is exposed and the length of time of exposure to the substance), the route of exposure (by inhalation, ingestion, absorption through the skin or eyes, or injection), and myriad other factors such as gender, stage in the reproductive cycle, age, lifestyle, previous sensitization, allergic factors, and genetic disposition. It is prudent to act as though you could be susceptible to serious toxic consequences and to therefore follow the necessary precautions when working with chemicals in the laboratory.

The toxic effects can be immediate or delayed, reversible or irreversible, local or systemic. The toxic effects vary from mild and reversible (e.g. a headache from a single episode of inhaling the

vapors of ethyl acetate that disappears when the victim inhales fresh air) to serious and irreversible (e.g. birth defects from excessive exposure to a teratogen during pregnancy).

Some important details about toxic effects:

- Acute poisoning is characterized by rapid assimilation of the substance. Often, but not always, the effect is sudden and can be painful or severe and even fatal. Normally, a single exposure is involved. Examples: carbon monoxide or cyanide poisoning.
- Chronic poisoning is characterized by repeated exposures with a duration measured in months, or years. Symptoms may not be immediately apparent. Examples: lead or mercury poisoning, pesticide exposures.
- Substances in combination may result in the synergistic effect. When two or more hazardous materials are present, the resulting effect can be greater than the effect predicted for the individual substances. Example: exposure to alcohol and chlorinated solvents. The opposite is also possible; two poisonous substances can lessen each other's effects, called the antagonistic effect. Example: cyanide and amyl nitrite.
- Allergens are agents that produce an immunologic reaction, and you may encounter them in the laboratory. Asthma-like symptoms or dermatitis are typical allergic reactions. Not everyone is susceptible to allergens. A susceptible individual will not suffer an allergenic reaction unless he or she has been sensitized by at least one previous exposure. For some allergens, an individual must be exposed several times before suffering an allergenic response. Tell the CHO if you know or suspect that you are allergic to a chemical in your laboratory.

Except for allergenic exposures, the toxic effects from exposure to a chemical depend on the severity of the exposures. Generally, the larger or more frequent the exposure, the more severe the result. Consequently, you can reduce or even avoid harm by keeping exposures to a minimum.

4.1.1.2 Routes of Exposure

There are four main routes of exposure for chemicals: inhalation, direct contact (to skin, eyes and or mucous membranes), ingestion, and injection. An understanding of these routes of entries enables on to develop procedures or controls to prevent hazardous exposures to chemicals.

- **Inhalation**: Inhalation of gases, vapors, dusts, fumes or mists is a common route of exposure. Chemicals can enter and irritate the nose, airways and lungs. They can become deposited in the airways or be absorbed through the lungs into the bloodstream. The blood can then carry these substances to the rest of the body.
- **Direct (skin/eye) contact and/or absorption**: Many chemicals can injure the skin directly (corrosives), while others may cause irritation or an allergic reaction. In addition to causing local effects, many chemicals may be absorbed through the skin and/or eyes in sufficient quantity to cause systemic effects. The main avenues by which chemicals enter the body through the skin are hair follicles, sebaceous glands, sweat glands, and cuts or abrasions of the skin. Direct contact effects and absorption of chemicals through the skin depend on a number of factors, including chemical concentration, chemical reactivity, solubility of the chemical in fat and water, condition of the skin, and duration of contact.
- **Ingestion**: Chemicals that get in or on food, cigarettes, utensils or hands can be swallowed. Substances can be absorbed into the blood and then transported to the rest of the body.
- **Injection**: Injections can occur through high pressure streams of liquids or gases, needles or broken contaminated glassware.

4.1.2 Physical Hazards

Physical hazard means a chemical for which there is scientifically valid evidence that it is a combustible liquid, a compressed gas, explosive, flammable, an organic peroxide, an oxidizer, pyrophoric, unstable (reactive) or water-reactive.

The following are brief descriptions of the classes of physical hazards. Complete definitions are found in the OSHA Lab Standard (29 CFR 1910.1450).

- **Combustible liquid**: Any liquid having a flashpoint at or above 100ºF (37.8ºC), but below 200ºF (93.3ºC); except any mixture having components with flashpoints of 200ºF (93.3ºC) or higher, the total volume of which make up 99% or more of the total volume of the mixture.
- **Compressed gas**: A gas or gas mixture with an absolute pressure exceeding 40 psi at 70ºF (21.1ºC), or exceeding 104 psi at 130ºF (54.4ºC); or a liquid having a vapor pressure exceeding 40 psi at 100ºF (37.8ºC).
- **Explosive**: A chemical that causes a sudden, almost instantaneous release of gas, pressure, and heat when subjected to sudden shock or high temperature or pressure.
- **Flammable**:
    - *Aerosol*: A chemical that can produce a flame or flashback from a valve opening.
    - *Gas*: Any gas at ambient conditions that will cause a flammable mixture with air in concentrations of 13% or less.
    - *Liquid*: Any liquid having a flashpoint below 100ºF (37.8ºC), except any mixture having components with flashpoints of 100ºF (37.8ºC) or higher, the total of which make up 99% or more of the total volume of the mixture.
    - *Solid*: A solid that is liable to cause fire through friction, contact with moisture, spontaneous reaction, or retained heat, or which can be readily ignited and burns with enough persistence or violence to cause a serious health hazard.
- **Nanoparticles**: Defined as a sub-classification of ultrafine particles with lengths in two or three dimensions greater than 0.001 micrometer (1 nanometer) and smaller than about 0.1 micrometer (100 nanometers) per ASTM Standard E-2456-06. When working with engineered nanoparticles, the hazards and possibly the controls needed to minimize risks will be different from research project to research process, and the characteristics of the resulting engineered nanoparticles. Because the hazards and risks are not well defined, it is recommended that special care be taken in concert with the CHO in order to assure a reasonable level of safety.
- **Organic peroxides**: An organic compound with a bivalent O-O structure, which may be considered a peroxide derivative with one or both of the hydrogen atoms replaced with an organic molecule. They present dangerous fire and explosion risk; many are strong oxidizers.
- **Oxidizer**: A chemical that initiates or supports combustion of other materials, causing fire by itself or by the release of oxygen or other gases.
- **Pyrophoric**: A chemical that will ignite spontaneously in air at or below 130ºF (54.4ºC).
- **Unstable**: Any chemical, which will vigorously decompose, polymerize, condense, or will become self reactive when exposed to conditions of shock, pressure, or temperature.
- **Water-reactive**: A chemical that can react with water or steam to produce a gas which is either toxic or flammable.

4.2 Labeling

Each chemical container must be labeled as to its contents and any applicable hazard categories. Even non-hazardous chemicals should be identified as such to remove any confusion.

4.2.1 Container Labeling

The label must be printed in English and give the name of the chemical, appropriate hazard warnings, and the name and address of the chemical manufacturer. Most chemicals purchased after

1986 provide this information on the manufacturer's label. Care must be taken that none of this information is obscured by any marking added to the label.

OSHA requires secondary containers be marked with the identity of the chemical contents and the appropriate hazard warnings. The PLU Division of Natural Sciences requires that containers that will not be emptied immediately must be labeled with the chemical identification and the hazards posed by the material. In this way, a temporary container that inadvertently becomes a more permanent container will be properly identified.

Chemical names may be abbreviated (such as Ethanol – EtOH) if everyone in the lab is knowledgeable of the abbreviation. Creating a table of common chemical abbreviations for the lab is strongly advised.

4.2.2 Common Labeling Systems

In addition to hazard symbols, manufacturer's container labels may include the markings from the National Fire Protection Association (NFPA). The NFPA 704 Standard System for the Identification of the Hazards of Materials for Emergency Response provides a readily recognized, easily understood system for identifying specific hazards and their severity using spatial, visual, and numerical methods to describe in simple terms the relative hazards of a material. It addresses the health, flammability, instability, and related hazards that may be presented as short-term, acute exposures that are most likely to occur as a result of fire, spill, or similar emergency.

The system is characterized by the diamond shape. It identifies the hazards of a material and the degree of severity of the health, flammability, and instability hazards. Hazard severity is indicated by a numerical rating that ranges from zero (0) indicating a minimal hazard, to four (4) indicating a severe hazard. The hazards are arranged spatially as follows: health at nine o'clock position (blue), flammability at twelve o'clock position (red), and instability at three o'clock position (yellow).

The six o'clock position on the symbol represents special hazards and has a white background. The special hazards in use are ~~**W**~~, which indicates unusual reactivity with water and is a caution about the use of water in either fire fighting or spill control response; **OX**, which indicates that the material is an oxidizer; and **SA**, which indicates that the material is a simple asphyxiant, limited to the gases nitrogen, helium, neon, argon, krypton and xenon.

4.2.3 Department of Transportation (DOT)

The US DOT uses hazard classes (1-9). These classes are based on physical and health hazards. When a hazardous material is in transport, it must bear the appropriate labels(s). These labels must remain in place until the container is empty.

The nine hazard classes are:

- **Class 1: Explosives**

  An explosive is a substance or article, including a device, that is designed to function by explosion (i.e., an extremely rapid release of gas and heat) or which, by chemical reaction within itself, is able to function in a similar manner even if not designed to function by explosion, unless the substance or article is otherwise classified under the provision of the regulations.

- **Class 2: Gases**

  Division 2.1: Flammable Gas

  A flammable gas is any material that is a gas at 20ºC (68ºF) or less and 101.3 kPa (14.7 psi) of pressure and is ignitable at 101.3 kPA (14.7 psi) when in a mixture of 13% or less by volume in air, or has a flammable range at 101.3 kPA (14.7 psi) with air of at least 12% regardless of the lower limit.

  Division 2.2: Non-flammable, Non-poisonous Compressed Gas

  Any material or mixture (including compressed gas, liquefied gas, compressed gas in solution, asphyxiant gas and oxidizing gas) that exerts in the packaging an absolute

pressure of 280 kPA (40.6 psi) or greater at 20ºC (68ºF), or is a cryogenic liquid, and does not meet the definition of Division 2.1 or 2.3.

Division 2.3: Gas Poisonous by Inhalation

A gas poisonous by inhalation is a material that is a gas at 20ºC (68ºF) or lower and a pressure of 101.3 kPA (14.7 psi) and either:

- Is known to be so toxic to humans as to pose a hazard to health during transportation,
- Or, in the absence of adequate data on human toxicity, is presumed to be toxic to humans because when tested on laboratory animals, it has a LC_{50} value of not more than 5,000 mL/m^3.

- **Class 3: Flammable and Combustible Liquids**

A flammable liquid is either:

- A liquid having a flash point of note more than 60ºC (140ºF).
- Any material in a liquid phase with a flash point at or above 37.8ºC (100ºF) that is intentionally heated and offered for transportation or transported at or above its flash point in a bulk package.

A combustible liquid is a liquid that does not meet the definition of any other hazard class and has a flash point above 60ºC (140ºF) and below 93ºC (200ºF).

- **Class 4: Flammable Solids**

Division 4.1

- Wetted Explosives: Class 1 explosives when dry, other that those of compatibility group A, that are sufficiently wetted to suppress explosive properties.
- Self-reactive materials: Materials that are thermally unstable and can undergo a strongly exothermic decomposition even in the absence of oxygen (air).
- Readily combustible solids: Solids that can cause fire through friction, such as matches.

Division 4.2: Spontaneously Combustible

- Pyrophoric materials: Liquids or solids that can, without an external ignition source, ignite with five minutes after coming in contact with air when tested according to the "UN Manual of Tests and Criteria."
- Self-heating materials: Substances that are liable to self-heat when in contact with air and without an energy supply. Materials are classified as Division 4.2 if they exhibit spontaneous ignition or if the temperature exceeds 200ºC (395ºF) during the 24-hour test period when tested in accordance with "UN Manual of Tests and Criteria."

Division 4.3: Dangerous When Wet

Materials that by contact with water, are liable to become spontaneously flammable or to give off flammable or toxic gas at a rate greater than 1L/kg of the material per hour, when tested in accordance with the "UN Manual of Tests and Criteria."

- **Class 5: Oxidizers and Organic Peroxides**

Division 5.1: Oxidizers

A material that can, generally by yielding oxygen, cause or enhance the combustion of other materials.

Division 5.2: Organic Peroxides

Any organic compound containing oxygen (O) in the bivalent –O-O- structure and that may be considered a derivative of hydrogen peroxide, where one or more of the hydrogen atoms have been replaced by organic radicals.

- **Class 6: Poisonous Materials and Infectious Substances**

Division 6.1: Poisonous Materials

A material other than a gas known to be so toxic to humans that it poses a health hazard during transportation.

Division 6.2: Infectious Substances

Includes materials known to contain or suspected to contain a pathogen. A pathogen is a microorganism (including viruses, bacteria, parasites, fungi, and rickettsiae) or other agent, such as a proteinaceous infectious particle (prion) that has the potential to cause disease in humans or animals.

- **Class 7: Radioactive Material**
  Any material containing radionuclides in which both the activity concentration and the total activity in the consignment exceed the values specified in the table at 49 CFR 173.436 or values derived according to the formula at 49 CFR 173.433.
- **Class 8: Corrosive Material**
  Liquids or solids that cause full thickness destruction of human skin at the site of contact within a specified period of time. There is no correlation to pH.
- **Class 9: Miscellaneous Hazardous Materials**
  Materials that present a hazard during transportation but do not meet the definition of any other hazard class. This class includes:
  - Any material that has an anesthetic, noxious, or similar property that could cause extreme annoyance or discomfort to a flight crew member so as to prevent the correct performance of assigned duties.
  - Any material that meets the definition in 49 CFR 171.8 of an elevated temperature material, a hazardous substance, a hazardous waste, or a marine pollutant.

4.3 Safety Data Sheets (MSDS)

Material Safety Data Sheets (MSDS) or Safety Data Sheets (SDS) are common sources of information on hazardous chemicals, as manufacturers are required to provide one for each chemical product sold. For any chemical you receive, the MSDS or SDS must be maintained. To assist with this requirement, the Biology lab manager and Chemistry lab supervisor maintain the data sheets for their respective departments. The EHS Manager maintains a repository of the data sheets for the entire campus.

4.4 Employee Information and Training

Employees in the Rieke Science Center may encounter hazards of various types, including biological, chemical, and radioactive, as well as fire. Employees should be familiarized with these hazards and the risks they pose. A training program should provide proper orientation in the use of safety equipment and in the implementation of related procedures and policies.

The ultimate responsibility for ensuring a safe working environment rests with the employee. He or she should assume an active role in maintaining a safe working environment by reporting problems or non-compliance with policies to the CHO or their department chair.

The CHO should develop classes to inform employees on the information present in the CHP regarding hazards in the workplace, the safety measures available, and how to use their safety equipment properly. These classes should be provided to all new employees and conducted regularly for continuing workers.

All full-time employees who work with flammable chemicals will receive basic training in fire safety, techniques for handling and storing flammables, using fire extinguishers, and the proper use of fume hoods.

All employees will receive training in hazard communication (29 CFR 1910.120), container labeling, chemical safety, MSDS use, and emergency evacuation procedures. In addition, the location of the Chemical Hygiene Plan should be made known to each employee and the contents of the plan made accessible to each employee.

Employees working with specific chemicals should be trained in proper work practices, personal protective equipment, emergency response, and other procedures to protect from chemical exposure. Whenever a new chemical is brought into the workplace, this type of training should be performed for affected employees.

The PELs and other action limits should be available for all the chemicals employees handle. The employees should know the location of MSDSs and have access to their information so that chemicals can be handled safely and disposed of properly. Employees should also be made familiar with the signs and symptoms of over-exposure, and the methods used to detect the chemicals they work with. Lesson plans for the training courses provided are available to all employees to be used as refresher materials.

IN CASE OF AN EMERGENCY, call 911 (9-911 from a campus phone)
and then Campus Safety x7911

Including the following emergencies:

- Medical Emergencies
- Complicated Spills
- Fires
- Explosions

Be prepared to provide the following information:

- Type of emergency
- Location
- Phone number

5 Emergency Procedures

Accidents happen unexpectedly. Accidents can result in personal injury, property damage, environmental impact, and disruption of academic research. Accordingly, emergency procedures are required components of a Chemical Hygiene Plan, which shall be relevant to the laboratory's specific hazards and research materials, and which shall be reviewed and understood by all laboratory personnel. All laboratory workers must know how to report a fire, injury, chemical spill, or other emergency, how to summon emergency response, and know the location of the nearest available exit.

In the event of an emergency, the trained lab employee is the initial incident commander on site. They are responsible for the immediate response to the incident.

1. Make an initial judgment as to the extent of the danger to students, staff, and facilities
2. Take remedial action for a minor incident
3. Call 9-911, then PLU Campus Safety at 7-911 for assistance
4. Evacuate the building and call for help

For more information see the Office of Emergency Management:

Emergency Procedures at: http://www.plu.edu/emergency/Emergency-Procedures/home.php.

5.1 Emergency Contact Signs

Emergency responders (e.g., Fire Department, Paramedics, and Police) need information on the physical and toxic hazards present before entering a room. Posting a NFPA hazard warning diamond at the entrance into all hazardous work/storage areas or laboratories in a way that emergency personnel can view the sign for associated hazards fulfills this requirement.

An emergency contact card is recommended on each laboratory entrance. This card should contain emergency phone numbers for the primary contact persons who are familiar and/or responsible for the oversight of the laboratory. The primary investigator should update contact or hazard information as it changes. For accuracy, an annual check should be performed for all door signs for accuracy. Date all cards when posted or when checked.

OSHA recommends the use of signs to alert employees to hazards. Danger signs indicate immediate specific hazards and that special precaution is necessary. Caution signs are used to warn against potential hazards or to caution against unsafe practices. Safety signs are used to provide general instructions and suggestions about safety measures.

5.2 Exit Egress Routes

Do not allow objects to block movement through aisles or exits. Laboratory personnel must have a clear route of egress out of the room. Emergency personnel must be able to access all areas of the laboratory, and be able to move freely in the aisles, particularly if smoke is present.
Do no clutter floor space with storage. Minimize physical hazards (e.g., tripping hazards, items that could fall on someone, etc.). Do not store flammable, combustible, corrosive, oxidizers, dangerous when wet, or toxic materials in such a way that they will slide, collapse, fall or spill blocking an emergency exit egress route.

If the laboratory door is outfitted with a window, it needs to remain unobstructed for emergency responders to see freely into the room.

5.3 Emergency Equipment

All laboratory emergency equipment shall be used for intended purpose only. Emergency equipment shall not be obstructed, altered or tampered with. All laboratory workers must know the locations of (and how to operate) the following safety items: safety showers & eyewashes, fire extinguishers, and spill control equipment.

5.3.1 First Aid Kits

First aid kits should be available and unobstructed. Consider the various injuries that could happen in the laboratory, and assemble the first aid kit accordingly (e.g., if hydrofluoric acid is used in the laboratory, then a calcium gluconate gel should be available for the first aid treatment of skin exposure). Personnel should be trained on the proper use of the first aid kit's components. The primary investigator should evaluate the hazards present in the laboratory, and adjust the first aid kit contents as needed.

5.3.2 Emergency Eyewashes and Showers

Emergency eyewash and showers are designed to provide first aid treatment to prevent permanent eye and skin damage from chemical burns or foreign substances. The equipment must meet the requirements of ANSI Z358.1-1998.

Emergency eyewashes and showers shall be properly located and maintained. These units should be located in areas that will be immediately accessible (reachable within 10 seconds/50 feet). There should be no obstructions that might inhibit the use of this equipment. Everyone should be sure that access to eyewash fountains and safety showers is not restricted or blocked by temporary

storage of objects or in any other way. Equipment shall be identified with a sign that is visible within the area served. Emergency showers shall be activated and tested weekly to verify the plumbing supply has not been disrupted. Emergency eyewashes shall be activated and tested weekly. Regular activation ensures the emergency stations are operating properly, helps to keep basins free of clutter, and helps prevent the growth of bacteria within the plumbing lines, which can cause eye infections. Initial and date tags to record these tests.

Eyewashes shall be available in labs where there is the potential for injury to the eye due to contact with a toxic, corrosive, or strong irritant chemical, or where there is the potential for exposure to biological materials. Hand-held eyewash bottles do not qualify as approved eyewashes. Hand-held eyewash bottles are acceptable to use in conjunction with approved hard plumbed, sink mounted (< 2 valves to operate) or portable eyewash unit.

Emergency showers shall be available in labs where there is the potential for injury to the major portion of the body due to contact with a corrosive, severely irritating, or toxic chemical.

The principal investigator is responsible for ensuring that access to emergency showers and eyewashes are kept free of clutter and ensuring the eyewash nozzle dust covers are kept in place (nozzle covers protect the eyewash unit from dust or other particles can clog the nozzles and result in poor or no water flow and can also result in dust or other particles being forced into the eyes when the eyewash is used). If an emergency eyewash or shower is not functioning properly PLU Facility Management should be notified to correct the deficiency.

5.3.2.1 Using an Emergency Eyewash

- If you get a chemical or foreign material in your eyes, call out for help!
- Immediately proceed to the nearest eyewash and push the activation handle all the way on.
- Put your eyes or other exposed area in the stream of water and begin flushing.
- Open your eyelids with your fingers and roll your eyeball side to side, up/down, and around in circles to get maximum irrigation of the eyes.
- Keep flushing for at least 15 minutes or until help arrives. **The importance of flushing the eyes first for <u>at least</u> 15 minutes cannot be overstated!**
- For accidents involving hydrofluoric acid and bromine, follow the special hydrofluoric acid and bromine medical precautions noted in the Medical Emergency Section
- If you are alone, call 911 (9-911 from PLU phone after you have finished flushing your eyes for at least 15 minutes.
- Seek medical attention.
- Complete an accident report.

<u>Buddy System:</u> If someone in the lab needs to use an eyewash, assist them to the eyewash, activate the eyewash, and help them get started flushing their eyes using the procedures above and then call 911 (9-911 from PLU phone). After calling 911, go back to assist the person and continue flushing for 15 minutes or until help arrives and have the person seek medical attention.

5.3.2.2 Using an Emergency Shower

- If you get chemical contamination on an extensive part of an arm or leg or any part of the torso resulting from an accident, call out for help!
- Immediately go to the nearest emergency shower and pull the activation handle.
- Once under the stream of water, begin removing your clothing to wash off all chemicals. Now is not the time for shyness.
- Keep flushing for at least 15 minutes or until help arrives. **The importance of flushing the eyes first for <u>at least</u> 15 minutes cannot be overstated!**
- For accidents involving hydrofluoric acid and bromine follow the special hydrofluoric acid and bromine medical precautions noted in the Medical Emergency Section.

- If you are alone, call 911 (9-911 from PLU phone) after you have finished flushing for at least 15 minutes.
- Seek medical attention.
- Complete an accident report.

Buddy System: If someone else in the lab needs to use an emergency shower (and it is safe for you to do so), assist them to the emergency shower, activate the shower for them, and help them get started flushing using the procedures above and then call 911 (9-911 from PLU phone). After calling 911, go back to assist the person using the shower and continue flushing for 15 minutes or until help arrives and have the person seek medical attention.

NOTE: Although an emergency is no time for modesty, if a person is too modest and reluctant to use the emergency shower, you can assist them by using a lab coat or other piece of clothing or barrier to help ease their mind while they undress under the shower. If you are assisting someone else, you should wear gloves to avoid contaminating yourself. When using an emergency shower, do not be concerned about the damage from flooding. The important thing to remember is to keep flushing for 15 minutes.

5.3.3 Fire Extinguishers

In the event of a fire, call 911 (9-911 from PLU phone) immediately then call PLU Campus Safety at x7911

Fire extinguishers must be available, charged, and hung in a location, which is immediately accessible (reachable within 10 seconds). There should be no obstructions that might inhibit the use of this equipment. Make sure that all extinguishers are checked annually. Each extinguisher should have a tag indicating the date it was last checked. Know the location of extinguishers in your immediate area, and know how to use them (i.e., get training and read the instructions) before an emergency occurs. Report missing extinguishers to PLU Facilities Management at x7380. PLU makes available fire extinguisher training for individuals in all areas of the university. Contact PLU - Environmental, Health and Safety @ x7233 for training schedule.

5.3.3.1 Types of Fire Extinguishers

- Type: A/B/C
  - Multipurpose fire extinguisher: Used for combustibles (i.e. wood, paper, trash, clothing); flammable liquids (i.e. oils, grease, gasoline, paints, solvents); and electrical equipment (i.e. wiring, equipment, fuse boxes, outlets).
- Type D
  - Combustible metals, such as sodium, potassium, aluminum, and magnesium

5.3.3.2 Using a Fire Extinguisher – REMEMBER "PASS"

- How to Use: **PASS = Pull, Aim, Squeeze and Sweep**
  - **Pull**: Pull and twist to remove the pin.
  - **Aim**: Aim the nozzle at the base of the fire standing back at least eight feet.
  - **Squeeze**: Squeeze the handle to activate the fire extinguisher.
  - **Sweep**: Sweep the fire extinguisher from side to side.
- Fire extinguisher agent will not last long...only about 10 seconds.

5.3.4 Chemical Spill Kits

A spill clean-up kit should be available and unobstructed. Consider the spills that could happen in the laboratory, and assemble the appropriate spill clean-up kit. Materials should be evaluated for compatibility with the hazards in the laboratory that could be spilled. Universal sorbents and spill pads are recommended for spill kits. If any materials are used, they should be re- stocked immediately. The CHO and Principal Investigator should periodically evaluate the spill clean-up kit,

and adjust the kit contents as needed. When the spill kit has been used, notify the CHO (See Section 5.6.2 for more information).

5.4 Medical Emergencies

In a Medical Emergency call 911 (9-911 from PLU phone) immediately then call PLU Campus Safety at x7911

For serious injuries do not try to take care of the victim by yourself. PLU Campus Safety personnel are trained in first aid and are available 24/7. If medical help is needed provide a copy of the appropriate MSDS to the responding paramedic.

For incidents when paramedics are called, have someone stay with the victim at all times. Keep the victim reassured and watch for signs of shock.

- **Minor Cuts:** If the injured person has experienced a minor cut, flush the wound with tepid running water to remove any possible chemical contaminants. For a cut on a gloved hand: If you do not suspect that the cut has been injected with chemicals, do not immediately remove the glove. First, rinse off the glove to avoid contamination of the cut with chemicals. If you do suspect that the cut has been injected with chemicals, then immediately remove the glove and flush the wound with tepid water. Apply a sterile bandage and advise the victim that he or she should report any signs of infection to a physician. If there is a possibility that the wound is contaminated by broken glass or chemicals, the victim should seek immediate medical attention.
- **Major Cuts:** If the injured person has experienced a more serious injury (if sutures might be necessary) call 911 (9-911 on PLU phone) and apply sterile gauze pads to the wound. If necessary, apply direct pressure to the wound to stop the bleeding. Apply additional pads if the blood soaks through the first sterile pad. Do not remove the original pads. If unable to stop the bleeding, remain calm and carefully explain the situation to the 911 dispatcher. The dispatcher will advise you on further action.
- **Thermal Burns:** For thermal burns do not apply ointments or ice to the wound. For first-degree wounds, flush with copious amounts of tepid running water. Apply a moist dressing and bandage loosely. For second degree (with open blisters) and third degree burns, do not flush with water. Apply a dry dressing and bandage loosely. Immediately seek medical attention.
- **Chemical Splashes & Burns:** Seek medical help immediately! Immediately flush the affected area with tepid running water for 15 minutes. Chemical splashes of strong corrosives can result in chemical burns and are to be treated with the utmost concern and speed. Do not wait for symptoms (such as pain) to develop. Call 911 (9-911 on PLU phone) for paramedics. Use a sink faucet if a hand or only a portion of the lower arm is affected. Use the safety shower an extensive part of an arm or leg or any part of the torso is affected. Use the eyewash if you even suspect that chemicals may have come in contact with an eye, face, or head. Watch the victim. You may need to help hold the victim's head close to the eyewash, and may even need to use your fingers to hold the eyelids open so that water can thoroughly rinse the eye socket. Remove all affected clothing. While drenching the person with water help he/she remove the affected pieces of clothing. Have all others leave the room except for perhaps 1-2 people who can stay behind to hold fire blankets up to allow the victim some additional privacy while they continue to be flushed with water. In addition to removing all contaminated clothing & shoes, remove any jewelry so that the chemical cannot sit against the skin and do further damage. Do not apply ointments, baking soda, ice, or gauze coverings to the affected area.
    - *Hydrofluoric Acid (HF)* – seek medical help immediately! Hydrofluoric acid is an extremely corrosive liquid that can cause severe injury because it readily penetrates the skin and causes decalcification of the bones. Contact with HF can come via skin and eye contact, inhalation, and ingestion. Laboratory workers who are using HF must be trained with first-aid procedures for HF exposure before beginning work with HF.

Calcium gluconate gel (2.5% w/w) must be present and readily accessible in work areas where any potential HF exposure exists. If contact with HF occurs, first aid must be started within seconds and 911 (9-911 from PLU phone) must be called immediately. If the vapor is inhaled, immediately move the victim to fresh air. Immediately flush the exposed area with tepid water, remove all contaminated clothing, and call 911. Apply the calcium gluconate gel after 5 minutes of flushing with water. If you are helping a victim, do not allow the HF to touch your body!

- *Bromine* – seek medical help immediately! Flush with running water. Apply a compress saturated with a dilute sodium thiosulfate solution.

- **Cold Burns:** For injuries from cold burns – seek medical help immediately! Tissue contact with cryogenic liquids produces damage similar to that associated with thermal burns and can cause severe deep-freezing with extensive destruction of tissue. Flush affected areas with large volumes of tepid water to reduce freezing. *DO NOT APPLY HEAT*. Loosen any clothing that may restrict circulation. Cover the affected area with a sterile protective dressing or with clean sheets if the area is large, and protect the area from further injury. If the body temperature is depressed, the patient must be warmed gradually. Shock may occur during the correction of sever hypothermia.

  NOTE: Frozen tissues are painless and appear waxy with a pallid yellow color. Tissues become painful and edematous upon thawing and the pale color turns to pink or red as circulation of blood is restored. Tissues that have been frozen show severe, widespread cellular injury and are highly susceptible to infections and additional trauma. Therefore, rapid re-warming of tissues is not recommended.
- **Chemical Ingestion:** Seek medical help immediately! DO NOT WASTE TIME. Call 911 (9-911 from PLU phone) and the Poison Control Center at 1-800-222-1222, and consult the MSDS for the appropriate action. Do not encourage vomiting except under the advice of a physician. Save all chemical containers and a small amount of vomit, if possible, for analysis.
- **Unconsciousness or Convulsions:** Seek medical help immediately! Call 911 (9-911 from PLU phone). If it is safe for you to enter the area:
  - If the victim is unconscious: Place the victim on his or her back keeping airway open, cover torso and extremities with a blanket. Do not attempt to remove the victim from the area unless an immediate danger exists. Clear the area of any chemical spill or broken glassware.
  - If the victim is convulsing: Remove anything that might cause harm to the victim. Try to protect the victim from further danger with as little interference as possible. Clear the area of any chemical spills or broken glassware.
  - If the victim begins to vomit, turn the head so that the stomach contents are not aspirated into the lungs.
- **CPR/First Aid/Bloodborne Pathogen Training:** Training is encouraged and available for all PLU employees and is offered free. Contact the EHS Manager @ x7233 for a training schedule.

5.4.1 University Employees

In the event of an accident or injury on the job, each employee is covered by the Washington State Industrial Insurance Program (Worker's Compensation). Injury reports help the university process insurance claims and investigate and correct hazardous work conditions. Employees and supervisors should be thorough when filling out the report, sign and date. The safety committee also reviews each injury report. To assist medical personnel, bring the Material Safety Data Sheet (MSDS) of any chemical involved in an injury or incident. Do not delay seeking medical attention if you cannot locate the MSDS.

- Report job-related injuries to your supervisor as soon as possible.

- Supervisors must investigate all reported accidents to determine root causes.
- PLU will correct causes leading to the injury.
- As soon as the injured party is physically able to fill out the injury report, the injured employee should complete and mail the form to Human Resource Services. The injury report form can be found at: http://www.plu.edu/human-resources/documents-forms/documents/Safety/injury-report-2.doc.

5.4.2 Students, Visitors, and Other Non-Employed Personnel

PLU visitors who are involved in activities for which they are not paid and suffer an injury requiring emergency medical treatment (i.e. chemical exposure), should immediately seek treatment at a local emergency room. Students may also seek basic medical care at the PLU Health Center or with their personal physician. Students may also go to the local emergency rooms in this case. Costs associated with most injuries incurred during these activities are the responsibility of the individual through their personal insurance or student insurance.

A person suffering an injury during activities for which they are not paid, an injury report form found at: http://www.plu.edu/human-resources/documents-forms/documents/Safety/injury-report-2.doc should be filled out and forwarded to Campus Safety. The injury report should be completed regardless of where the injury occurred or whether the person received medical follow-up.

5.5 Fires

Each person should be continually on the alert for fire safety hazards. Please report any observed hazards to the Chemical Hygiene Officer.

Some examples of the most frequent fire safety hazards are:

- Permitting aisles, corridors, and routes of egress to become obstructed.
- Using extension cords, ungrounded plugs, and unfused multiple outlet adapters for various small appliances. These are NOT PERMITTED and will only overload the electrical circuit.
- Illegal storage in corridors, ventilation rooms, electrical & equipment rooms, under stairways, etc. These areas must be kept clear at all times.
- Improper handling and storage of chemicals and flammable liquids. These must be limited to acceptable quantities and stored only in approved cabinets.
- Wedging open of fire rated doors. These doors are designed to slow the spread of smoke and fire. Keep them closed at all times.
- Improper smoking habits. PLU is a non-smoking campus. No smoking allowed.

Be Prepared: Know the exit routes from your laboratory, office, floor, and building. Study the egress maps in advance. It is easy to get disoriented during an actual emergency. Know the location of fire extinguishers and how to use them. Report missing extinguishers to PLU FAMA immediately.

Make sure that emergency numbers are posted on your telephone. If these numbers are not posted on your phone, call the EHS Manager @ x7233 for a sticker.

If a Fire Occurs: Notify anyone in the immediate area.

- Activate the nearest fire alarm pull station
- Call 911 (9-911 from PLU phone)
- Confine the fire by closing doors and windows
- Attempt to extinguish the fire only if it is safe to do so
- If there is smoke or heat, stay low
- DO NOT USE ELEVATORS

Before opening any door, feel it near the top. If it is hot, do not open, but: Call 911 (9-911 from PLU phone) and tell them your exact location and situation. Place a blanket or similar article along the bottom of your door to keep out smoke. If possible, wet the material first. Close as many doors

between you and the fire as possible. Hang a light colored material out the window to attract attention from below. DO NOT JUMP! If the door is not hot: Open the door cautiously. Stand behind the door and be prepared to close if quickly if there is excessive smoke. Conduct a final search before leaving, if safe to do so.

If your mobility is limited by wheelchair, crutches, etc., and you have a telephone, stay where you are and call 911 (9-911 from PLU phone) for help. If you do not have a telephone, leave the area and position yourself in the stairwell landing (if applicable), if it is clear, and wait for responding emergency personnel.

Report to Rieke Science Center designated assembly area. Do not re-enter the building until notified.

Fire Do's:

- Do report the fire – do not assume someone else has called the fire department.
- Do activate the nearest pull alarm station – know their locations.
- Do close doors – closed doors slow the spread of smoke and fire.
- Do use stairs to vacate the building. Report to the designated emergency assembly points.
- Do evacuate your floor, when there is smoke visible or you are instructed to leave by the floor Emergency Building Coordinators or Fire Department personnel.

Fire Don’ts:

- Don’t use elevators – elevators can be very dangerous in a fire, even when they appear safe. Always use the stairs instead of an elevator.
- Don’t arbitrarily break windows – falling glass is a serious threat to both pedestrians and fire fighting personnel.
- Don’t exit until you have felt the top of the exit door and the door knob. If either is hot, or if excessive smoke prevents your exit, keep the door closed. Fire on the other side will flash through the slightest opening with tremendous force.
- Don’t go back for your things if you are ordered to leave.
- Don’t congregate in the stairways – keep to the right and keep going until it is safe to exit. Always proceed along egress route until you reach the exit.
- Don’t panic – remain calm. Help is on the way.

5.6 Chemical Spills

PLU science personnel take pride in being careful while handling chemicals; however, all laboratory workers must be prepared for accidentals spills. Simple spills can be safely and adequately cleaned up using the spills kits that are distributed throughout the laboratories. In the event of an accidental chemical release or spill of a larger quantity or of complicated nature, personnel should refer to the following general guidelines. Consult with the CHO if you have any questions regarding the following procedures.

5.6.1 Preventing Spills

Listed below are some basic spill prevention steps that apply to storage, transportation, and transfer of chemicals.

- **General Precautions:** Reduce clutter and unnecessary materials in your work areas. Eliminate tripping hazards and other obstructions. Have all needed equipment readily available before starting work.
- **Storage Precautions:** Use sturdy shelves. Chemicals shall be stored by compatibility first, then alphabetically. Larger containers should be stored closer to the floor. Containers on shelves should be stored back from the edge to reduce the danger of falling. Storage shelves should have lips to further reduce the danger of containers falling. Inspect storage areas

regularly for leaking or defective containers. Use appropriate storage containers. Periodically check containers under laboratory chemical hoods, sinks and lab benches for signs of deterioration.

- **Transportation Precautions:** Use carts, where appropriate. Use safety containers, where appropriate. Use of bottle carriers for any glass bottle greater than 250mL is recommended. Use straps to secure gas cylinders. Think about potential hazards before transporting chemicals.
- **Precautions in Transferring Chemicals:** Pay careful attention to the size of container to avoid overfilling. Use pumps, funnels, or other mechanical devices rather than simple pouring. Provide containment to capture leaks and spills. Use of plastic coated “shatter resistant" bottles is recommended when having to transfer chemicals from a larger to smaller container.

5.6.2 Preparing for Spills

Before working with chemicals, assess potential spill hazards. Principal Investigators and laboratory instructors should be aware of the volume of material that could be released, its chemical, physical and hazardous properties, familiar with general spill response and any unusual spill cleanup procedures. Written protocols should be developed when extremely hazardous or large quantities of chemicals are used. Have readily available all necessary personal protective equipment and spill cleanup materials.

- **Evaluate Hazards:** When spills occur, an appropriate response can prevent serious consequences. However, the wrong response can make things worse. In order to respond promptly and appropriately potential hazards should be evaluated in advance of using the chemicals. The first source of information to consult would be the Material Safety Data Sheets (MSDSs). You can obtain an MSDS from the CHO and online at EHS website. Of most concern in spill situations are chemicals that are air reactive, water reactive, flammable, polymerizable, corrosive, and/or highly toxic. Based on these hazards, you can then determine: appropriate personal protective equipment for spill response; types of fire suppression equipment; appropriate clean up materials; and first aid procedures.
- **Establish Spill Response Protocols:** Before working with chemicals Principal Investigators should evaluate potential incidents and how to respond. As a result of this evaluation, written protocols should be prepared for use in the event of a spill. These protocols need to be communicated to all persons who might be affected by a spill. The best place to document spill response protocols in the laboratory is in the Chemical Hygiene Plan. In addition, basic spill clean-up materials should be readily available should anything go wrong. More information on spill clean-up materials is listed below. Always create written spill protocols before using a chemical.
- **Assemble a Spill Kit:** Prior to starting any research with chemicals, make sure that all the necessary personal protective devices, safety equipment, and containment/clean up materials are readily available. Every lab should have a spill kit. All personnel who may be involved in spill response or clean up must know the purpose and limitations of all personal protective equipment, safety equipment and clean up materials. Spill kits, at a minimum, should contain: Disposable nitrile and neoprene gloves; safety goggles; hand broom; plastic dustpan; plastic bags; appropriate absorbent material (such as spill pads, spill pillows or loose sorbents). The location of spill control kits should be clearly marked and highly visible. Make sure all personnel know the kit’s location, are familiar with the kit’s contents, and understand its limitations.

5.6.3 Spill Response Procedures

Spills of toxic substances or hazardous chemicals should be resolved immediately. Laboratory personnel should be aware of the volume of material that could be released; its chemical, physical

and hazardous properties by checking the MSDS and any recommended unusual spill cleanup procedures. All spills will be handled by trained cleanup personnel by calling the CHO. A spill report shall be submitted to the CHO.

Chemical spills and leaks can be categorized into two basic types:

1. Complicated spills which require outside emergency responder assistance; and
2. Simple spills that trained Principal Investigators and laboratory personnel can clean up.

- **Complicated Spills:** Immediately call 911 (9-911 from PLU phone) then Campus Safety at x7911 if a spill meets **ANY** of the following conditions:
  - A person is injured;
  - The identity of the chemical is unknown;
  - Multiple chemicals are involved;
  - The chemical is highly toxic, flammable or reactive;
  - The spill has the potential to spread to other parts of the building such as through the ventilation system;
  - The clean up procedures are not known or appropriate materials are not readily available;
  - The clean up requires the use of an air purifying respirator (See Section 3.5);
  - The spill may endanger the environment by reaching domestic/storm water conveyance system, or outside ground.
- **Complicated Spill Procedures:**
  - Evacuate the area, alerting others in the area to follow.
  - If possible, close doors and windows to prevent the spread of fumes and vapors.
  - From a safe location, call 911 (9-911 from PLU phone) then Campus Safety at x7911 immediately. Be ready to answer the following questions:
    - What is the name of the chemical spilled?
    - What quantity of the chemical is spilled?
    - Where is the spill (building name and room number)?
    - Is anyone injured or splashed with the chemical?
    - Is a fire or explosion involved in the spill?
    - What is your name and phone number?
  - Secure the area so no one will enter until the emergency responders arrive.
  - Someone with knowledge of the chemical spilled should meet the fire department at the Emergency Vehicle Access (EVA) roundabout (NW of Rieke Science Center). If a Material Safety Data Sheet (MSDS) is readily available, the contact should take a copy to provide to the responders.
- **Simple Spill Procedures:** If the spill does not meet any of the conditions for a complicated spill, the spill is defined as a simple spill. Principal Investigators and laboratory personnel can clean up simple spills as described below:
  - If possible, close doors and windows to prevent the spread of fumes and vapors.
  - Turn off all potential sources of ignition (Bunsen burners, pumps, mechanical equipment not designed to be spark-proof, etc) if the spilled material is flammable (it may be necessary to turn off power from a remote circuit breaker).
  - Put on gloves, lab coat, apron, eye protection, and other PPE, as necessary.
  - Absorb liquids using appropriate absorbent material (such as spill pads, spill pillows or loose sorbents):
    - Do not attempt to neutralize acids or bases - absorb each liquid spill as is.
    - Do not use silica products to clean up hydrofluoric acid.
    - Do not use combustible materials to clean up oxidizers. For instance, do not use paper towels for nitric acid spills.
  - Carefully sweep powder spills to avoid contaminating the air with chemical dust.

- Collect and contain clean-up materials in a plastic container or thick plastic bag and affix descriptive labels.
- Decontaminate affected area and equipment (soap and water can be used to clean most surfaces) and ventilate the area, if necessary.
- Contact the Chemical Hygiene Officer to assure the proper handling, storage, and disposal of the hazardous waste clean-up material.

- **SPECIAL CASE – Mercury Spill:** The best method of dealing with mercury spills is to prevent them in the first place. Examine all uses of mercury to see if non-mercury alternatives are available. If not, use trays or other equipment to provide containment in the event of a spill. If mercury-containing devices must be used in the lab the spill clean-up kit should also contain Hg Absorb™ (available from companies such as Lab Safety Supply).

  Mercury Spill Procedures:
  - In the event of a mercury spill, cordon off the area to prevent mercury from being spread by foot traffic.
  - For broken mercury thermometers use mercury-absorbing powder. The powder creates an amalgam that does not emit mercury vapor. After cleaning up the mercury, place the clean-up debris and broken thermometer (with heavy tape over the broken ends) in a sturdy plastic bag. Close and label the bag "Waste-broken mercury thermometer." Contact the Chemical Hygiene Officer to assure the proper handling, storage, and disposal.
  - For small spills of mercury use mercury-absorbing powder. Close and label the bag "Waste-mercury debris." Contact the Chemical Hygiene Officer to assure the proper handling, storage, and disposal.
  - For large spills, follow the complicated spill procedures.

  NOTE: Do not use a regular vacuum cleaner or Shop-Vac® to clean up mercury spills. Doing so will produce toxic mercury vapor in the immediate area and contaminate the vacuum cleaner. Do not use nitric acid to clean up spills. Mercury and nitric acid will react, creating toxic nitrogen oxide gases, and a mercury nitrate waste.

APPENDIX A

29 CFR 1910.1450
"Occupational Exposure to Hazardous Chemicals in Laboratories"
(commonly referred to as the "Laboratory Standard")

1910.1450(a) Scope and application.
1910.1450(a)(1) This section shall apply to all employers engaged in the laboratory use of hazardous chemicals as defined below.
1910.1450(a)(2) Where this section applies, it shall supersede, for laboratories, the requirements of all other OSHA health standards in 29 CFR part 1910, subpart Z, except as follows:
1910.1450(a)(2)(i) For any OSHA health standard, only the requirement to limit employee exposure to the specific permissible exposure limit shall apply for laboratories, unless that particular standard states otherwise or unless the conditions of paragraph (a)(2)(iii) of this section apply.
1910.1450(a)(2)(ii) Prohibition of eye and skin contact where specified by any OSHA health standard shall be observed.
1910.1450(a)(2)(iii) Where the action level (or in the absence of an action level, the permissible exposure limit) is routinely exceeded for an OSHA regulated substance with exposure monitoring and medical surveillance requirements paragraphs (d) and (g)(1)(ii) of this section shall apply.
1910.1450(a)(3) This section shall not apply to:
1910.1450(a)(3)(i) Uses of hazardous chemicals which do not meet the definition of laboratory use, and in such cases, the employer shall comply with the relevant standard in 29 CFR part 1910, subpart Z, even if such use occurs in a laboratory.
1910.1450(a)(3)(ii) Laboratory uses of hazardous chemicals which provide no potential for employee exposure. Examples of such conditions might include:
1910.1450(a)(3)(ii)(A) Procedures using chemically-impregnated test media such as Dip-and-Read tests where a reagent strip is dipped into the specimen to be tested and the results are interpreted by comparing the color reaction to a color chart supplied by the manufacturer of the test strip; and
1910.1450(a)(3)(ii)(B) Commercially prepared kits such as those used in performing pregnancy tests in which all of the reagents needed to conduct the test are contained in the kit.
1910.1450(b) Definitions—

"**Action level**" means a concentration designated in 29 CFR part 1910 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.

"**Assistant Secretary**" means the Assistant Secretary of Labor for Occupational Safety and Health, U.S. Department of Labor, or designee.

"**Carcinogen**" (see "**select carcinogen**").

"**Chemical Hygiene Officer**" means an employee who is designated by the employer, and who is qualified by training or experience, to provide technical guidance in the development and implementation of the provisions of the Chemical Hygiene Plan. This definition is not intended to place limitations on the position description or job classification that the designated individual shall hold within the employer's organizational structure.

"**Chemical Hygiene Plan**" means a written program developed and implemented by the employer which sets forth procedures, equipment, personal protective equipment and work practices that (i) are capable of protecting employees from the health hazards presented by hazardous chemicals used in that particular workplace and (ii) meets the requirements of paragraph (e) of this section.

"**Combustible liquid**" means any liquid having a flashpoint at or above 100 deg. F (37.8 deg. C), but below 200 deg. F (93.3 deg. C), except any mixture having components with flashpoints of 200 deg. F (93.3 deg. C), or higher, the total volume of which make up 99 percent or more of the total volume of the mixture.

"**Compressed gas**" means:

(i) A gas or mixture of gases having, in a container, an absolute pressure exceeding 40 psi at 70 deg. F (21.1 deg. C); or

(ii) A gas or mixture of gases having, in a container, an absolute pressure exceeding 104 psi at 130 deg. F (54.4 deg C) regardless of the pressure at 70 deg. F (21.1 deg. C); or

(iii) A liquid having a vapor pressure exceeding 40 psi at 100 deg. F (37.8 C) as determined by ASTM D-323-72.

"**Designated area**" means 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.

"**Emergency**" means any occurrence such as, but not limited to, equipment failure, rupture of containers or failure of control equipment which results in an uncontrolled release of a hazardous chemical into the workplace.

"**Employee**" means an individual employed in a laboratory workplace who may be exposed to hazardous chemicals in the course of his or her assignments.

"**Explosive**" means a chemical that causes a sudden, almost instantaneous release of pressure, gas, and heat when subjected to sudden shock, pressure, or high temperature.

"**Flammable**" means a chemical that falls into one of the following categories:

(i) Aerosol, flammable means 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;

(ii) Gas, flammable means:

(A) 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

(B) 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.

(iii) Liquid, flammable means any liquid having a flashpoint below 100 deg F (37.8 deg. C), except any mixture having components with flashpoints of 100 deg. C) or higher, the total of which make up 99 percent or more of the total volume of the mixture.

(iv) Solid, flammable means a solid, other than a blasting agent or explosive as defined in § 1910.109(a), that is liable to cause fire through friction, absorption of moisture, spontaneous chemical change, or retained heat from manufacturing or 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 to be 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.

"**Flashpoint**" means the minimum temperature at which a liquid gives off a vapor in sufficient concentration to ignite when tested as follows:

(i) Tagliabue Closed Tester (See American National Standard Method of Test for Flash Point by Tag Closed Tester, Z11.24 - 1979 (ASTM D 56-79)) - for liquids with a viscosity of less than 45 Saybolt Universal Seconds (SUS) at 100 deg. F (37.8 deg. C), that do not contain suspended solids and do not have a tendency to form a surface film under test; or

(ii) Pensky-Martens Closed Tester (See American National Standard Method of Test for Flashpoint by Pensky-Martens Closed Tester, Z11.7 - 1979 (ASTM D 93-79)) - for liquids with a viscosity equal to or greater than 45 SUS at 100 deg. F (37.8 deg. C), or that contain suspended solids, or that have a tendency to form a surface film under test; or

(iii) Setaflash Closed Tester (see American National Standard Method of test for Flash Point by Setaflash Closed Tester (ASTM D 3278-78).

(iv) Organic peroxides, which undergo auto accelerating thermal decomposition, are excluded from any of the flashpoint determination methods specified above.

"**Hazardous chemical**" means a chemical 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. The term "health hazard" includes chemicals which are 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. Appendices A and B of the Hazard Communication Standard (29 CFR 1910.1200) provide further guidance in defining the scope of health hazards and determining whether or not a chemical is to be considered hazardous for purposes of this standard.

"**Laboratory**" means a facility where the "laboratory use of hazardous chemicals" occurs. It is a workplace where relatively small quantities of hazardous chemicals are used on a non-production basis.

"**Laboratory scale**" means work with substances in which the containers used for reactions, transfers, and other handling of substances are designed to be easily and safety manipulated by one person. "Laboratory scale" excludes those workplaces whose function is to produce commercial quantities of materials.

"**Laboratory-type hood**" means a device located in a laboratory, enclosure on five sides with a movable sash or fixed partial enclosed on the remaining side; constructed and maintained to draw air from the laboratory and to prevent or minimize the escape of air contaminants into the laboratory; and allows chemical manipulations to be conducted in the enclosure without insertion of any portion of the employee's body other than hands and arms. Walk-in hoods with adjustable sashes meet the above definition provided that the sashes are adjusted during use so that the airflow and the exhaust of air contaminants are not compromised and employees do not work inside the enclosure during the release of airborne hazardous chemicals.

"**Laboratory use of hazardous chemicals**" means handling or use of such chemicals in which all of the following conditions are met:

(i) Chemical manipulations are carried out on a "laboratory scale;"

(ii) Multiple chemical procedures or chemicals are used;

(iii) The procedures involved are not part of a production process, nor in any way simulate a production process; and

(iv) "Protective laboratory practices and equipment" are available and in common use to minimize the potential for employee exposure to hazardous chemicals.

"**Medical consultation**" means a consultation which takes place between an employee and a licensed physician for the purpose of determining what medical examinations or procedures, if any, are appropriate in cases where a significant exposure to a hazardous chemical may have taken place.

"**Organic peroxide**" means an organic compound that contains the bivalent -O-O- structure and which may be considered to be a structural derivative of hydrogen peroxide where one or both of the hydrogen atoms has been replaced by an organic radical.

"**Oxidizer**" means a chemical other than a blasting agent or explosive as defined in § 1910.109(a), that initiates or promotes combustion in other materials, thereby causing fire either of itself or through the release of oxygen or other gases.

"**Physical hazard**" means a chemical for which there is scientifically valid evidence tat it is a combustible liquid, a compressed gas, explosive, flammable, an organic peroxide, an oxidizer pyrophoric, unstable (reactive) or water-reactive.

"**Protective**" laboratory practices and equipment means those laboratory procedures, practices and equipment accepted by laboratory health and safety experts as effective, or that the employer can show to be effective, in minimizing the potential for employee exposure to hazardous chemicals.

"**Reproductive toxins**" means chemicals which affect the reproductive chemicals which affect the reproductive capabilities including chromosomal damage (mutations) and effects on fetuses (teratogenesis).

"**Select carcinogen**" means any substance which meets one of the following criteria:

(i) It is regulated by OSHA as a carcinogen; or

(ii) It is listed under the category, "known to be carcinogens," in the Annual Report on Carcinogens published by the National Toxicology Program (NTP)(latest edition); or

(iii) It is listed under Group 1 ("carcinogenic to humans") by the International Agency for research on Cancer Monographs (IARC)(latest editions); or

(iv) It is listed in either Group 2A or 2B by IARC or under the category, "reasonably anticipated to be carcinogens" by NTP, and causes statistically significant tumor incidence in experimental animals in accordance with any of the following criteria:

(A) After inhalation exposure of 6-7 hours per day, 5 days per week, for a significant portion of a lifetime to dosages of less than 10 mg/m(3);

(B) After repeated skin application of less than 300 (mg/kg of body weight) per week; or

(C) After oral dosages of less than 50 mg/kg of body weight per day.

"**Unstable (reactive)**" means a chemical which is the pure state, or as produced or transported, will vigorously polymerize, decompose, condense, or will become self-reactive under conditions of shocks, pressure or temperature.

"**Water-reactive**" means a chemical that reacts with water to release a gas that is either flammable or presents a health hazard.

1910.1450(c) Permissible exposure limits. For laboratory uses of OSHA regulated substances, the employer shall assure that laboratory employees' exposures to such substances do not exceed the permissible exposure limits specified in 29 CFR part 1910, subpart Z.

1910.1450(d) Employee exposure determination—

1910.1450(d)(1) Initial monitoring. The employer shall measure the employee's exposure to any substance regulated by a standard which requires monitoring if there is reason to believe that exposure levels for that substance routinely exceed the action level (or in the absence of an action level, the PEL).

1910.1450(d)(2) Periodic monitoring. If the initial monitoring prescribed by paragraph (d)(1) of this section discloses employee exposure over the action level (or in the absence of an action level, the PEL), the employer shall immediately comply with the exposure monitoring provisions of the relevant standard.

1910.1450(d)(3) Termination of monitoring. Monitoring may be terminated in accordance with the relevant standard.

1910.1450(d)(4) Employee notification of monitoring results. The employer shall, within 15 working days after the receipt of any monitoring results, notify the employee of these results in writing either individually or by posting results in an appropriate location that is accessible to employees.

1910.1450(e) Chemical hygiene plan -- General. (Appendix A of this section is non-mandatory but provides guidance to assist employers in the development of the Chemical Hygiene Plan).

1910.1450(e)(1) Where hazardous chemicals as defined by this standard are used in the workplace, the employer shall develop and carry out the provisions of a written Chemical Hygiene Plan which is:

1910.1450(e)(1)(i) Capable of protecting employees from health hazards associated with hazardous chemicals in that laboratory and

1910.1450(e)(1)(ii) Capable of keeping exposures below the limits specified in paragraph (c) of this section.

1910.1450(e)(2) The Chemical Hygiene Plan shall be readily available to employees, employee representatives and, upon request, to the Assistant Secretary.

1910.1450(e)(3) The Chemical Hygiene Plan shall include each of the following elements and shall indicate specific measures that the employer will take to ensure laboratory employee protection;

1910.1450(e)(3)(i) Standard operating procedures relevant to safety and health considerations to be followed when laboratory work involves the use of hazardous chemicals;

1910.1450(e)(3)(ii) Criteria that the employer will use to determine and implement control measures to reduce employee exposure to hazardous chemicals including engineering controls, the use of personal protective equipment and hygiene practices; particular attention shall be given to the selection of control measures for chemicals that are known to be extremely hazardous;

1910.1450(e)(3)(iii) A requirement that fume hoods and other protective equipment are functioning properly and specific measures that shall be taken to ensure proper and adequate performance of such equipment;

1910.1450(e)(3)(iv) Provisions for employee information and training as prescribed in paragraph (f) of this section;

1910.1450(e)(3)(v) The circumstances under which a particular laboratory operation, procedure or activity shall require prior approval from the employer or the employer's designee before implementation;

1910.1450(e)(3)(vi) Provisions for medical consultation and medical examinations in accordance with paragraph (g) of this section;

1910.1450(e)(3)(vii) Designation of personnel responsible for implementation of the Chemical Hygiene Plan including the assignment of a Chemical Hygiene Officer, and, if appropriate, establishment of a Chemical Hygiene Committee; and

1910.1450(e)(3)(viii) Provisions for additional employee protection for work with particularly hazardous substances. These include "select carcinogens," reproductive toxins and substances which have a high degree of acute toxicity. Specific consideration shall be given to the following provisions which shall be included where appropriate:

1910.1450(e)(3)(viii)(A) Establishment of a designated area;

1910.1450(e)(3)(viii)(B) Use of containment devices such as fume hoods or glove boxes;

1910.1450(e)(3)(viii)(C) Procedures for safe removal of contaminated waste; and

1910.1450(e)(3)(viii)(D) Decontamination procedures.

1910.1450(e)(4) The employer shall review and evaluate the effectiveness of the Chemical Hygiene Plan at least annually and update it as necessary.

1910.1450(f) Employee information and training.

1910.1450(f)(1) The employer shall provide employees with information and training to ensure that they are apprised of the hazards of chemicals present in their work area.

1910.1450(f)(2) Such information 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. The frequency of refresher information and training shall be determined by the employer.

1910.1450(f)(3) Information. Employees shall be informed of:

1910.1450(f)(3)(i) The contents of this standard and its appendices which shall be made available to employees;

1910.1450(f)(3)(ii) The location and availability of the employer's Chemical Hygiene Plan;
1910.1450(f)(3)(iii) The permissible exposure limits for OSHA regulated substances or recommended exposure limits for other hazardous chemicals where there is no applicable OSHA standard;
1910.1450(f)(3)(iv) Signs and symptoms associated with exposures to hazardous chemicals used in the laboratory; and
1910.1450(f)(3)(v) 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 received from the chemical supplier.
1910.1450(f)(4) Training.
1910.1450(f)(4)(i) Employee training shall include:
1910.1450(f)(4)(i)(A) Methods and observations that may be used to detect the presence or release of a hazardous chemical (such as monitoring conducted by the employer, continuous monitoring devices, visual appearance or odor of hazardous chemicals when being released, etc.);
1910.1450(f)(4)(i)(B) The physical and health hazards of chemicals in the work area; and
1910.1450(f)(4)(i)(C) The measures employees can take to protect themselves from these hazards, including specific procedures the employer has implemented to protect employees from exposure to hazardous chemicals, such as appropriate work practices, emergency procedures, and personal protective equipment to be used.
1910.1450(f)(4)(ii) The employee shall be trained on the applicable details of the employer's written Chemical Hygiene Plan.
1910.1450(g) Medical consultation and medical examinations.
1910.1450(g)(1) The employer shall provide all employees who work with hazardous chemicals an opportunity to receive medical attention, including any follow-up examinations which the examining physician determines to be necessary, under the following circumstances:
1910.1450(g)(1)(i) Whenever an employee develops signs or symptoms associated with a hazardous chemical to which the employee may have been exposed in the laboratory, the employee shall be provided an opportunity to receive an appropriate medical examination.
1910.1450(g)(1)(ii) Where exposure monitoring reveals an exposure level routinely above the action level (or in the absence of an action level, the PEL) for an OSHA regulated substance for which there are exposure monitoring and medical surveillance requirements, medical surveillance shall be established for the affected employee as prescribed by the particular standard.
1910.1450(g)(1)(iii) Whenever an event takes place in the work area such as a spill, leak, explosion or other occurrence resulting in the likelihood of a hazardous exposure, the affected employee shall be provided an opportunity for a medical consultation. Such consultation shall be for the purpose of determining the need for a medical examination.
1910.1450(g)(2) All medical examinations and consultations shall be performed by or under the direct supervision of a licensed physician and shall be provided without cost to the employee, without loss of pay and at a reasonable time and place.
1910.1450(g)(3) Information provided to the physician. The employer shall provide the following information to the physician:
1910.1450(g)(3)(i) The identity of the hazardous chemical(s) to which the employee may have been exposed;
1910.1450(g)(3)(ii) A description of the conditions under which the exposure occurred including quantitative exposure data, if available; and
1910.1450(g)(3)(iii) A description of the signs and symptoms of exposure that the employee is experiencing, if any.
1910.1450(g)(4) Physician's written opinion.
1910.1450(g)(4)(i) For examination or consultation required under this standard, the employer shall obtain a written opinion from the examining physician which shall include the following:

1910.1450(g)(4)(i)(A) Any recommendation for further medical follow-up;
1910.1450(g)(4)(i)(B) The results of the medical examination and any associated tests;
1910.1450(g)(4)(i)(C) Any medical condition which may be revealed in the course of the examination which may place the employee at increased risk as a result of exposure to a hazardous workplace; and
1910.1450(g)(4)(i)(D) A statement that the employee has been informed by the physician of the results of the consultation or medical examination and any medical condition that may require further examination or treatment.
1910.1450(g)(4)(ii) The written opinion shall not reveal specific findings of diagnoses unrelated to occupational exposure.
1910.1450(h) Hazard identification.
1910.1450(h)(1) With respect to labels and material safety data sheets:
1910.1450(h)(1)(i) Employers shall ensure that labels on incoming containers of hazardous chemicals are not removed or defaced.
1910.1450(h)(1)(ii) Employers shall maintain any material safety data sheets that are received with incoming shipments of hazardous chemicals, and ensure that they are readily accessible to laboratory employees.
1910.1450(h)(2) The following provisions shall apply to chemical substances developed in the laboratory:
1910.1450(h)(2)(i) If the composition of the chemical substance which is produced exclusively for the laboratory's use is known, the employer shall determine if it is a hazardous chemical as defined in paragraph (b) of this section. If the chemical is determined to be hazardous, the employer shall provide appropriate training as required under paragraph (f) of this section.
1910.1450(h)(2)(ii) If the chemical produced is a byproduct whose composition is not known, the employer shall assume that the substance is hazardous and shall implement paragraph (e) of this section.
1910.1450(h)(2)(iii) If the chemical substance is produced for another user outside of the laboratory, the employer shall comply with the Hazard Communication Standard (29 CFR 1910.1200) including the requirements for preparation of material safety data sheets and labeling.
1910.1450(i) Use of respirators. Where the use of respirators is necessary to maintain exposure below permissible exposure limits, the employer shall provide, at no cost to the employee, the proper respiratory equipment. Respirators shall be selected and used in accordance with the requirements of 29 CFR 1910.134.
1910.1450(j) Recordkeeping.
1910.1450(j)(1) The employer shall establish and maintain for each employee an accurate record of any measurements taken to monitor employee exposures and any medical consultation and examinations including tests or written opinions required by this standard.
1910.1450(j)(2) The employer shall assure that such records are kept, transferred, and made available in accordance with 29 CFR 1910.1020.
1910.1450(k) Dates—
1910.1450(k)(1) Effective date. This section shall become effective May 1, 1990.
1910.1450(k)(2) Start-up dates.
1910.1450(k)(2)(i) Employers shall have developed and implemented a written Chemical Hygiene Plan no later than January 31, 1991.
1910.1450(k)(2)(ii) Paragraph (a)(2) of this section shall not take effect until the employer has developed and implemented a written Chemical Hygiene Plan.

Appendix A to 1910.1450 — National Research Council Recommendations Concerning Chemical Hygiene in Laboratories (Non-Mandatory)

Pacific Lutheran University

Chemical Hygiene Plan

A. General Principles
    1. Minimize all Chemical Exposures
    2. Avoid Underestimation of Risk
    3. Provide Adequate Ventilation
    4. Institute a Chemical Hygiene Program
    5. Observe the PELs and TLVs
B. Responsibilities
    1. Chief Executive Officer
    2. Supervisor of Administrative Unit
    3. Chemical Hygiene Officer
    4. Laboratory Supervisor
    5. Project Director
    6. Laboratory Worker
C. The Laboratory Facility
    1. Design
    2. Maintenance
    3. Usage
    4. Ventilation
D. Components of the Chemical Hygiene Plan
    1. Basic Rules and Procedures
    2. Chemical Procurement, Distribution, and Storage
    3. Environmental Monitoring
    4. Housekeeping, Maintenance and Inspections
    5. Medical Program
    6. Personal Protective Apparel and Equipment
    7. Records
    8. Signs and Labels
    9. Spills and Accidents
    10. Training and Information
    11. Waste Disposal
E. General Procedures for Working With Chemicals
    1. General Rules for all Laboratory Work with Chemicals
    2. Allergens and Embryotoxins
    3. Chemicals of Moderate Chronic or High Acute Toxicity
    4. Chemicals of High Chronic Toxicity
    5. Animal Work with Chemicals of High Chronic Toxicity
F. Safety Recommendations
G. Material Safety Data Sheets

As guidance for each employer's development of an appropriate laboratory Chemical Hygiene Plan, the following non-mandatory recommendations are provided. They were extracted from "Prudent Practices" for Handling Hazardous Chemicals in Laboratories" (referred to below as "Prudent Practices"), which was published in 1981 by the National Research Council and is available from the National Academy Press, 2101 Constitution Ave., NW, Washington DC 20418.

"Prudent Practices" is cited because of its wide distribution and acceptance and because of its preparation by members of the laboratory community through the sponsorship of the National Research Council. However, none of the recommendations given here will modify any requirements of the laboratory standard. This Appendix merely presents pertinent recommendations from "Prudent Practices", organized into a form convenient for quick reference during operation of a laboratory facility and during development and application of a Chemical Hygiene Plan. Users of this appendix

should consult "Prudent Practices" for a more extended presentation and justification for each recommendation.

"Prudent Practices" deal with both safety and chemical hazards while the laboratory standard is concerned primarily with chemical hazards. Therefore, only those recommendations directed primarily toward control of toxic exposures are cited in this appendix, with the term "chemical hygiene" being substituted for the word "safety." However, since conditions producing or threatening physical injury often pose toxic risks as well, page references concerning major categories of safety hazards in the laboratory are given in section F. The recommendations from "Prudent Practices" have been paraphrased, combined, or otherwise reorganized, and headings have been added. However, their sense has not been changed.

The following table is given for the convenience of those who are developing a Chemical Hygiene Plan which will satisfy the requirements of paragraph (e) of the standard. It indicates those sections of this appendix which are most pertinent to each of the sections of paragraph (e) and related paragraphs.

Paragraph and topic in laboratory standard	Relevant Appendix Section
(e)(3)(i) Standard operating procedures for handling toxic chemicals.	C, D, E
(e)(3)(ii) Criteria to be used for implementation of measures to reduce exposures.	D
(e)(3)(iii) Fume hood performance	C4b
(e)(3)(iv) Employee information and training (including emergency procedures).	D10, D9
(e)(3)(v) Requirements for prior approval of laboratory activities.	E2b, E4b
(e)(3)(vi) Medical consultation and medical examinations.	D5, E4f
(e)(3)(vii) Chemical hygiene responsibilities.	B
(e)(3)(viii) Special precautions for work with particularly hazardous substances.	E2, E3, E4

In this appendix, those recommendations directed primarily at administrators and supervisors are given in sections A-D. Those recommendations of primary concern to employees who are actually handling laboratory chemicals are given in section E. (Reference to page numbers in "Prudent Practices" are given in parentheses.)

A. General Principles for Work with Laboratory Chemicals

In addition to the more detailed recommendations listed below in sections B-E, "Prudent Practices" expresses certain general principles, including the following:

1. It is prudent to minimize all chemical exposures. Because few laboratory chemicals are without hazards, general precautions for handling all laboratory chemicals should be adopted, rather than specific guidelines for particular chemicals (2,10). Skin contact with chemicals should be avoided as a cardinal rule (198).
2. Avoid underestimation of risk. Even for substances of no known significant hazard, exposure should be minimized; for work with substances which present special hazards, special precautions should be taken (10, 37, 38). One should assume that any mixture will be more toxic than its most toxic component (30, 103) and that all substances of unknown toxicity are toxic (3, 34).

3. Provide adequate ventilation. The best way to prevent exposure to airborne substances is to prevent their escape into the working atmosphere by use of hoods and other ventilation devices (32, 198).
4. Institute a chemical hygiene program. A mandatory chemical hygiene program designed to minimize exposures is needed; it should be a regular, continuing effort, not merely a standby or short-term activity (6,11). Its recommendations should be followed in academic teaching laboratories as well as by full-time laboratory workers (13).
5. Observe the PELs, TLVs. The Permissible Exposure Limits of OSHA and the Threshold Limit Values of the American Conference of Governmental Industrial Hygienists should not be exceeded (13).

B. Chemical Hygiene Responsibilities

Responsibility for chemical hygiene rests at all levels (6, 11, 21) including the:

1. Chief executive officer, who has ultimate responsibility for chemical hygiene within the institution and must, with other administrators, provide continuing support for institutional chemical hygiene (7, 11).
2. Supervisor of the department or other administrative unit, who is responsible for chemical hygiene in that unit (7).
3. Chemical hygiene officer(s), whose appointment is essential (7) and who must:
   (a) Work with administrators and other employees to develop and implement appropriate chemical hygiene policies and practices (7);
   (b) Monitor procurement, use, and disposal of chemicals used in the lab (8);
   (c) See that appropriate audits are maintained (8);
   (d) Help project directors develop precautions and adequate facilities (10);
   (e) Know the current legal requirements concerning regulated substances (50); and
   (f) Seek ways to improve the chemical hygiene program (8, 11).
4. Laboratory supervisor, who has overall responsibility for chemical hygiene in the laboratory (21) including responsibility to:
   (a) Ensure that workers know and follow the chemical hygiene rules, that protective equipment is available and in working order, and that appropriate training has been provided (21, 22);
   (b) Provide regular, formal chemical hygiene and housekeeping inspections including routine inspections of emergency equipment (21, 171);
   (c) Know the current legal requirements concerning regulated substances (50, 231);
   (d) Determine the required levels of protective apparel and equipment (156, 160, 162); and
   (e) Ensure that facilities and training for use of any material being ordered are adequate (215).
5. Project director or director of other specific operation, who has primary responsibility for chemical hygiene procedures for that operation (7).
6. Laboratory worker, who is responsible for:
   (a) Planning and conducting each operation in accordance with the institutional chemical hygiene procedures (7,21, 22, 230); and
   (b) Developing good personal chemical hygiene habits (22).

C. The Laboratory Facility

1. Design. The laboratory facility should have:
   (a) An appropriate general ventilation system (see C4 below) with air intakes and exhausts located so as to avoid intake of contaminated air (194);
   (b) Adequate, well-ventilated stockrooms/storerooms (218, 219).
   (c) Laboratory hoods and sinks (12, 162);
   (d) Other safety equipment including eyewash fountains and drench showers (162, 169); and
   (e) Arrangements for waste disposal (12, 240).

2. Maintenance. Chemical-hygiene-related equipment (hoods, incinerator, etc.) should undergo continual appraisal and be modified if inadequate (11, 12).
3. Usage. The work conducted (10) and its scale (12) must be appropriate to the physical facilities available and, especially, to the quality of ventilation (13).
4. Ventilation –
   (a) General laboratory ventilation. This system should: Provide a source of air for breathing and for input to local ventilation devices (199); it should not be relied on for protection from toxic substances released into the laboratory (198); ensure that laboratory air is continually replaced, preventing increase of air concentrations of toxic substances during the working day (194); direct air flow into the laboratory from non-laboratory areas and out to the exterior of the building (194).
   (b) Hoods. A laboratory hood with 2.5 linear feet of hood space per person should be provided for every 2 workers if they spend most of their time working with chemicals (199); each hood should have a continuous monitoring device to allow convenient confirmation of adequate hood performance before use (200, 209). If this is not possible, work with substances of unknown toxicity should be avoided (13) or other types of local ventilation devices should be provided (199). See pp. 201-206 for a discussion of hood design, construction, and evaluation.
   (c) Other local ventilation devices. Ventilated storage cabinets, canopy hoods, snorkels, etc. should be provided as needed (199). Each canopy hood and snorkel should have a separate exhaust duct (207).
   (d) Special ventilation areas. Exhaust air from glove boxes and isolation rooms should be passed through scrubbers or other treatment before release into the regular exhaust system (208). Cold rooms and warm rooms should have provisions for rapid escape and for escape in the event of electrical failure (209).
   (e) Modifications. Any alteration of the ventilation system should be made only if thorough testing indicates that worker protection from airborne toxic substances will continue to be adequate (12, 193, 204).
   (f) Performance. Rate: 4-12 room air changes/hour is normally adequate general ventilation if local exhaust systems such as hoods are used as the primary method of control (194).
   (g) Quality. General air flow should not be turbulent and should be relatively uniform throughout the laboratory, with no high velocity or static areas (194, 195); airflow into and within the hood should not be excessively turbulent (200); hood face velocity should be adequate (typically 60-100 lfm) (200, 204).
   (h) Evaluation. Quality and quantity of ventilation should be evaluated on installation (202), regularly monitored (at least every 3 months) (6, 12, 14, 195), and reevaluated whenever a change in local ventilation devices is made (12, 195, 207). See pp 195-198 for methods of evaluation and for calculation of estimated airborne contaminant concentrations.

D. Components of the Chemical Hygiene Plan

1. Basic Rules and Procedures (Recommendations for these are given in section E, below)
2. Chemical Procurement, Distribution, and Storage
   (a) Procurement. Before a substance is received, information on proper handling, storage, and disposal should be known to those who will be involved (215, 216). No container should be accepted without an adequate identifying label (216). Preferably, all substances should be received in a central location (216).
   (b) Stockrooms/storerooms. Toxic substances should be segregated in a well-identified area with local exhaust ventilation (221). Chemicals which are highly toxic (227) or other chemicals whose containers have been opened should be in unbreakable secondary containers (219). Stored chemicals should be examined periodically (at least annually) for replacement, deterioration, and container integrity (218-19). Stockrooms/storerooms should

not be used as preparation or repackaging areas, should be open during normal working hours, and should be controlled by one person (219).

(c) Distribution. When chemicals are hand carried, the container should be placed in an outside container or bucket. Freight-only elevators should be used if possible (223).

(d) Laboratory storage. Amounts permitted should be as small as practical. Storage on bench tops and in hoods is inadvisable. Exposure to heat or direct sunlight should be avoided. Periodic inventories should be conducted, with unneeded items being discarded or returned to the storeroom/stockroom (225-6, 229).

3. Environmental Monitoring. Regular instrumental monitoring of airborne concentrations is not usually justified or practical in laboratories but may be appropriate when testing or redesigning hoods or other ventilation devices (12) or when a highly toxic substance is stored or used regularly (e.g., 3 times/week) (13).

4. Housekeeping, Maintenance, and Inspections.

(a) Cleaning. Floors should be cleaned regularly (24).

(b) Inspections. Formal housekeeping and chemical hygiene inspections should be held at least quarterly (6, 21) for units which have frequent personnel changes and semiannually for others; informal inspections should be continual (21).

(c) Maintenance. Eye wash fountains should be inspected at intervals of not less than 3 months (6). Respirators for routine use should be inspected periodically by the laboratory supervisor (169). Other safety equipment should be inspected regularly. (e.g., every 3-6 months) (6, 24, 171). Procedures to prevent restarting of out-of-service equipment should be established (25).

(d) Passageways. Stairways and hallways should not be used as storage areas (24). Access to exits, emergency equipment, and utility controls should never be blocked (24).

5. Medical Program

(a) Compliance with regulations. Regular medical surveillance should be established to the extent required by regulations (12).

(b) Routine surveillance. Anyone whose work involves regular and frequent handling of toxicologically significant quantities of a chemical should consult a qualified physician to determine on an individual basis whether a regular schedule of medical surveillance is desirable (11, 50).

(c) First aid. Personnel trained in first aid should be available during working hours and an emergency room with medical personnel should be nearby (173). See pp. 176-178 for description of some emergency first aid procedures.

6. Protective Apparel and Equipment

These should include for each laboratory:

(a) Protective apparel compatible with the required degree of protection for substances being handled (158-161);

(b) An easily accessible drench-type safety shower (162, 169);

(c) An eyewash fountain (162)

(d) A fire extinguisher (162-164);

(e) Respiratory protection (164-9), fire alarm and telephone for emergency use (162) should be available nearby; and

(f) Other items designated by the laboratory supervisor (156, 160).

7. Records

(a) Accident records should be written and retained (174).

(b) Chemical Hygiene Plan records should document that the facilities and precautions were compatible with current knowledge and regulations (7).

(c) Inventory and usage records for high-risk substances should be kept as specified in sections E3e below.

(d) Medical records should be retained by the institution in accordance with the requirements of state and federal regulations (12).

8. Signs and Labels

Prominent signs and labels of the following types should be posted:

(a) Emergency telephone numbers of emergency personnel/facilities, supervisors, and laboratory workers (28);

(b) Identity labels, showing contents of containers (including waste receptacles) and associated hazards (27, 48);

(c) Location signs for safety showers, eyewash stations, other safety and first aid equipment, exits (27) and areas where food and beverage consumption and storage are permitted (24); and

(d) Warnings at areas or equipment where special or unusual hazards exist (27).

9. Spills and Accidents

(a) A written emergency plan should be established and communicated to all personnel; it should include procedures for ventilation failure (200), evacuation, medical care, reporting, and drills (172).

(b) There should be an alarm system to alert people in all parts of the facility including isolation areas such as cold rooms (172).

(c) A spill control policy should be developed and should include consideration of prevention, containment, cleanup, and reporting (175).

(d) All accidents or near accidents should be carefully analyzed with the results distributed to all who might benefit (8, 28).

10. Information and Training Program

(a) Aim: To assure that all individuals at risk are adequately informed about the work in the laboratory, its risks, and what to do if an accident occurs (5, 15).

(b) Emergency and Personal Protection Training: Every laboratory worker should know the location and proper use of available protective apparel and equipment (154, 169). Some of the full-time personnel of the laboratory should be trained in the proper use of emergency equipment and procedures (6). Such training as well as first aid instruction should be available to (154) and encouraged for (176) everyone who might need it.

(c) Receiving and stockroom/storeroom personnel should know about hazards, handling equipment, protective apparel, and relevant regulations (217).

(d) Frequency of Training: The training and education program should be a regular, continuing activity – not simply an annual presentation (15).

(e) Literature/Consultation: Literature and consulting advice concerning chemical hygiene should be readily available to laboratory personnel, who should be encouraged to use these information resources (14).

11. Waste Disposal Program

(a) Aim: To assure that minimal harm to people, other organisms, and the environment will result from the disposal of waste laboratory chemicals (5).

(b) Content (14, 232, 233, 240): The waste disposal program should specify how waste is to be collected, segregated, stored, and transported and include consideration of what materials can be incinerated. Transport from the institution must be in accordance with DOT regulations (244).

(c) Discarding Chemical Stocks: Unlabeled containers of chemicals and solutions should undergo prompt disposal; if partially used, they should not be opened (24, 27). Before a worker's employment in the laboratory ends, chemicals for which that person was responsible should be discarded or returned to storage (226).

(d) Frequency of Disposal: Waste should be removed from laboratories to a central waste storage area at least once per week and from the central waste storage area at regular intervals (14).

(e) Method of Disposal: Incineration in an environmentally acceptable manner is the most practical disposal method for combustible laboratory waste (14, 238, 241). Indiscriminate disposal by pouring waste chemicals down the drain (14, 231, 242) or adding them to mixed refuse for landfill burial is unacceptable (14). Hoods should not be used as a means of disposal for volatile chemicals (40, 200). Disposal by recycling (233, 243) or chemical decontamination (40, 230) should be used when possible.

E. Basic Rules and Procedures for Working with Chemicals

The Chemical Hygiene Plan should require that laboratory workers know and follow its rules and procedures. In addition to the procedures of the sub programs mentioned above, these should include the rules listed below.

1. General Rules

The following should be used for essentially all laboratory work with chemicals:

(a) Accidents and spills - Eye Contact: Promptly flush eyes with water for a prolonged period (15 minutes) and seek medical attention (33, 172). Ingestion: Encourage the victim to drink large amounts of water (178). Skin Contact: Promptly flush the affected area with water (33, 172, 178) and remove any contaminated clothing (172, 178). If symptoms persist after washing, seek medical attention (33). Clean-up. Promptly clean up spills, using appropriate protective apparel and equipment and proper disposal (24, 33). See pp. 233-237 for specific clean-up recommendations.

(b) Avoidance of "routine" exposure: Develop and encourage safe habits (23); avoid unnecessary exposure to chemicals by any route (23); Do not smell or taste chemicals (32). Vent apparatus which may discharge toxic chemicals (vacuum pumps, distillation columns, etc.) into local exhaust devices (199). Inspect gloves (157) and test glove boxes (208) before use. Do not allow release of toxic substances in cold rooms and warm rooms, since these have contained recirculated atmospheres (209).

(c) Choice of chemicals: Use only those chemicals for which the quality of the available ventilation system is appropriate (13).

(d) Eating, smoking, etc.: Avoid eating, drinking, smoking, gum chewing, or application of cosmetics in areas where laboratory chemicals are present (22, 24, 32, 40); wash hands before conducting these activities (23, 24). Avoid storage, handling, or consumption of food or beverages in storage areas, refrigerators, glassware or utensils which are also used for laboratory operations (23, 24, 226).

(e) Equipment and glassware: Handle and store laboratory glassware with care to avoid damage; do not use damaged glassware (25). Use extra care with Dewar flasks and other evacuated glass apparatus; shield or wrap them to contain chemicals and fragments should implosion occur (25). Use equipment only for its designed purpose (23, 26).

(f) Exiting: Wash areas of exposed skin well before leaving the laboratory (23).

(g) Horseplay: Avoid practical jokes or other behavior which might confuse, startle or distract another worker (23).

(h) Mouth suction: Do not use mouth suction for pipeting or starting a siphon (23, 32).

(i) Personal apparel: Confine long hair and loose clothing (23, 158). Wear shoes at all times in the laboratory but do not wear sandals, perforated shoes, or sneakers (158).

(j) Personal housekeeping: Keep the work area clean and uncluttered, with chemicals and equipment being properly labeled and stored; clean up the work area on completion of an operation or at the end of each day (24).

(k) Personal protection: Assure that appropriate eye protection (154-156) is worn by all persons, including visitors, where chemicals are stored or handled (22, 23, 33, 154). Wear appropriate gloves when the potential for contact with toxic materials exists (157); inspect the gloves before each use, wash them before removal, and replace them periodically (157). (A table of resistance to chemicals of common glove materials is given p. 159). Use

appropriate (164-168) respiratory equipment when air contaminant concentrations are not sufficiently restricted by engineering controls (164-5), inspecting the respirator before use (169). Use any other protective and emergency apparel and equipment as appropriate (22, 157-162). Avoid use of contact lenses in the laboratory unless necessary; if they are used, inform supervisor so special precautions can be taken (155). Remove laboratory coats immediately on significant contamination (161).

(l) Planning: Seek information and advice about hazards (7), plan appropriate protective procedures, and plan positioning of equipment before beginning any new operation (22, 23).

(m) Unattended operations: Leave lights on, place an appropriate sign on the door, and provide for containment of toxic substances in the event of failure of a utility service (such as cooling water) to an unattended operation (27,128).

(n) Use of hood: Use the hood for operations which might result in release of toxic chemical vapors or dust (198-9). As a rule of thumb, use a hood or other local ventilation device when working with any appreciably volatile substance with a TLV of less than 50 ppm (13). Confirm adequate hood performance before use; keep hood closed at all times except when adjustments within the hood are being made (200); keep materials stored in hoods to a minimum and do not allow them to block vents or air flow (200). Leave the hood "on" when it is not in active use if toxic substances are stored in it or if it is uncertain whether adequate general laboratory ventilation will be maintained when it is "off" (200).

(o) Vigilance: Be alert to unsafe conditions and see that they are corrected when detected (22).

(p) Waste disposal: Assure that the plan for each laboratory operation includes plans and training for waste disposal (230). Deposit chemical waste in appropriately labeled receptacles and follow all other waste disposal procedures of the Chemical Hygiene Plan (22, 24). Do not discharge to the sewer concentrated acids or bases (231); highly toxic, malodorous, or lachrymatory substances (231); or any substances which might interfere with the biological activity of waste water treatment plants, create fire or explosion hazards, cause structural damage or obstruct flow (242).

(q) Working alone: Avoid working alone in a building; do not work alone in a laboratory if the procedures being conducted are hazardous (28).

2. Working with Allergens and Embryotoxins

(a) Allergens (examples: diazomethane, isocyanates, bichromates): Wear suitable gloves to prevent hand contact with allergens or substances of unknown allergenic activity (35).

(b) Embryotoxins (34-5) (examples: organomercurials, lead compounds, formamide): If you are a woman of childbearing age, handle these substances only in a hood whose satisfactory performance has been confirmed, using appropriate protective apparel (especially gloves) to prevent skin contact. Review each use of these materials with the research supervisor and review continuing uses annually or whenever a procedural change is made. Store these substances, properly labeled, in an adequately ventilated area in an unbreakable secondary container. Notify supervisors of all incidents of exposure or spills; consult a qualified physician when appropriate.

3. Work with Chemicals of Moderate Chronic or High Acute Toxicity

Examples: diisopropylfluorophosphate (41), hydrofluoric acid (43), hydrogen cyanide (45).

Supplemental rules to be followed in addition to those mentioned above (Procedure B of "Prudent Practices", pp. 39-41):

(a) Aim: To minimize exposure to these toxic substances by any route using all reasonable precautions (39).

(b) Applicability: These precautions are appropriate for substances with moderate chronic or high acute toxicity used in significant quantities (39).

(c) Location: Use and store these substances only in areas of restricted access with special warning signs (40, 229). Always use a hood (previously evaluated to confirm adequate

performance with a face velocity of at least 60 linear feet per minute) (40) or other containment device for procedures which may result in the generation of aerosols or vapors containing the substance (39); trap released vapors to revent their discharge with the hood exhaust (40).

(d) Personal protection: Always avoid skin contact by use of gloves and long sleeves (and other protective apparel as appropriate) (39). Always wash hands and arms immediately after working with these materials (40).

(e) Records: Maintain records of the amounts of these materials on hand, amounts used, and the names of the workers involved (40, 229).

(f) Prevention of spills and accidents: Be prepared for accidents and spills (41). Assure that at least 2 people are present at all times if a compound in use is highly toxic or of unknown toxicity (39). Store breakable containers of these substances in chemically resistant trays; also work and mount apparatus above such trays or cover work and storage surfaces with removable, absorbent, plastic backed paper (40). If a major spill occurs outside the hood, evacuate the area; assure that cleanup personnel wear suitable protective apparel and equipment (41).

(g) Waste: Thoroughly decontaminate or incinerate contaminated clothing or shoes (41). If possible, chemically decontaminate by chemical conversion (40). Store contaminated waste in closed, suitably labeled, impervious containers (for liquids, in glass or plastic bottles half-filled with vermiculite) (40).

4. Work with Chemicals of High Chronic Toxicity

(Examples: dimethylmercury and nickel carbonyl (48), benzo-a-pyrene (51), N-nitrosodiethylamine (54), other human carcinogens or substances with high carcinogenic potency in animals (38)). Further supplemental rules to be followed, in addition to all these mentioned above, for work with substances of known high chronic toxicity (in quantities above a few milligrams to a few grams, depending on the substance) (47). (Procedure A of "Prudent Practices" pp. 47-50).

(a) Access: Conduct all transfers and work with these substances in a "controlled area": a restricted access hood, glove box, or portion of a lab, designated for use of highly toxic substances, for which all people with access are aware of the substances being used and necessary precautions (48).

(b) Approvals: Prepare a plan for use and disposal of these materials and obtain the approval of the laboratory supervisor (48).

(c) Non-contamination/Decontamination: Protect vacuum pumps against contamination by scrubbers or HEPA filters and vent them into the hood (49). Decontaminate vacuum pumps or other contaminated equipment, including glassware, in the hood before removing them from the controlled area (49, 50). Decontaminate the controlled area before normal work is resumed there (50).

(d) Exiting: On leaving a controlled area, remove any protective apparel (placing it in an appropriate, labeled container) and thoroughly wash hands, forearms, face, and neck (49).

(e) Housekeeping: Use a wet mop or a vacuum cleaner equipped with a HEPA filter instead of dry sweeping if the toxic substance was a dry powder (50).

(f) Medical surveillance: If using toxicologically significant quantities of such a substance on a regular basis (e.g. 3 times per week), consult a qualified physician concerning desirability of regular medical surveillance (50).

(g) Records: Keep accurate records of the amounts of these substances stored (229) and used, the dates of use, and names of users (48).

(h) Signs and labels: Assure that the controlled area is conspicuously marked with warning and restricted access signs (49) and that all containers of these substances are appropriately labeled with identity and warning labels (48).

(i) Spills: Assure that contingency plans, equipment, and materials to minimize exposures of people and property in case of accident are available (233-4).

(j) Storage: Store containers of these chemicals only in a ventilated, limited access (48, 227, 229) area in appropriately labeled, unbreakable, chemically resistant, secondary containers (48, 229).

(k) Glove boxes: For a negative pressure glove box, ventilation rate must be at least 2 volume changes/hour and pressure at least 0.5 inches of water (48). For a positive pressure glove box, thoroughly check for leaks before each use (49). In either case, trap the exit gases or filter them through a HEPA filter and then release them into the hood (49).

(l) Waste: Use chemical decontamination whenever possible; ensure that containers of contaminated waste (including washings from contaminated flasks) are transferred from the controlled area in a secondary container under the supervision of authorized personnel (49, 50, 233).

5. Animal Work with Chemicals of High Chronic Toxicity

(a) Access: For large scale studies, special facilities with restricted access are preferable (56).

(b) Administration of the toxic substance: When possible, administer the substance by injection or gavage instead of in the diet. If administration is in the diet, use a caging system under negative pressure or under laminar air flow directed toward HEPA filters (56).

(c) Aerosol suppression: Devise procedures which minimize formation and dispersal of contaminated aerosols, including those from food, urine, and feces (e.g., use HEPA filtered vacuum equipment for cleaning, moisten contaminated bedding before removal from the cage, mix diets in closed containers in a hood) (55, 56).

(d) Personal protection: When working in the animal room, wear plastic or rubber gloves, fully buttoned laboratory coat or jumpsuit and, if needed because of incomplete suppression of aerosols, other apparel and equipment (shoe and head coverings, respirator) (56).

(e) Waste disposal: Dispose of contaminated animal tissues and excreta by incineration if the available incinerator can convert the contaminant to non-toxic products (238); otherwise, package the waste appropriately for burial in an EPA-approved site (239).

F. Safety Recommendations

The above recommendations from "Prudent Practices" do not include those which are directed primarily toward prevention of physical injury rather than toxic exposure. However, failure of precautions against injury will often have the secondary effect of causing toxic exposures. Therefore, we list below page references for recommendations concerning some of the major categories of safety hazards which also have implications for chemical hygiene:

1. Corrosive agents: (35-6)
2. Electrically powered laboratory apparatus: (179-92)
3. Fires, explosions: (26, 57-74, 162-64, 174-5, 219-20, 226-7)
4. Low temperature procedures: (26, 88)
5. Pressurized and vacuum operations (including use of compressed gas cylinders): (27, 75-101)

G. Material Safety Data Sheets

Material safety data sheets are presented in "Prudent Practices" for the chemicals listed below. (Asterisks denote that comprehensive material safety data sheets are provided).

* Acetyl peroxide (105)
* Acrolein (106)
* Acrylonitrile
Ammonia (anhydrous)(91)
* Aniline (109)
* Benzene (110)
* Benzo[a]pyrene (112)
* Bis(chloromethyl) ether (113)
Boron trichloride (91)
Boron trifluoride (92)
Bromine (114)
* Tert-butyl hydroperoxide (148)
* Carbon disulfide (116)
Carbon monoxide (92)
* Carbon tetrachloride (118)
* Chlorine (119)

Chlorine trifluoride (94)
* Chloroform (121)
Chloromethane (93)
* Diethyl ether (122)
Diisopropyl fluorophosphate (41)
* Dimethylformamide (123)
* Dimethyl sulfate (125)
* Dioxane (126)
* Ethylene dibromide (128)
* Fluorine (95)
* Formaldehyde (130)
* Hydrazine and salts (132)
Hydrofluoric acid (43)
Hydrogen bromide (98)
Hydrogen chloride (98)
* Hydrogen cyanide (133)
* Hydrogen sulfide (135)
Mercury and compounds (52)
* Methanol (137)
* Morpholine (138)
* Nickel carbonyl (99)
* Nitrobenzene (139)
Nitrogen dioxide (100)
N-nitrosodiethylamine (54)
* Peracetic acid (141)
* Phenol (142)
* Phosgene (143)
* Pyridine (144)
* Sodium azide (145)
* Sodium cyanide (147)
Sulfur dioxide (101)
* Trichloroethylene (149)
* Vinyl chloride (150)

Appendix B 10 1910.1450—References (Non-Mandatory)

The following references are provided to assist the employer in the development of a Chemical Hygiene Plan. The materials listed below are offered as non-mandatory guidance. References listed here do not imply specific endorsement of a book, opinion, technique, policy or a specific solution for a safety or health problem. Other references not listed here may better meet the needs of a specific laboratory.

(a) Materials for the development of the Chemical Hygiene Plan:

1. American Chemical Society, Safety in Academic Chemistry Laboratories, 4th edition, 1985.
2. Fawcett, H.H. and W.S. Wood, Safety and Accident Prevention in Chemical Operations, 2nd edition, Wiley- Interscience, New York, 1982.
3. Flury, Patricia A., Environmental Health and Safety in the Hospital Laboratory, Charles C. Thomas Publisher, Springfield IL, 1978.
4. Green, Michael E. and Turk, Amos, Safety in Working with Chemicals, Macmillan Publishing Co., NY, 1978.
5. Kaufman, James A., Laboratory Safety Guidelines, Dow Chemical Co., Box 1713, Midland, MI 48640, 1977.
6. National Institutes of Health, NIH Guidelines for the Laboratory use of Chemical Carcinogens, NIH Pub. No. 81-2385, GPO, Washington, DC 20402, 1981.
7. National Research Council, Prudent Practices for Disposal of Chemicals from Laboratories, National Academy Press, Washington, DC, 1983.
8. National Research Council, Prudent Practices for Handling Hazardous Chemicals in Laboratories, National Academy Press, Washington, DC, 1981.
9. Renfrew, Malcolm, Ed., Safety in the Chemical Laboratory, Vol. IV, J. Chem. Ed., American Chemical Society, Easlon, PA, 1981.
10. Steere, Norman V., Ed., Safety in the Chemical Laboratory, J. Chem. Ed. American Chemical Society, Easlon, PA, 18042, Vol. I, 1967, Vol. II, 1971, Vol. III, 1974.
11. Steere, Norman V., Handbook of Laboratory Safety, the Chemical Rubber Company Cleveland, OH, 1971.
12. Young, Jay A., Ed., Improving Safety in the Chemical Laboratory, John Wiley & Sons, Inc. New York, 1987.

(b) Hazardous Substances Information:

1. American Conference of Governmental Industrial Hygienists, Threshold Limit Values for Chemical Substances and Physical Agents in the Workroom Environment with Intended Changes, 6500 Glenway Avenue, Bldg. D-7, Cincinnati, OH 45211-4438.

2. Annual Report on Carcinogens, National Toxicology Program U.S. Department of Health and Human Services, Public Health Service, U.S. Government Printing Office, Washington, DC, (latest edition).
3. Best Company, Best Safety Directory, Vols. I and II, Oldwick, N.J., 1981.
4. Bretherick, L., Handbook of Reactive Chemical Hazards, 2nd edition, Butterworths, London, 1979.
5. Bretherick, L., Hazards in the Chemical Laboratory, 3rd edition, Royal Society of Chemistry, London, 1986.
6. Code of Federal Regulations, 29 CFR part 1910 subpart Z. U.S. Govt. Printing Office, Washington, DC 20402 (latest edition).
7. IARC Monographs on the Evaluation of the Carcinogenic Risk of chemicals to Man, World Health Organization Publications Center, 49 Sheridan Avenue, Albany, New York 12210 (latest editions).
8. NIOSH/OSHA Pocket Guide to Chemical Hazards. NIOSH Pub. No. 85-114, U.S. Government Printing Office, Washington, DC, 1985 (or latest edition).
9. Occupational Health Guidelines, NIOSH/OSHA. NIOSH Pub. No. 81-123 U.S. Government Printing Office, Washington, DC, 1981.
10. Patty, F.A., Industrial Hygiene and Toxicology, John Wiley & Sons, Inc., New York, NY (Five Volumes).
11. Registry of Toxic Effects of Chemical Substances, U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, Revised Annually, for sale from Superintendent of documents US. Govt. Printing Office, Washington, DC 20402.
12. The Merck Index: An Encyclopedia of Chemicals and Drugs. Merck and Company Inc. Rahway, N.J., 1976 (or latest edition).
13. Sax, N.I. Dangerous Properties of Industrial Materials, 5th edition, Van Nostrand Reinhold, NY., 1979.
14. Sittig, Marshall, Handbook of Toxic and Hazardous Chemicals, Noyes Publications. Park Ridge, NJ, 1981.

(c) Information on Ventilation:

1. American Conference of Governmental Industrial Hygienists Industrial Ventilation (latest edition), 6500 Glenway Avenue, Bldg. D-7, Cincinnati, Ohio 45211-4438.
2. American National Standards Institute, Inc. American National Standards Fundamentals Governing the Design and Operation of Local Exhaust Systems ANSI Z 9.2-1979 American National Standards Institute, N.Y. 1979.
3. Imad, A.P. and Watson, C.L. Ventilation Index: An Easy Way to Decide about Hazardous Liquids, Professional Safety pp 15-18, April 1980.
4. National Fire Protection Association, Fire Protection for Laboratories Using Chemicals NFPA-45, 1982. Safety Standard for Laboratories in Health Related Institutions, NFPA, 56c, 1980. Fire Protection Guide on Hazardous Materials, 7th edition, 1978. National Fire Protection Association, Batterymarch Park, Quincy, MA 02269.
5. Scientific Apparatus Makers Association (SAMA), Standard for Laboratory Fume Hoods, SAMA LF7-1980, 1101 16th Street, NW., Washington, DC 20036.

(d) Information on Availability of Referenced Material:

1. American National Standards Institute (ANSI), 1430 Broadway, New York, NY 10018.
2. American Society for Testing and Materials (ASTM), 1916 Race Street, Philadelphia, PA 19103.

APPENDIX B

29 CFR 1910.1000, Tables Z-1,2,3
"Permissible Exposure Limits for OSHA Regulated Substances"

TABLE Z-1 LIMITS FOR AIR CONTAMINANTS

NOTE: Because of the length of the table, explanatory Footnotes applicable to all substances are given below as well as at the end of the table. Footnotes specific only to a limited number of substances are also shown within the table.

Footnote(1) The PELs are 8-hour Time Weighted Averages (TWAs) unless otherwise noted; a (C) designation denotes a ceiling limit. They are to be determined from breathing-zone air samples.

(a) Parts of vapor or gas per million parts of contaminated air by volume at 25 degrees C and 760 torr.

(b) Milligrams of substance per cubic meter of air. When entry is in this column only, the value is exact; when listed with a ppm entry, it is approximate.

(c) The CAS number is for information only. Enforcement is based on the substance name. For an entry covering more than one metal compound measured as the metal, the CAS number for the metal is given - not CAS numbers for the individual compounds.

(d) The final benzene standard in 1910.1028 applies to all occupational exposures to benzene except in some circumstances the distribution and sale of fuels, sealed containers and pipelines, coke production, oil and gas drilling and production, natural gas processing, and the percentage exclusion for liquid mixtures; for the excepted subsegments, the benzene limits in Table Z-2 apply. See 1910.1028 for specific circumstances.

(e) This 8-hour TWA applies to respirable dust as measured by a vertical elutriator cotton dust sampler or equivalent instrument. The time-weighted average applies to the cotton waste processing operations of waste recycling (sorting, blending, cleaning and willowing) and garnetting. See also 1910.1043 for cotton dust limits applicable to other sectors.

(f) All inert or nuisance dusts, whether mineral, inorganic, or organic, not listed specifically by substance name are covered by the Particulates Not Otherwise Regulated (PNOR) limit which is the same as the inert or nuisance dust limit of Table Z-3.

Footnote(2) See Table Z-2.

Footnote(3) See Table Z-3.

Footnote(4) Varies with compound.

Footnote(5) See Table Z-2 for the exposure limits for any operations or sectors where the exposure limits in 1910.1026 are suspended or are otherwise not in effect.

TABLE Z-1. - LIMITS FOR AIR CONTAMINANTS

Substance	CAS No. (c)	ppm (a)(1)	mg/m(3) (b)(1)	Skin designation
Acetaldehyde	75-07-0	200	360	
Acetic acid	64-19-7	10	25	
Acetic anhydride	108-24-7	5	20	
Acetone	67-64-1	1000	2400	
Acetonitrile	75-05-8	40	70	
2-Acetylaminofluorene; see 1910.1014	53-96-3			
Acetylene dichloride; see 1,2-Dichloroethylene				
Acetylene tetrabromide	79-27-6	1	14	
Acrolein	107-02-8	0.1	0.25	
Acrylamide	79-06-1	.....	0.3	X
Acrylonitrile; see 1910.1045	107-13-1			
Aldrin	309-00-2	.....	0.25	X
Allyl alcohol	107-18-6	2	5	X
Allyl chloride	107-05-1	1	3	
Allyl glycidyl ether (AGE)	106-92-3	(C)10	(C)45	
Allyl propyl disulfide	2179-59-1	2	12	
alpha-Alumina	1344-28-1			
Total dust		.....	15	
Respirable fraction		.....	5	
Aluminum Metal (as Al)	7429-90-5			
Total dust		.....	15	
Respirable fraction		.....	5	
4-Aminodiphenyl; see 1910.1011	92-67-1			
2-Aminoethanol; see Ethanolamine				
2-Aminopyridine	504-29-0	0.5	2	
Ammonia	7664-41-7	50	35	
Ammonium sulfamate	7773-06-0			
Total dust		.....	15	
Respirable fraction		.....	5	
n-Amyl acetate	628-63-7	100	525	
sec-Amyl acetate	626-38-0	125	650	
Aniline and homologs	62-53-3	5	19	X
Anisidine (o-,p-isomers)	29191-52-4	.....	0.5	X
Antimony and compounds (as Sb)	7440-36-0	.....	0.5	
ANTU (alpha Naphthylthiourea)	86-88-4	.....	0.3	

Arsenic, inorganic compounds (as As); see 1910.1018	7440-38-2			
Arsenic, organic compounds (as As)	7440-38-2	.....	0.5	
Arsine	7784-42-1	0.05	0.2	
Asbestos; see 1910.1001	(4)			
Azinphos-methyl	86-50-0	.....	0.2	X
Barium, soluble compounds (as Ba)	7440-39-3	.....	0.5	
Barium sulfate	7727-43-7			
Total dust		.....	15	
Respirable fraction		.....	5	
Benomyl	17804-35-2			
Total dust		.....	15	
Respirable fraction		.....	5	
Benzene; See 1910.1028. See Table Z-2 for the limits applicable in the operations or sectors excluded in 1910.1028(d)	71-43-2			
Benzidine; See 1910.1010	92-87-5			
p-Benzoquinone; see Quinone.				
Benzo(a)pyrene; see Coal tar pitch volatiles				
Benzoyl peroxide	94-36-0	.....	5	
Benzyl chloride	100-44-7	1	5	
Beryllium and beryllium compounds (as Be)	7440-41-7		(2)	
Biphenyl; see Diphenyl.				
Bismuth telluride, Undoped	1304-82-1			
Total dust		.....	15	
Respirable fraction		.....	5	
Boron oxide	1303-86-2			
Total dust		.....	15	
Boron trifluoride	7637-07-2	(C)1	(C)3	
Bromine	7726-95-6	0.1	0.7	
Bromoform	75-25-2	0.5	5	X
Butadiene (1,3-Butadiene); See 29 CFR 1910.1051; 29 CFR 1910.19(1)	106-99-0	1 ppm/5 ppm STEL		
Butanethiol; see Butyl mercaptan.				

2-Butanone (Methyl ethyl ketone)	78-93-3	200	590	
2-Butoxyethanol	111-76-2	50	240	X
n-Butyl-acetate	123-86-4	150	710	
sec-Butyl acetate	105-46-4	200	950	
tert-Butyl-acetate	540-88-5	200	950	
n-Butyl alcohol	71-36-3	100	300	
sec-Butyl alcohol	78-92-2	150	450	
tert-Butyl alcohol	75-65-0	100	300	
Butylamine	109-73-9	(C)5	(C)15	X
tert-Butyl chromate (as CrO(3)) see 1910.1026	1189-85-1			
n-Butyl glycidyl ether (BGE)	2426-08-6	50	270	
Butyl mercaptan	109-79-5	10	35	
p-tert-Butyltoluene	98-51-1	10	60	
Cadmium (as Cd); see 1910.1027	7440-43-9			
Calcium Carbonate	1317-65-3			
Total dust		.....	15	
Respirable fraction		.....	5	
Calcium hydroxide	1305-62-0			
Total dust		.....	15	
Respirable fraction		.....	5	
Calcium oxide	1305-78-8	.....	5	
Calcium silicate	1344-95-2			
Total dust		.....	15	
Respirable fraction		.....	5	
Calcium sulfate	7778-18-9			
Total dust		.....	15	
Respirable fraction		.....	5	
Camphor, synthetic	76-22-2	.....	2	
Carbaryl (Sevin)	63-25-2	.....	5	
Carbon black	1333-86-4	.....	3.5	
Carbon dioxide	124-38-9	5000	9000	
Carbon disulfide	75-15-0		(2)	
Carbon monoxide	630-08-0	50	55	
Carbon tetrachloride	56-23-5		(2)	
Cellulose	9004-34-6			
Total dust		.....	15	
Respirable fraction		.....	5	
Chlordane	57-74-9	.....	0.5	X
Chlorinated camphene	8001-35-2	.....	0.5	X
Chlorinated diphenyl oxide	55720-99-5	.....	0.5	
Chlorine	7782-50-5	(C)1	(C)3	
Chlorine dioxide	10049-04-4	0.1	0.3	
Chlorine trifluoride	7790-91-2	(C)0.1	(C)0.4	
Chloroacetaldehyde	107-20-0	(C)1	(C)3	
a-Chloroacetophenone (Phenacyl chloride)	532-27-4	0.05	0.3	

Chlorobenzene.....	108-90-7	75	350	
o-Chlorobenzylidene malononitrile.....	2698-41-1	0.05	0.4	
Chlorobromomethane.....	74-97-5	200	1050	
2-Chloro-1,3-butadiene; See beta-Chloroprene.				
Chlorodiphenyl (42% Chlorine)(PCB)..	53469-21-9	.....	1	X
Chlorodiphenyl (54% Chlorine)(PCB)..	11097-69-1	.....	0.5	X
1-Chloro-2, 3-epoxypropane; See Epichlorohydrin.				
2-Chloroethanol; See Ethylene chlorohydrin				
Chloroethylene; See Vinyl chloride.				
Chloroform (Trichloromethane)...	67-66-3	(C)50	(C)240	
bis(Chloromethyl) ether; see 1910.1008.	542-88-1			
Chloromethyl methyl ether; see 1910.1006.	107-30-2			
1-Chloro-1-nitropropane	600-25-9	20	100	
Chloropicrin.....	76-06-2	0.1	0.7	
beta-Chloroprene.....	126-99-8	25	90	X
2-Chloro-6 (trichloromethyl) pyridine.....	1929-82-4			
Total dust.....		.....	15	
Respirable fraction..		.....	5	
Chromic acid and chromates (as CrO(3))	(4)		(2)	
Chromium (II) compounds (as Cr).....	7440-47-3	.....	0.5	
Chromium (III) compounds (as Cr)....	7440-47-3	.....	0.5	
Chromium (VI) compounds See 1910.1026(5)				
Chromium metal and insol. salts (as Cr).	7440-47-3	.....	1	
Chrysene; see Coal tar pitch volatiles.....				
Clopidol.....	2971-90-6			
Total dust.....		.....	15	
Respirable fraction..		.....	5	
Coal dust (less than 5% SiO(2)), respirable fraction..			(3)	
Coal dust (greater than or equal to 5% SiO(2)), respirable				

fraction			(3)	
Coal tar pitch volatiles (benzene soluble fraction), anthracene, BaP, phenanthrene, acridine, chrysene, pyrene	65966-93-2	.....	0.2	
Cobalt metal, dust, and fume (as Co)	7440-48-4	.....	0.1	
Coke oven emissions; see 1910.1029				
Copper	7440-50-8			
Fume (as Cu)		.....	0.1	
Dusts and mists (as Cu)		.....	1	
Cotton dust (e), see 1910.1043		.....	1	
Crag herbicide (Sesone)	136-78-7			
Total dust		.....	15	
Respirable fraction		.....	5	
Cresol, all isomers	1319-77-3	5	22	X
Crotonaldehyde	123-73-9	2	6	
	4170-30-3			
Cumene	98-82-8	50	245	X
Cyanides (as CN)	(4)	.....	5	X
Cyclohexane	110-82-7	300	1050	
Cyclohexanol	108-93-0	50	200	
Cyclohexanone	108-94-1	50	200	
Cyclohexene	110-83-8	300	1015	
Cyclopentadiene	542-92-7	75	200	
2,4-D (Dichlorophen-oxyacetic acid)	94-75-7	.....	10	
Decaborane	17702-41-9	0.05	0.3	X
Demeton (Systox)	8065-48-3	.....	0.1	X
Diacetone alcohol (4-Hydroxy-4-methyl-2-pentanone)	123-42-2	50	240	
1,2-Diaminoethane; see Ethylenediamine				
Diazomethane	334-88-3	0.2	0.4	
Diborane	19287-45-7	0.1	0.1	
1,2-Dibromo-3-chloropropane (DBCP); see 1910.1044	96-12-8			
1,2-Dibromoethane; see Ethylene dibromide				
Dibutyl phosphate	107-66-4	1	5	
Dibutyl phthalate	84-74-2	.....	5	
o-Dichlorobenzene	95-50-1	(C)50	(C)300	
p-Dichlorobenzene	106-46-7	75	450	
3,3'-Dichlorobenzidine;				

see 1910.1007.....	91-94-1			
Dichlorodifluoromethane	75-71-8	1000	4950	
1,3-Dichloro-5,				
5-dimethyl hydantoin.	118-52-5	.....	0.2	
Dichlorodiphenyltri-				
chloroethane (DDT)...	50-29-3	.....	1	X
1,1-Dichloroethane.....	75-34-3	100	400	
1,2-Dichloroethane; see				
Ethylene dichloride..				
1,2-Dichloroethylene...	540-59-0	200	790	
Dichloroethyl ether....	111-44-4	(C)15	(C)90	X
Dichloromethane; see				
Methylene chloride...				
Dichloromonofluoro-				
methane.....	75-43-4	1000	4200	
1,1-Dichloro-1-				
nitroethane.....	594-72-9	(C)10	(C)60	
1,2-Dichloropropane;				
see				
Propylene dichloride.				
Dichlorotetrafluoro-				
ethane.....	76-14-2	1000	7000	
Dichlorvos (DDVP).....	62-73-7	.....	1	X
Dicyclopentadienyl iron	102-54-5			
Total dust.....		.....	15	
Respirable fraction..		.....	5	
Dieldrin.....	60-57-1	.....	0.25	X
Diethylamine.....	109-89-7	25	75	
2-Diethylaminoethanol	100-37-8	10	50	X
Diethyl ether;				
see Ethyl ether.....				
Difluorodibromomethane.	75-61-6	100	860	
Diglycidyl ether (DGE).	2238-07-5	(C)0.5	(C)2.8	
Dihydroxybenzene;				
see Hydroquinone.....				
Diisobutyl ketone.....	108-83-8	50	290	
Diisopropylamine.....	108-18-9	5	20	X
4-Dimethylaminoazo-				
benzene;				
see 1910.1015.....	60-11-7			
Dimethoxymethane;				
see Methylal.....				
Dimethyl acetamide.....	127-19-5	10	35	X
Dimethylamine.....	124-40-3	10	18	
Dimethylaminobenzene;				
see Xylidine.....				
Dimethylaniline				
(N,N-Dimethylaniline)	121-69-7	5	25	X
Dimethylbenzene;				
see Xylene.....				
Dimethyl-1,2-dibromo-2,				
2-dichloroethyl				

phosphate	300-76-5	.....	3	
Dimethylformamide	68-12-2	10	30	X
2,6-Dimethyl-4-heptanone; see Diisobutyl ketone				
1,1-Dimethylhydrazine	57-14-7	0.5	1	X
Dimethylphthalate	131-11-3	.....	5	
Dimethyl sulfate	77-78-1	1	5	X
Dinitrobenzene				
(all isomers)			1	X
(ortho)	528-29-0			
(meta)	99-65-0			
(para)	100-25-4			
Dinitro-o-cresol	534-52-1	.....	0.2	X
Dinitrotoluene	25321-14-6	.....	1.5	X
Dioxane				
(Diethylene dioxide)	123-91-1	100	360	X
Diphenyl (Biphenyl)	92-52-4	0.2	1	
Diphenylmethane diisocyanate; see Methylene bisphenyl isocyanate				
Dipropylene glycol methyl ether	34590-94-8	100	600	X
Di-sec octyl phthalate (Di-(2-ethylhexyl) phthalate)	117-81-7	.....	5	
Emery	12415-34-8			
Total dust		.....	15	
Respirable fraction		.....	5	
Endrin	72-20-8	.....	0.1	X
Epichlorohydrin	106-89-8	5	19	X
EPN	2104-64-5	.....	0.5	X
1,2-Epoxypropane; see Propylene oxide				
2,3-Epoxy-1-propanol; see Glycidol				
Ethanethiol; see Ethyl mercaptan				
Ethanolamine	141-43-5	3	6	
2-Ethoxyethanol (Cellosolve)	110-80-5	200	740	X
2-Ethoxyethyl acetate (Cellosolve acetate)	111-15-9	100	540	X
Ethyl acetate	141-78-6	400	1400	
Ethyl acrylate	140-88-5	25	100	X
Ethyl alcohol (Ethanol)	64-17-5	1000	1900	
Ethylamine	75-04-7	10	18	
Ethyl amyl ketone (5-Methyl-3-heptanone)	541-85-5	25	130	
Ethyl benzene	100-41-4	100	435	

Ethyl bromide.....	74-96-4	200	890	
Ethyl butyl ketone (3-Heptanone).....	106-35-4	50	230	
Ethyl chloride.....	75-00-3	1000	2600	
Ethyl ether.....	60-29-7	400	1200	
Ethyl formate.....	109-94-4	100	300	
Ethyl mercaptan.....	75-08-1	(C)10	(C)25	
Ethyl silicate.....	78-10-4	100	850	
Ethylene chlorohydrin..	107-07-3	5	16	X
Ethylenediamine.....	107-15-3	10	25	
Ethylene dibromide.....	106-93-4		(2)	
Ethylene dichloride (1,2-Dichloroethane).	107-06-2		(2)	
Ethylene glycol dinitrate.....	628-96-6	(C)0.2	(C)1	X
Ethylene glycol methyl acetate; see Methyl cellosolve acetate...				
Ethyleneimine; see 1910.1012.....	151-56-4			
Ethylene oxide; see 1910.1047.....	75-21-8			
Ethylidene chloride; see 1,1-Dichlorethane				
N-Ethylmorpholine.....	100-74-3	20	94	X
Ferbam.....	14484-64-1			
Total dust.....		.....	15	
Ferrovanadium dust.....	12604-58-9	.....	1	
Fluorides (as F).....	(4)	.....	2.5	
Fluorine.....	7782-41-4	0.1	0.2	
Fluorotrichloromethane (Trichloro-fluoromethane).....	75-69-4	1000	5600	
Formaldehyde; see 1910.1048.....	50-00-0			
Formic acid.....	64-18-6	5	9	
Furfural.....	98-01-1	5	20	X
Furfuryl alcohol.....	98-00-0	50	200	
Grain dust (oat, wheat barley).....	.....	.....	10	
Glycerin (mist).....	56-81-5			
Total dust.....		.....	15	
Respirable fraction..		.....	5	
Glycidol.....	556-52-5	50	150	
Glycol monoethyl ether; see 2-Ethoxyethanol..				
Graphite, natural respirable dust.....	7782-42-5		(3)	
Graphite, synthetic....				
Total dust.....		.....	15	
Respirable Fraction..		.....	5	
Guthion;				

see Azinphos methyl..				
Gypsum.....	13397-24-5			
Total dust.....		.....	15	
Respirable fraction..		.....	5	
Hafnium.....	7440-58-6	.....	0.5	
Heptachlor.....	76-44-8	.....	0.5	X
Heptane (n-Heptane)....	142-82-5	500	2000	
Hexachloroethane.....	67-72-1	1	10	X
Hexachloronaphthalene..	1335-87-1	.....	0.2	X
n-Hexane.....	110-54-3	500	1800	
2-Hexanone (Methyl				
n-butyl ketone).....	591-78-6	100	410	
Hexone (Methyl				
isobutyl ketone).....	108-10-1	100	410	
sec-Hexyl acetate.....	108-84-9	50	300	
Hydrazine.....	302-01-2	1	1.3	X
Hydrogen bromide.....	10035-10-6	3	10	
Hydrogen chloride.....	7647-01-0	(C)5	(C)7	
Hydrogen cyanide.....	74-90-8	10	11	X
Hydrogen fluoride				
(as F).....	7664-39-3		(2)	
Hydrogen peroxide.....	7722-84-1	1	1.4	
Hydrogen selenide				
(as Se).....	7783-07-5	0.05	0.2	
Hydrogen sulfide.....	7783-06-4		(2)	
Hydroquinone.....	123-31-9	.....	2	
Iodine.....	7553-56-2	(C)0.1	(C)1	
Iron oxide fume.....	1309-37-1	.....	10	
Isomyl acetate.....	123-92-2	100	525	
Isomyl alcohol				
(primary and				
secondary).....	123-51-3	100	360	
Isobutyl acetate.....	110-19-0	150	700	
Isobutyl alcohol.....	78-83-1	100	300	
Isophorone.....	78-59-1	25	140	
Isopropyl acetate.....	108-21-4	250	950	
Isopropyl alcohol.....	67-63-0	400	980	
Isopropylamine.....	75-31-0	5	12	
Isopropyl ether.....	108-20-3	500	2100	
Isopropyl glycidyl				
ether (IGE).....	4016-14-2	50	240	
Kaolin.....	1332-58-7			
Total dust.....		.....	15	
Respirable fraction..		.....	5	
Ketene.....	463-51-4	0.5	0.9	
Lead inorganic (as Pb);				
see 1910.1025.....	7439-92-1			
Limestone.....	1317-65-3			
Total dust.....		.....	15	
Respirable fraction..		.....	5	
Lindane.....	58-89-9	.....	0.5	X
Lithium hydride.....	7580-67-8	.....	0.025	

L.P.G. (Liquified petroleum gas)	68476-85-7	1000	1800	
Magnesite	546-93-0			
Total dust		.....	15	
Respirable fraction		.....	5	
Magnesium oxide fume	1309-48-4			
Total Particulate		.....	15	
Malathion	121-75-5			
Total dust		.....	15	X
Maleic anhydride	108-31-6	0.25	1	
Manganese compounds (as Mn)	7439-96-5	.....	(C)5	
Manganese fume (as Mn)	7439-96-5	.....	(C)5	
Marble	1317-65-3			
Total dust		.....	15	
Respirable fraction		.....	5	
Mercury (aryl and inorganic)(as Hg)	7439-97-6		(2)	
Mercury (organo) alkyl compounds (as Hg)	7439-97-6		(2)	
Mercury (vapor) (as Hg)	7439-97-6		(2)	
Mesityl oxide	141-79-7	25	100	
Methanethiol; see Methyl mercaptan				
Methoxychlor	72-43-5			
Total dust		.....	15	
2-Methoxyethanol; (Methyl cellosolve)	109-86-4	25	80	X
2-Methoxyethyl acetate (Methyl cellosolve acetate)	110-49-6	25	120	X
Methyl acetate	79-20-9	200	610	
Methyl acetylene (Propyne)	74-99-7	1000	1650	
Methyl acetylene propadiene mixture (MAPP)		1000	1800	
Methyl acrylate	96-33-3	10	35	X
Methylal (Dimethoxy-methane)	109-87-5	1000	3100	
Methyl alcohol	67-56-1	200	260	
Methylamine	74-89-5	10	12	
Methyl amyl alcohol; see Methyl Isobutyl carbinol				
Methyl n-amyl ketone	110-43-0	100	465	
Methyl bromide	74-83-9	(C)20	(C)80	X
Methyl butyl ketone; see 2-Hexanone				
Methyl cellosolve; see 2-Methoxyethanol				
Methyl cellosolve				

acetate; see 2-Methoxyethyl acetate				
Methyl chloride	74-87-3		(2)	
Methyl chloroform (1,1,1-Trichloro-ethane)	71-55-6	350	1900	
Methylcyclohexane	108-87-2	500	2000	
Methylcyclohexanol	25639-42-3	100	470	
o-Methylcyclohexanone	583-60-8	100	460	X
Methylene chloride	75-09-2		(2)	
Methyl ethyl ketone (MEK); see 2-Butanone				
Methyl formate	107-31-3	100	250	
Methyl hydrazine (Monomethyl hydrazine)	60-34-4	(C)0.2	(C)0.35	X
Methyl iodide	74-88-4	5	28	X
Methyl isoamyl ketone	110-12-3	100	475	
Methyl isobutyl carbinol	108-11-2	25	100	X
Methyl isobutyl ketone; see Hexone				
Methyl isocyanate	624-83-9	0.02	0.05	X
Methyl mercaptan	74-93-1	(C)10	(C)20	
Methyl methacrylate	80-62-6	100	410	
Methyl propyl ketone; see 2-Pentanone				
alpha-Methyl styrene	98-83-9	(C)100	(C)480	
Methylene bisphenyl isocyanate (MDI)	101-68-8	(C)0.02	(C)0.2	
Mica; see Silicates				
Molybdenum (as Mo)	7439-98-7			
Soluble compounds		.....	5	
Insoluble Compounds				
Total dust		.....	15	
Monomethyl aniline	100-61-8	2	9	X
Monomethyl hydrazine; see Methyl hydrazine.				
Morpholine	110-91-8	20	70	X
Naphtha (Coal tar)	8030-30-6	100	400	
Naphthalene	91-20-3	10	50	
alpha-Naphthylamine; see 1910.1004	134-32-7			
beta-Naphthylamine; see 1910.1009	91-59-8			
Nickel carbonyl (as Ni)	13463-39-3	0.001	0.007	
Nickel, metal and insoluble compounds (as Ni)	7440-02-0	.....	1	
Nickel, soluble compounds (as Ni)	7440-02-0	.....	1	

Nicotine	54-11-5	.....	0.5	X
Nitric acid	7697-37-2	2	5	
Nitric oxide	10102-43-9	25	30	
p-Nitroaniline	100-01-6	1	6	X
Nitrobenzene	98-95-3	1	5	X
p-Nitrochlorobenzene	100-00-5	.....	1	X
4-Nitrodiphenyl; see 1910.1003	92-93-3			
Nitroethane	79-24-3	100	310	
Nitrogen dioxide	10102-44-0	(C)5	(C)9	
Nitrogen trifluoride	7783-54-2	10	29	
Nitroglycerin	55-63-0	(C)0.2	(C)2	X
Nitromethane	75-52-5	100	250	
1-Nitropropane	108-03-2	25	90	
2-Nitropropane	79-46-9	25	90	
N-Nitrosodimethylamine; see 1910.1016				
Nitrotoluene (all isomers)		5	30	X
o-isomer	88-72-2			
m-isomer	99-08-1			
p-isomer	99-99-0			
Nitrotrichloromethane; see Chloropicrin				
Octachloronaphthalene	2234-13-1	.....	0.1	X
Octane	111-65-9	500	2350	
Oil mist, mineral	8012-95-1	.....	5	
Osmium tetroxide (as Os)	20816-12-0	.....	0.002	
Oxalic acid	144-62-7	.....	1	
Oxygen difluoride	7783-41-7	0.05	0.1	
Ozone	10028-15-6	0.1	0.2	
Paraquat, respirable dust	4685-14-7	.....	0.5	X
	1910-42-5			
	2074-50-2			
Parathion	56-38-2	.....	0.1	X
Particulates not otherwise regulated (PNOR)(f)				
Total dust		.....	15	
Respirable fraction		.....	5	
PCB; see Chlorodiphenyl (42% and 54% chlorine)				
Pentaborane	19624-22-7	0.005	0.01	
Pentachloronaphthalene	1321-64-8	.....	0.5	X
Pentachlorophenol	87-86-5	.....	0.5	X
Pentaerythritol	115-77-5			
Total dust		.....	15	
Respirable fraction		.....	5	
Pentane	109-66-0	1000	2950	

2-Pentanone (Methyl propyl ketone)	107-87-9	200	700	
Perchloroethylene (Tetrachloroethylene)	127-18-4		(2)	
Perchloromethyl mercaptan	594-42-3	0.1	0.8	
Perchloryl fluoride	7616-94-6	3	13.5	
Petroleum distillates (Naphtha)(Rubber Solvent)		500	2000	
Phenol	108-95-2	5	19	X
p-Phenylene diamine	106-50-3	.....	0.1	X
Phenyl ether, vapor	101-84-8	1	7	
Phenyl ether-biphenyl mixture, vapor		1	7	
Phenylethylene; see Styrene				
Phenyl glycidyl ether (PGE)	122-60-1	10	60	
Phenylhydrazine	100-63-0	5	22	X
Phosdrin (Mevinphos)	7786-34-7	.....	0.1	X
Phosgene (Carbonyl chloride)	75-44-5	0.1	0.4	
Phosphine	7803-51-2	0.3	0.4	
Phosphoric acid	7664-38-2	.....	1	
Phosphorus (yellow)	7723-14-0	.....	0.1	
Phosphorus pentachloride	10026-13-8	.....	1	
Phosphorus pentasulfide	1314-80-3	.....	1	
Phosphorus trichloride	7719-12-2	0.5	3	
Phthalic anhydride	85-44-9	2	12	
Picloram	1918-02-1			
Total dust		.....	15	
Respirable fraction		.....	5	
Picric acid	88-89-1	.....	0.1	X
Pindone (2-Pivalyl-1, 3-indandione)	83-26-1	.....	0.1	
Plaster of paris	26499-65-0			
Total dust		.....	15	
Respirable fraction		.....	5	
Platinum (as Pt)	7440-06-4			
Metal		.....	.....	
Soluble Salts		.....	0.002	
Portland cement	65997-15-1			
Total dust		.....	15	
Respirable fraction		.....	5	
Propane	74-98-6	1000	1800	
beta-Propriolactone; see 1910.1013	57-57-8			
n-Propyl acetate	109-60-4	200	840	
n-Propyl alcohol	71-23-8	200	500	
n-Propyl nitrate	627-13-4	25	110	

Propylene dichloride...	78-87-5	75	350	
Propylene imine.....	75-55-8	2	5	X
Propylene oxide.....	75-56-9	100	240	
Propyne; see Methyl acetylene.....				
Pyrethrum.....	8003-34-7	.....	5	
Pyridine.....	110-86-1	5	15	
Quinone.....	106-51-4	0.1	0.4	
RDX: see Cyclonite.....				
Rhodium (as Rh), metal fume and insoluble compounds.....	7440-16-6	.....	0.1	
Rhodium (as Rh), soluble compounds....	7440-16-6	.....	0.001	
Ronnel.....	299-84-3	.....	15	
Rotenone.....	83-79-4	.....	5	
Rouge.....				
Total dust.....		.....	15	
Respirable fraction..		.....	5	
Selenium compounds (as Se).....	7782-49-2	.....	0.2	
Selenium hexafluoride (as Se).....	7783-79-1	0.05	0.4	
Silica, amorphous, precipitated and gel.	112926-00-8		(3)	
Silica, amorphous, diatomaceous earth, containing less than 1% crystalline silica	61790-53-2		(3)	
Silica, crystalline cristobalite, respirable dust.....	14464-46-1		(3)	
Silica, crystalline quartz, respirable dust.....	14808-60-7		(3)	
Silica, crystalline tripoli (as quartz), respirable dust.....	1317-95-9		(3)	
Silica, crystalline tridymite, respirable dust.....	15468-32-3		(3)	
Silica, fused, respirable dust.....	60676-86-0		(3)	
Silicates (less than 1% crystalline silica) Mica (respirable dust).....	12001-26-2		(3)	
Soapstone, total dust..	.....		(3)	
Soapstone, respirable dust.....	.....		(3)	
Talc (containing asbestos): use				

asbestos limit: see 29 CFR 1910.1001.....			(3)	
Talc (containing no asbestos), respiratory dust.....	14807-96-6		(3)	
Tremolite, asbestiform; see 1910.1001.....				
Silicon.....	7440-21-3			
Total dust.....		.....	15	
Respirable fraction..		.....	5	
Silicon carbide.....	409-21-2			
Total dust.....		.....	15	
Respirable fraction..		.....	5	
Silver, metal and soluble compounds (as Ag).....	7440-22-4	.....	0.01	
Soapstone; see Silicates.....				
Sodium fluoroacetate...	62-74-8	.....	0.05	X
Sodium hydroxide.....	1310-73-2	.....	2	
Starch.....	9005-25-8			
Total dust.....		.....	15	
Respirable fraction..		.....	5	
Stibine.....	7803-52-3	0.1	0.5	
Stoddard solvent.....	8052-41-3	500	2900	
Strychnine.....	57-24-9	.....	0.15	
Styrene.....	100-42-5		(2)	
Sucrose.....	57-50-1			
Total dust.....		.....	15	
Respirable fraction..		.....	5	
Sulfur dioxide.....	7446-09-5	5	13	
Sulfur hexafluoride....	2551-62-4	1000	6000	
Sulfuric acid.....	7664-93-9	.....	1	
Sulfur monochloride....	10025-67-9	1	6	
Sulfur pentafluoride...	5714-22-7	0.025	0.25	
Sulfuryl fluoride.....	2699-79-8	5	20	
Systox; see Demeton...				
2,4,5-T (2,4,5-trichlorophenoxyacetic acid).....	93-76-5	.....	10	
Talc; see Silicates...				
Tantalum, metal and oxide dust.....	7440-25-7	.....	5	
TEDP (Sulfotep).....	3689-24-5	.....	0.2	X
Tellurium and compounds (as Te)....	13494-80-9	.....	0.1	
Tellurium hexafluoride (as Te).....	7783-80-4	0.02	0.2	
Temephos.....	3383-96-8			
Total dust.....		.....	15	
Respirable fraction..		.....	5	

TEPP (Tetraethyl pyrophosphaate)	107-49-3	.....	0.05	X
Terphenylis	26140-60-3	(C)1	(C)9	
1,1,1,2-Tetrachloro-2, 2-difluoroethane	76-11-9	500	4170	
1,1,2,2-Tetrachloro-1, 2-difluoroethane	76-12-0	500	4170	
1,1,2,2-Tetrachloro-ethane	79-34-5	5	35	X
Tetrachoroethylene; see Perchloroethylene				
Tetrachloromethane; see Carbon tetrachloride.				
Tetrachloronaphthalene.	1335-88-2	.....	2	X
Tetraethyl lead (as Pb)	78-00-2	.....	0.075	X
Tetrahydrofuran	109-99-9	200	590	
Tetramethyl lead, (as Pb)	75-74-1	.....	0.075	X
Tetramethyl succinonitrile	3333-52-6	0.5	3	X
Tetranitromethane	509-14-8	1	8	
Tetryl (2,4,6-Trinitro-phenylmethyl-nitramine)	479-45-8	.....	1.5	X
Thallium, soluble compounds (as Tl)	7440-28-0	.....	0.1	X
4,4'-Thiobis(6-tert, Butyl-m-cresol)	96-69-5			
Total dust		.....	15	
Respirable fraction.		.....	5	
Thiram	137-26-8	.....	5	
Tin, inorganic compounds (except oxides) (as Sn)	7440-31-5	.....	2	
Tin, organic compounds (as Sn)	7440-31-5	.....	0.1	
Titanium dioxide	13463-67-7			
Total dust		.....	15	
Toluene	108-88-3		(2)	
Toluene-2, 4-diisocyanate (TDI).	584-84-9	(C)0.02	(C)0.14	
o-Toluidine	95-53-4	5	22	X
Toxaphene; see Chlorinated camphene.				
Tremolite; see Silicates				
Tributyl phosphate	126-73-8	.....	5	
1,1,1-Trichloroethane; see Methyl chloroform				
1,1,2-Trichloroethane.	79-00-5	10	45	X
Trichloroethylene	79-01-6		(2)	
Trichloromethane;				

see Chloroform				
Trichloronaphthalene...	1321-65-9	.....	5	X
1,2,3-Trichloropropane.	96-18-4	50	300	
1,1,2-Trichloro-1,2,				
2-trifluoroethane....	76-13-1	1000	7600	
Triethylamine.....	121-44-8	25	100	
Trifluorobromomethane..	75-63-8	1000	6100	
2,4,6-Trinitrophenol;				
see Picric acid.....				
2,4,6-Trinitrophenyl-				
methyl nitramine;				
see Tetryl.....				
2,4,6-Trinitrotoluene				
(TNT).....	118-96-7	.....	1.5	X
Triorthocresyl				
phosphate.....	78-30-8	.....	0.1	
Triphenyl phosphate....	115-86-6	.....	3	
Turpentine.....	8006-64-2	100	560	
Uranium (as U).....	7440-61-1			
Soluble compounds....		.....	0.05	
Insoluble compounds..		.....	0.25	
Vanadium.....	1314-62-1			
Respirable dust				
(as V_2O_5)).....		.....	(C)0.5	
Fume (as V_2O_5).....		.....	(C)0.1	
Vegetable oil mist.....				
Total dust.....		.....	15	
Respirable fraction..		.....	5	
Vinyl benzene;				
see Styrene.....				
Vinyl chloride;				
see 1910.1017.....	75-01-4			
Vinyl cyanide;				
see Acrylonitrile				
Vinyl toluene.....	25013-15-4	100	480	
Warfarin.....	81-81-2	.....	0.1	
Xylenes				
(o-, m-, p-isomers)..	1330-20-7	100	435	
Xylidine.....	1300-73-8	5	25	X
Yttrium.....	7440-65-5	.....	1	
Zinc chloride fume.....	7646-85-7	.....	1	
Zinc oxide fume.....	1314-13-2	.....	5	
Zinc oxide.....	1314-13-2			
Total dust.....		.....	15	
Respirable fraction..		.....	5	
Zinc stearate.....	557-05-1			
Total dust.....		.....	15	
Respirable fraction..		.....	5	
Zirconium compounds				
(as Zr).....	7440-67-7	.....	5	

Footnote(1) The PELs are 8-hour Time Weighted Averages (TWAs) unless otherwise noted; a (C) designation denotes a ceiling limit. They are to be determined from breathing-zone air samples.

(a) Parts of vapor or gas per million parts of contaminated air by volume at 25 degrees C and 760 torr.

(b) Milligrams of substance per cubic meter of air. When entry is in this column only, the value is exact; when listed with a ppm entry, it is approximate.

(c) The CAS number is for information only. Enforcement is based on the substance name. For an entry covering more than one metal compound measured as the metal, the CAS number for the metal is given - not CAS numbers for the individual compounds.

(d) The final benzene standard in 1910.1028 applies to all occupational exposures to benzene except in some circumstances the distribution and sale of fuels, sealed containers and pipelines, coke production, oil and gas drilling and production, natural gas processing, and the percentage exclusion for liquid mixtures; for the excepted subsegments, the benzene limits in Table Z-2 apply. See 1910.1028 for specific circumstances.

(e) This 8-hour TWA applies to respirable dust as measured by a vertical elutriator cotton dust sampler or equivalent instrument. The time-weighted average applies to the cotton waste processing operations of waste recycling (sorting, blending, cleaning and willowing) and garnetting. See also 1910.1043 for cotton dust limits applicable to other sectors.

(f) All inert or nuisance dusts, whether mineral, inorganic, or organic, not listed specifically by substance name are covered by the Particulates Not Otherwise Regulated (PNOR) limit which is the same as the inert or nuisance dust limit of Table Z-3.

Footnote(2) See Table Z-2.

Footnote(3) See Table Z-3.

Footnote(4) Varies with compound.

Footnote(5) See Table Z-2 for the exposure limits for any operations or sectors where the exposure limits in 1910.1026 are suspended or are otherwise not in effect.

TABLE Z-2

Substance	8-hour time weighted average	Acceptable ceiling concentration	Acceptable maximum peak above the acceptable ceiling concentration for an 8-hr shift	
			Concentration	Maximum duration
Benzene[(a)] (Z37.40-1969)	10 ppm	25 ppm	50 ppm	10 minutes.
Beryllium and beryllium compounds (Z37.29-1970)	2 ug/m(3)	5 ug/m(3)	25 ug/m(3)	30 minutes.
Cadmium fume[(b)] (Z37.5-1970)	0.1 mg/m(3)	0.3 mg/m(3)	.....	
Cadmium dust[(b)] (Z37.5-1970)	0.2 mg/m(3)	0.6 mg/m(3)		
Carbon disulfide (Z37.3-1968)	20 ppm	30 ppm	100 ppm	30 minutes.

Carbon tetrachloride (Z37.17-1967)	10 ppm	25 ppm	200 ppm	5 min. in any 3 hrs.
Chromic acid and chromates (Z37-7-1971)[c]	.....	1 mg/10 m(3)		
Ethylene dibromide (Z37.31-1970)	20 ppm	30 ppm	50 ppm	5 minutes.
Ethylene dichloride (Z37.21-1969)	50 ppm	100 ppm	200 ppm	5 min. in any 3 hrs.
Fluoride as dust (Z37.28-1969)	2.5 mg/m(3)	.....	.....	
Formaldehyde: see 1910.1048	.....	.....	.....	
Hydrogen fluoride (Z37.28-1969)	3 ppm	.....	.....	
Hydrogen sulfide (Z37.2-1966)	.....	20 ppm	50 ppm	10 mins. once only if no other meas. exp. occurs.
Mercury (Z37.8-1971)	.....	1 mg/10m(3)	.....	
Methyl chloride (Z37.18-1969)	100 ppm	200 ppm	300 ppm	5 mins. in any 3 hrs.
Methylene Chloride: see 1910.1052				
Organo (alkyl) mercury (Z37.30-1969)	0.01mg/m(3)	0.04 mg/m(3)	.....	
Styrene (Z37.15-1969)	100 ppm	200 ppm	600 ppm	5 mins. in any 3 hrs.
Tetrachloroethylene	100 ppm	200 ppm	300 ppm	5 mins. in any 3 hrs.
Toluene (Z37.12-1967)	200 ppm	300 ppm	500 ppm	10 minutes
Trichloroethylene (Z37.19-1967)	100 ppm	200 ppm	300 ppm	5 mins. in any 2 hrs.

Footnote[a] This standard applies to the industry segments exempt from the 1 ppm 8-hour TWA and 5 ppm STEL of the benzene standard at 1910.1028.

Footnote[b] This standard applies to any operations or sectors for which the Cadmium standard, 1910.1027, is stayed or otherwise not in effect.

Footnote[c] Footnote(c) This standard applies to any operations or sectors for which the exposures limit in the Chromium (VI) standard, Sec. 1910.1026, is stayed or is otherwise not in effect.

TABLE Z-3 Mineral Dusts

Substance	mppcf [a]	mg/m^3
Silica:		
Crystalline		
Quartz (Respirable)	$\frac{250^{b}}{\%SiO_2+5}$	$\frac{10\ mg/m^{3\ e}}{\%SiO_2+2}$
Quartz (Total Dust)	. . . . .	$\frac{30\ mg/m^3}{\%SiO_2+2}$
▪ Cristobalite: Use ½ the value calculated from the count or mass formulae for quartz. ▪ Tridymite: Use ½ the value calculated from the formulae for quartz.		
Amorphous, including natural diatomaceous earth	20	$\frac{80\ mg/m^3}{\%SiO_2}$
Silicates (less than 1% crystalline silica):		
Mica	20	
Soapstone	20	
Talc (not containing asbestos)	20[c]	
Talc (containing asbestos) Use asbestos limit		
Tremolite, asbestiform (see 29 CFR 1910.1001)		
Portland cement . . .	50	
Graphite (Natural)	15	
Coal Dust:		
Respirable fraction less than 5% SiO_2	. . . . .	2.4 mg/m$^{3\ e}$
Respirable fraction greater than 5% SiO_2	. . . . .	$\frac{10\ mg/m^{3\ e}}{\%SiO_2+2}$
Inert or Nuisance Dust:[d]		
Respirable fraction	15	5 mg/m^3
Total dust	50	15 mg/m^3

Note -- Conversion factors - mppcf X 35.3 = million particles per cubic meter = particles per c.c.

[a] Millions of particles per cubic foot of air, based on impinger samples counted by light-field techniques.
[b] The percentage of crystalline silica in the formula is the amount determined from airborne samples, except in those instances in which other methods have been shown to be applicable.
[c] Containing less than 1% quartz; if 1% quartz or more, use quartz limit.
[d] All inert or nuisance dusts, whether mineral, inorganic, or organic, not listed specifically by substance name are covered by this limit, which is the same as the Particulates Not Otherwise Regulated (PNOR) limit in Table Z-1.

[e] Both concentration and percent quartz for the application of this limit are to be determined from the fraction passing a size-selector with the following characteristics:

Aerodynamic diameter (unit density sphere)	**Percent passing selector**
2	90
2.5	75
3.5	50
5.0	25
10	0

The measurements under this note refer to the use of an AEC (now NRC) instrument. The repairable fraction of coal dust is determined with an MRE; the figure corresponding to that of 2.4 mg/m^3 in the table for coal dust is 4.5 mg/m^3.

APPENDIX C

PLU Voluntary Respirator Use Form

- Respirators protect against airborne hazards when properly selected and used. The Washington Industrial Safety & Health Act (WISHA) office recommends voluntary use of respirators when exposure to substances is below WISHA permissible exposure limits (PELs) because respirators can provide you an additional level of comfort and protection.
- If you choose to use a respirator be aware that respirators can create hazards for you, the user. You can avoid these hazards if you know how to use your respirator properly and how to keep it clean. Take these steps:
    - Read and follow all instructions provided by the manufacturer about use, maintenance (cleaning and care), and warnings regarding the respirator's limitations.
    - Choose respirators that have been certified for use to protect against the substance of concern. The National Institute for Occupational Safety and Health (NIOSH) certifies respirators. If a respirator isn't certified by NIOSH, you have no guarantee that it meets minimum design and performance standards for workplace use.
        - A NIOSH approval label will appear on or in the respirator packaging. It will tell you what protection the respirator provides.
    - Keep track of your respirator so you don't mistakenly use someone else's.
    - Do **not** wear your respirator into:
        - Atmospheres containing hazards that your respirator isn't designed to protect against. For example, a respirator designed to filter dust particles won't protect you against solvent vapor, smoke, or oxygen deficiency.
        - Situations where PELs and oxygen deficient atmospheres require the use of respirators. **Do Not** enter these environments.
- A respirator **will not** protect effectively if you have facial hair or if the respirator does not fit properly to form a seal.
- If you have any questions regarding the use of respirators in the classroom, please speak with your instructor or contact the Environmental Health & Safety Manager at 535-7233.

I have read, understand, and have been instructed as part of the class curriculum in respirator use. I am responsible to use and wear a respirator correctly. PLU, therefore, is not responsible for unauthorized or improper usage.

Name (Print) _____ PLU ID# _____

Signature_____ Date _____

Course # _____ Instructor _____

APPENDIX D

REPRODUCTIVE HAZARDS, TERATOGENIC AGENTS, and PREGANCY

Substances or agents that affect the reproductive health of women and men or the ability of couples to have healthy children are called reproductive hazards. A teratogen is a substance which interferes with embryonic or fetal development. Radiation, some chemicals, certain drugs (legal and illegal), cigarettes, some viruses and alcohol are other examples of reproductive hazards.

A reproductive hazard may cause one or more health effects, depending on the time and duration of the exposure. Reproductive hazards may not affect every person or every pregnancy in the same way. Whether a man, woman or fetus is harmed depends on how much of the hazard they are exposed to, when exposed, how long exposed, and how they are exposed.

Faculty members and laboratory supervisors are responsible for training and instructing laboratory personnel in the appropriate ways to protect themselves from the hazards in the laboratory. Faculty and staff are responsible for educating students, employees and visitors about laboratory hazards, using personal protective equipment, following proper laboratory practices and everyone should take the following steps to ensure their own safety:

1. Be sure to cap chemical containers after use.

2. Always wash hands after working in any science laboratory. Be especially diligent if any hazardous substance could have been contacted.

3. Avoid skin contact with chemicals.

4. Wear goggles at all times where chemicals or other hazardous materials are used or stored.

5. Use personal protective equipment (e.g., gloves, face shields, lab coats, aprons or other special clothing) to reduce exposures to chemical hazards. Inspect gloves for pin-holes, rips or tears before each use. Wash them before removal and replace when needed. Select gloves based on the break through, degradation, and permeation rates for the type of chemical handled.

6. Review the MSDS for each hazardous chemical used in the laboratory to become familiar with any reproductive hazard.

7. Discuss proper laboratory procedures with the faculty member or laboratory supervisor. Follow appropriate work practices and procedures to prevent exposures to reproductive hazards.

8. Consult a health care provider with any concerns about reproductive hazards.

Research or work with chemicals or biological agents possessing teratogenic or mutagenic capabilities may pose a significant health risk. Always consider the health risks associated with any chemical or biological agent before working with the agent and discuss any related concerns with your physician. Consult faculty members, laboratory supervisors, principal investigators or the Chemical Hygiene Officer if you have any questions or concerns about the research being conducted.