

Introduction - Lab-specific Chemical Hygiene Plan

General Laboratory Information

While this Generic Chemical Hygiene Plan contains University-wide information and procedures that may be sufficient for many activities it defines the minimum laboratory uses and procedures at the University of Cincinnati. Your specific Chemical Hygiene plan needs to describe, in writing, what actions need to be taken to protect people from the chemical hazards and unique operations in your laboratory, including:

- ✓ Standard operating procedures for chemical safety
- ✓ The criteria you use to implement exposure control measures
- ✓ Measures to ensure proper performance of fume hoods and other protective equipment
- ✓ Provision of chemical safety information and training to laboratory personnel
- ✓ Circumstances that require prior approval
- ✓ Provision for medical consultation and examination
- ✓ Designation of a Chemical Hygiene Officer
- ✓ Additional protection for work with particularly hazardous substances

The following Standard Operation Procedure (SOP) form was developed as a guide at the departmental or laboratory level for the principal investigator, laboratory director/supervisor or individual researcher. The PIs are responsible for editing or augmenting as necessary the chemical hygiene plan to fit the procedures followed in the laboratories under their direction and sharing the document with all affected workers. If a particular procedure in the generic Chemical Hygiene Plan can not be feasibly followed, then alternative techniques that offer equivalent protection should be documented herein. When complete add the supplemental requirements to the laboratory's specific Chemical Hygiene Plan. For more information or guidance, contact the Office of Environmental Health and Safety at 556-4968.

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Appendix A: The OSHA Laboratory Standard

Appendix B: Permissible Exposure Limits for Selected Chemicals

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Chemical Inventory Form; Safe Practices – Pyrophoric Chemicals

1. Emergency Procedures

Dial 911 for:

Fires

Toxic Gases

Serious Injuries

Give: The exact location (room number)

1. Type of emergency

Assistance needed

1.1 Fires

Call 911 immediately

Notify others in the area.

If the fire is large, evacuate the area. Pull the fire alarm

(Alarms are located in the hallways near the exits)

If the fire is small and you are confident you can extinguish it safely, you may attempt to do so, but only after others have been informed and 911 has been called.

1.2 Chemical accidents

- a. **Chemicals in the Eye:** If you get chemicals in your eyes, what you do in the first few seconds is the most important:
 - Yell for help, you will need it!
 - Get to an eyewash station or other source of water.
 - Flush with water for at least 15 minutes. Use thumb and forefinger to hold eyelids open.

- Do not rub your eyes or put medication in them.
 - Do not put neutralizers in the eyes.
 - Have someone call 911.
 - Always report to the University Health Services after flushing for 15 minutes. All accidents must be reported.
- b. **Chemical Splashes on Your Person:** Wash thoroughly with water. Depending on the extent of the contamination and hazard of the chemical you may need to:
- Yell for help!
 - Run for the safety shower! (a sink may be used if more appropriate).
 - Have someone call 911 (emergency).
 - Remove all contaminated clothing.
 - Wash thoroughly with water: 15 minutes is recommended.
 - Report to the University Health Service after washing. All injuries must be reported.
- c. **Inhalation of Chemicals:** If a person has been exposed by inhalation:
- **DO NOT become a victim yourself! If more than one person is down, a hazardous situation exists. DO NOT enter the room. Evacuate the area and dial 911 (emergency). Even one person down might indicate the presence of toxic gases. Call 911 and proceed only with extreme caution.**
 - Get the victim to fresh air if you can do so safely.
 - Apply artificial respiration as appropriate if you are properly trained to do so.
 - Call 911 (emergency).

1.3 Chemical Spills: Response depends on the quantity and nature of the spill:

IMPORTANT: ALL SPILLS:

1. Evacuate the laboratory at once **if you are not certain** the situation is non-hazardous and Call Environmental Health and Safety at 556-4968. If you **KNOW** the situation is non-hazardous, there is no need to evacuate the laboratory.
2. If you have any doubt about your ability to safely clean up the spill yourself, call 556-4968 to enlist the aid of the of Environmental Health and Safety. After consulting with Environmental Health and Safety it may be determined that it is safe for you to clean up the spill. Or it may be decided that it is appropriate for Environmental Health and Safety/Hazmat team to clean it up.
3. Hazards of a spill to consider:
 - Are there toxic vapors being given off that may be harmful to breathe?
 - Is it a flammable solvent that might burst into flame at any moment?
 - Are there sources of ignition such as a hot plate or vacuum pump nearby?
 - Could it be toxic if it got on your skin?
 - Is it an acid or base that could burn your skin or eyes?
 - Is it inside or outside a hood (Spills in laboratory fume hoods are much less hazardous).

Note: solvents, water and especially hydroxide solutions make a floor very slippery.

a. Water based spills over one liter:

- Call Environmental Health and Safety at 556-4968 for any spill of this size, even if you believe it to be non-hazardous. Environmental Health and Safety will consult with you on the best way to clean up the spill, and Environmental Health and Safety/Hazmat team will clean up for you if it is a hazardous spill.

b. Water based spills of less than one liter:

- You might be able to clean up spills in this range. Consider the hazards listed above.
- Only attempt to clean it up by yourself if you are completely confident that you can do so safely. Call Environmental Health and Safety at 556-4968 if you doubt your ability to safely handle the clean-up.

- c. Solvent based spills greater than 500 mls**
- Evacuate the area at once unless you KNOW the situation is non-hazardous
 - Call Environmental Health and Safety at 556-4968. A Hazmat response team will come to clean it up.
 - If you think you can do so safely, it may be appropriate for you to quickly throw some solvent spill kit material on the spill before you leave the laboratory.
- d. Solvent based spills less than 500 mls:**
- You might be able to handle this yourself. Consider the hazards listed above. Especially look for potential ignition sources in the area.
 - Only attempt to clean it up by yourself if you are completely confident that you can do so safely. Call Environmental Health and Safety at 556-4968 if you doubt your ability to safely handle it.
 - If you think you can do so safely, it may be appropriate for you to quickly throw some solvent spill kit material on the spill before you leave the laboratory.
- e. Mercury Spills:**
- For small spills (broken thermometers) collect as much mercury as possible using a pipette with a rubber bulb. Use a Mercury Spill Kit to clean up the rest. These kits are available from Lab Safety, Fisher Scientific, etc. Mercury wastes and contaminated sponges from the spill kit cleanup should be bottled and tagged and disposed of as hazardous waste.
 - For larger spills, call Environmental Health and Safety at 556-4968.

1.4 How to Clean Up Chemical Spills

- a. Wear the proper protective gear!**
- Wear safety goggles if the material could cause damage to your eyes.
 - Wear a lab coat.
 - Wear appropriate gloves. Consult with glove charts or call Environmental Health and Safety to determine appropriate type of glove for the chemicals or the operations.
- b. Spills of Relatively Non-hazardous Solid Materials**
- If you are confident in your ability to safely handle the spill, sweep it up carefully to avoid generating dust.
 - Put the waste material into a bottle or similar container
 - Dispose of the waste in an appropriate manner (see Section 11.5)

c. Spills of Organic Solvents

- Remove all nearby sources of ignition if you can do it safely.
- Use a solvent spill kit if you attempt to clean it up yourself. The activated charcoal in the spill kits absorbs both the vapors and solvent, minimizing vapors in the air that could ignite and making the spill less toxic. For spills of just a few milliliters, paper towels are OK.
- Start just outside the edge of the spill, and build a dam of charcoal to keep the spill from spreading
- Then fill in the area of the spill until all solvent is covered.
- Add more charcoal if the material appears wet or damp.
- Stir the material gently, and add even more charcoal until the entire mass appears to be dry.
- Scoop up the charcoal and place it in a bottle, bucket, or similar container.
- Dispose of the waste in an appropriate manner

d. Spills of Acids and Bases

- Use an acid or base spill kit, as appropriate. The materials in these kits have indicators that tell the researcher when the spill has been neutralized.
- Start just outside the edge of the spill, and build a dam of material to keep the spill from spreading.
- Then fill in the area of the spill until it is completely covered.
- Stir the material around, adding more as needed. The color of the spill material changes from its original color to a different one when it contacts acid or base. The second color means the spill has not been completely neutralized. When you have added enough material and stirred it around, it should all be back to the original color. That indicates the spill has been neutralized.
- Scoop up the material and place it in a bottle, bucket, or similar container.
- Dispose of the waste in an appropriate manner.

2. Chemical Hygiene Plan: General

2.1 Background of the Plan

The “Laboratory Standard” refers to a set of regulations issued by the Occupational Safety and Health Administration (OSHA), designed to protect the health and safety of workers in laboratories. It is attached as *Appendix A*. One provision of the Laboratory Standard is the requirement for employers to create and implement a Chemical Hygiene Plan, in which specific safe practices for working in the laboratory are to be detailed. This Chemical Hygiene Plan spell out the day-to-day safe work practices needed to protect employees from chemical hazards. The plan must be reviewed and updated as needed (**at least annually**) to keep it current with site laboratory facilities and work procedures. The Chemical Hygiene Officer working with the Principal Investigator and the divisions’ Safety Committee will conduct the plan review.

2.2 Safety Commitment of the University

The University of Cincinnati is committed to the safety of its employees. No work conducted is so important as to justify injury to a worker. Safety is the joint responsibility of the University, the Principal Investigator and the individual worker. These responsibilities are detailed in Section 2.3.

The Office of Environmental Health and Safety is firmly committed to providing a safe and healthy work environment for each University employee.

2.3 Who is responsible for safety?

Responsibility for chemical hygiene and general laboratory safety resides at all levels: including:

a. Laboratory Workers

The laboratory worker has basic responsibility for looking after his/her own safety. These employees are the ones most likely to become affected by chemicals or biohazards, and are also the ones most able to control exposure to themselves and others to those hazards through the use of proper safety equipment and appropriate handling techniques. The laboratory worker is responsible for:

1. Working in a manner so as not to endanger herself/himself and fellow workers.
2. Following the requirements of this Chemical Hygiene Plan.

3. Informing coworkers and supervisor of any especially hazardous procedures or chemicals being used.
4. Wearing personal protective equipment as required by this Chemical Hygiene Plan or by the requirements specific to the particular laboratory (as determined by the Principal Investigator or the Office of Environmental Health and Safety).
5. Maintaining the work area in a clean, safe condition.
6. Completing all required safety training (Hazard Communication, Hazardous Waste, Bloodborne Pathogens, etc.)
7. Reporting all accidents/incidents, unsafe practices or unsafe conditions to the Laboratory Supervisor and/or Principal Investigator and if appropriate the Office of Environmental Health and Safety and/or the Chemical Hygiene Officer.
8. Reporting to the University Health Service's office (584-4457) for any injuries or upon showing signs of chemical or biohazard exposure. Reporting any injuries to the immediate supervisor as well.
9. Confronting any unsafe behavior on the part of coworkers that could injure themselves or others. Reporting to the supervisor any recurring unsafe behavior.
10. Ensuring that visitors are aware of hazards in the laboratory and wear safety glasses as required.

b. Laboratory Supervisors

Any person who directly supervises a person who works in the laboratory is considered to be a laboratory supervisor. These supervisors are familiar with the work being carried out in the laboratories and are expected to be familiar with the safety conditions present. The supervisors are expected to ensure that the supervised individuals comply with the provisions of the chemical hygiene plan, and to see that any safety deficiencies in the work environment are corrected. The supervisors have the following responsibilities:

1. Ensure that appropriate eye protection (safety glasses or goggles) are worn at all times in the laboratory and that laboratory coats and gloves are used as required by the policies in this Chemical Hygiene Plan.
2. Ensure good housekeeping is in order to maintain safe work areas and minimize exposure of workers to chemical dusts and vapors.

3. Ensure that safety equipment (fume hoods, etc.) is in good working condition.
4. Ensure that Facilities Management personnel test eyewash stations weekly.
5. Ensure Material Safety Data Sheets (MSDSs) and other reference sources on hazards, safe handling, and disposal of chemicals are available in the work areas.
6. Ensure that laboratory workers are familiar with the hazards associated with the chemicals that are in the operations and procedures. This may be done through the University's web based Chemical Tracking System, material safety data sheets or other sources of information or through group or individual training.
7. Ensure that the procedures regulating the transport, storage, use, and disposal of chemicals are followed.
8. Inform the Chemical Hygiene Officer, the Principal Investigator, and University Health Services of possible signs or symptoms of chemical exposure experienced by the individual, subordinates, or contract personnel.

c. Principal Investigator

Principal Investigators have the role of setting the tone for safety within their operations. The PI's are in the best position to encourage and enforce safe behavior in their people, and to ensure that unsafe conditions are corrected. They have the responsibility to:

1. Require that their personnel know and follow the policies and procedures in this Chemical Hygiene Plan and practice safe laboratory behavior.
2. Responsible for appointing a Chemical Hygiene Officer for the laboratory work area
3. Ensure that proper eye protection (safety glasses or goggles) are worn at all times in the laboratories, and that laboratory coats and gloves are used as required by the policies and procedures in this Chemical Hygiene Plan.
4. Require that all laboratory support personnel attend all appropriate safety training (Hazard Communication, Hazardous Waste, Bloodborne Pathogens, etc.)
5. Ensure that the physical facilities are adequate for the work being done.

6. Recognize and reinforce safe behavior in the workplace.
7. Review the results of the laboratory inspections and ensure that corrective actions are taken to improve laboratory safety conditions. Participate in formal and informal inspections of the work area.

d. Department Heads

Department Heads have the role of setting the tone for safety within their departments. They are in the best position to encourage and enforce safe behavior in their faculty and staff, and to ensure that unsafe conditions are corrected. They have the responsibility to:

1. Require that their faculty and staff know and follow the rules of their Chemical Hygiene Plan and practice safe laboratory behavior.
2. Ensure that proper eye protection (safety glasses or goggles) are worn at all times in the laboratories (see Section 8.1.e) and the lab coats and gloves are used as required by the policies and practices of the Chemical Hygiene plan.
3. Require that staff members attend all appropriate safety training.
4. Ensure that the physical facilities are adequate for the work being done.
5. Recognize and reinforce safe behavior in the workplace.
6. Review the results of the laboratory inspections and ensure that corrective actions are taken to improve lab safety conditions.

e. Chemical Hygiene Officer

The responsibility of the Chemical Hygiene Officer include:

1. Writing a Chemical Hygiene Plan and reviewing/revising it as necessary (annually as a minimum).
2. Working with management, the Office of Environmental Health and Safety to develop and implement appropriate chemical hygiene policies and practices. These will be incorporated into the Chemical Hygiene Plan.
3. Ensure that laboratory safety training is provided as needed, and that the results of such training are documented. Specialized training for certain groups will be determined in consultation with the Principal Investigator.

4. Organizing and leading a Division Safety Committee to identify safety issues and work on solutions.
5. Ensuring that the Division Safety Committee conducts laboratory inspections.
6. Providing safety technical support to resolve safety issues for members of the laboratory operations.
7. Investigating accidents and consulting with the affected employee and immediate supervisor to establish accidental prevention measures. Informing the department and the Office of Environmental Health and Safety (556-4968) of the accident and recommended prevention measures.

f. Office of Environmental Health & Safety

The responsibility of the Office of Environmental Health and Safety include:

1. Providing technical guidance to the research area on matters of laboratory safety.
2. Inspecting the laboratories to assure compliance with safety and health guidelines and regulations, and to assist with remediation of safety issues.
3. Investigating accidents in accordance with OSHA recordkeeping criteria and recommend action to reduce the potential for recurrence.
4. Coordinating clean-up operations in the event of a large chemical or biological spill or if a spill reaches the environment.
5. Developing and conducting training programs in laboratory safety.
6. Working with state and local officials on matters of codes and enforcement.
7. Assisting laboratory personnel with evaluating, preventing and controlling hazards
8. Overseeing the adoption and implementation of all University health and safety policies.
9. Maintaining training and audit documentation.

2.4 The Laboratory Facility

- a. **General Laboratory Ventilation.** A general ventilation system with air intakes and exhausts located to prevent exposure to contaminated air. The system must:
1. Provide a source of clean air for breathing and for input to the laboratory fume hoods.
 2. Not to be relied upon for protection from toxic substances released into the laboratory. The general laboratory ventilation system is not designed to protect workers from toxic, carcinogenic and/or flammable materials being used on the bench top. Primary control of toxic substances is afforded by use of localized exhaust devices (fume hoods, biological safety cabinets, etc.)
 3. Ensure that laboratory air is continually replaced. A minimum exchange rate of 8 to 12 room changes/hour is normally adequate ventilation if local exhaust systems such as fume hoods are used as the primary method of control.
 4. Prevent increase of concentrations to toxic substances during the working day.
 5. Direct air flow into the laboratory from non-laboratory areas and out to the exterior of the building.
 6. Be modified only by trained personnel. Following any alterations of the ventilation system, thorough testing must be done to ensure that worker protection from airborne toxic substances continues to be adequate.
 7. Ensure that general air flow is not turbulent and is relatively uniform throughout the laboratory, with no high velocity or static areas.
- b. **Laboratory fume hoods** are provided for working with chemicals. All laboratory fume hoods must be adjusted to provide 100 feet per minute (fpm) face velocity with an acceptable range of 80 to 120 fpm. Fume hoods must be tested as typically used to assure that no eddy currents are carrying chemicals into workers breathing zones. The University will perform inspection and certification of laboratory fume hoods annually. The Office of Environmental Health and Safety will maintain records of these inspections.

- c. **Biological safety cabinets (BSCs)** are provided in those laboratories that are currently working with biohazardous materials that may be infectious by inhalation. In general, biological safety cabinets are **NOT** designed for use with chemicals or radionuclides. The HEPA filters are **NOT** designed to “trap” chemical vapors. Therefore, cabinets that exhaust into the laboratory can discharge chemical vapors resulting in exposures to laboratory workers and others in the building. Airborne chemicals can also damage HEPA filters, gaskets, and the housing assemblies. In addition, Biosafety Cabinets are not designed with intrinsically-safe electrical components and flammable chemical vapors can result in a fire or explosion in contact with these ignition sources. Volatile organic solvents or volatile radionuclides may **NOT** be used in Class I or II Type A1 cabinets. Only minute quantities of these materials may be used in Class II Type B2 and Class II Type A2 biological safety cabinets and when canopy connected to the building exhaust system. An outside contractor will perform inspections and certification of these cabinets annually. The individual laboratories will maintain records of these inspections. Researchers should be trained in the use of a Biosafety Cabinet prior to working in one.
- d. **Other localized ventilation devices.** Ventilated storage cabinets and point source ventilation, such as vented balance cabinets, laboratory snorkels, etc. shall be provided as needed.
- e. **Fire extinguishers** shall be present in each laboratory and their locations marked in a highly visible manner. Access to them must **NOT** be blocked. The State of Ohio Building Code determines the number, size, type and location of the extinguishers. Questions on fire extinguishers should be directed to **Emergency Services Fire Prevention (64992)** or the Chemical Hygiene Officer. Inspections of the extinguishers will be done monthly by the Facilities Management Department. This event will be recorded on a tag on the extinguisher. If an extinguisher has been used, report this to Emergency Services Fire Department who will see that the unit is recharged.
- f. **Eye Wash Stations:** The locations will be marked in a highly visible manner and all laboratory personnel should know the location. Access to the eye wash stations must not be blocked and installed in accordance with ANSI Standard Z358.1-1998. Each week laboratory personnel should flush eyewash stations in the laboratory to ensure that the water flows clean and meets in a steady stream in the center and will record the event by initialing and dating a tag fastened to the eyewash. Semiannually an eyewash station test will be conducted by Facilities Management, which will also record the event by initialing and dating a tag fastened to the eyewash. If problems are found with the eyewash notify the Maintenance Department (556-6404/558-2500) at once to fix the unit.

- g.** **Safety Showers** will be located in the laboratories no further than 10 seconds from a work area. These areas must be clearly marked, and all laboratory personnel should know the location. Access to the emergency showers must not be blocked and installed in accordance with ANSI Standard Z358.1-1998. The safety showers are tested semiannually by the Facilities Management Department.

3. Chemical Safety Information and Training Program

3.1 Goal of the Program

To ensure that all individuals at potential risk of chemical exposure are adequately informed about the hazards of the work in the laboratory, how to avoid exposure to chemicals, and what to do if an accident occurs.

3.2 Information Sources

- **Chemical Hygiene Plan:** All members of the laboratory operations will be provided ready access to a copy of this Chemical Hygiene Plan and OSHA Laboratory Standard (included as appendix A).
- **Permissible Exposure Limits (PELs)** for certain chemicals as established by the OSHA Air Contaminants are found in Appendix B.
- **MSDSs:** Information on the chemical hazards of individual chemicals is available from Material Safety Data Sheets
- **The University Library** has many books about chemical hazards and working safely with chemicals, including Merck Index, CRC Handbook of Laboratory Safety, and Hazards in the Chemical Laboratory.
- **Via the ChemSW Web Based Chemical Tracking System:** Information on the chemical hazards of individual chemicals is available online through the ChemWatch Collection.
- **Via your computer** are electronic versions of some information sources, such as the *Merck Index*, *Kirk-Othmer Encyclopedia of Chemical Technology and Toxnet*. Other excellent sources of information can be obtained through RTECS, NIOSH, and the National Toxicology Program Chemical Health and Safety database of over 2000 chemicals.
- **The Office of Environmental Health and Safety** has additional information on chemical and laboratory safety in the form of other books and videos available as information sources and for training purposes. Including on-line Advanced Laboratory Safety Training at <http://www.ehs.uc.edu/itc/labsafety.asp>.

3.3 Material Safety Data Sheets (MSDSs) for UC-Synthesized Research Samples

Chemicals that are synthesized in the laboratory and are sent off site are required to have MSDS sent with the chemicals. Provide all known chemical, physical, and toxicological data.

3.4 Material Safety Data Sheets for Purchased Chemicals

a. What to do if you receive an MSDS

Laboratory workers receiving an MSDS with their purchased chemical should make a copy and keep it for use in their laboratory. Send the original to the Chemical Hygiene Officer who will file the MSDS in the laboratory.

b. Where to obtain an MSDS

Material Safety Data Sheets may be obtained from several sources. The quality and quantity of information may vary from one source to another, and it may be useful to obtain an MSDS for a compound from more than one source.

1. MSDS databases on the computer

There is UC-Environmental Health & Safety internet page entitled MSDS that provides links to 1 internal and 2 external databases of MSDSs and other chemical information.

2. ChemWatch MSDS Collection database on the University's ChemSW Chemical Tracking System

There are over 1 million MSDSs available here, although many of them are for minor differences of the same chemical.

3. The Supplier

You may also call the product supplier or manufacturer of the chemical to request an MSDS. The product supplier or manufacturer is legally required to provide MSDSs upon request.

3.5 Chemical Hazard Training

All employees who might be exposed to chemicals will be trained on the associated hazards of these chemicals and how to protect themselves from these hazards through safe work practices and proper use of protective equipment. This training includes recognizing the signs/symptoms of exposure to chemicals. Labeling practices and the use of Material Safety Data Sheets will be incorporated into the training. The Chemical Hygiene officer and members of the Safety Committee will conduct this operation specific training, with assistance from laboratory supervisors as needed. In addition, the Office of Environmental Health and Safety has developed *Advanced Laboratory Safety Training*. The program resides on the Internet and is accessed from Environmental Health and Safety Home page <http://www.ehs.uc.edu/itc/labsafety.asp>. The On-line training program includes:

- Cell and Tissue Culture
- Autoclave Safety
- Ethylene Oxide
- Peroxide Forming Chemicals
- Gluteraldehyde
- And Others

- a. Safe Work Practices Training**
Training will be provided to employees on how to work with chemicals in their laboratories. This will include general laboratory safety training such as proper use of laboratory fume hoods and personal protective equipment, and also training in safe operating procedures specific to individual laboratories. The Chemical Hygiene Officer and members of the Safety Committee will conduct the training, with assistance from laboratory supervisors as needed.
- b. Training for Emergencies**
Training will be given to inform employees of correct procedures to follow in emergency situations. This will include the proper procedures to follow in event of a tornado alert or a general evacuation because of fire or other emergencies. Training will be provided on fire safety and how to use a fire extinguisher, as well as how to handle chemical spills.
- c. New-employee Training**
All new or transferred employees will receive safety training relevant to their needs and the work they will be performing. Training for emergencies will be included. The Chemical Hygiene Officer will conduct the training.
- d. Student Employees Training**
It must be assumed that student employees have had little or no prior safety training. They must receive the same training as new hires, *before they begin and work in a laboratory*. The Chemical Hygiene Officer will provide the training.
- e. Contract Employees Training**
Temporary help and other contract employees who are under daily supervision by UC staff will receive safety orientation training from the University. The contract company will train contract workers that are supervised by the contract company supervisor.
- f. Frequency of Training**
Laboratory safety training is a regular, on-going activity, not merely an annual presentation. As safety issues are identified that require training, training will be provided.
- g. Documentation of Training**
Attendance at safety training classes must be documented. The Chemical Hygiene Officer will maintain the training records.

4. Medical Consultations and Examinations

4.1 Who is Eligible?

Employees who work with hazardous chemicals will have the opportunity to receive a medical examination from University Health Services, and any follow-up examinations under any of the following circumstances:

1. Whenever an employee develops signs or symptoms possibly associated with a hazardous chemical to which the employee may have been exposed.
2. Where exposure monitoring reveals an exposure level routinely above the action level or the Permissible Exposure Limit (PEL) for an OSHA regulated substance. See Appendix B for a list of OSHA PELs. See Section 5 for monitoring of chemical exposures.
3. Whenever an event occurs, such as a leak, spill, or explosion, which results in the likelihood that the employee may have been exposed to a hazardous substance, the employee will have the opportunity for a consultation to determine if an examination is needed.

All medical examinations and consultations shall be performed by University Health Services and shall be provided without cost to the employee, without loss of pay, and at a reasonable time and place.

Any individual who believes he/she may have been exposed to a hazardous substance should notify his/her supervisor immediately and also contact the Office of Environmental Health and Safety (556-4968). Anyone who experiences any adverse health effects or symptoms from exposure to chemicals should immediately report to the University Health Services or the closest emergency department if adverse health effects occur when University Health Services is not open.

4.2 Information Provided by University Health Services to an External Treatment Provider

1. The identity of the hazardous chemical(s) to which employee may have been exposed. An MSDS of the chemical(s) upon request.
2. A description of the conditions under which the exposure occurred, including quantitative exposure data, if available.
3. A description of the signs and symptoms of exposure the employee is experiencing, if any.

4.3 Information University Health Services Receives from an External Treatment Provider

University Health Services will obtain in a timely manner from the examining physician a written statement that will include the following:

1. Any recommendation for further medical follow-up
2. The results of the examination and any associated tests.
3. Any medical condition revealed in the course of the examination that may place the employee at increased risk as a result of exposure to a hazardous chemical found in the workplace. Such a medical condition is not limited to ones that may have resulted from a chemical exposure,
4. A statement that the employee has been informed of the results of the consultation or medical examination and of any medical condition that may require further examination or treatment.

4.4 Access to Medical Records

Employees have the legal right to access their medical records. Contact University Health Services at 584-4457 to obtain a copy of the records with a record release. The records for contractors are maintained by their agency, and they should contact that agency to access their medical records.

5. Monitoring for Exposures

5.1 Monitoring for Chemical Exposures

a. Initial Monitoring

If you have reason to believe that you are being exposed (or could be exposed) to a hazardous chemical, report this to the Office of Environmental Health and Safety (556-4968) who will determine whether measurement of the air level for the substance is needed. Some chemicals have permissible exposure levels (PELs) set by OSHA, and monitoring may be done to determine whether exposure is above those limits. In certain cases monitoring may be appropriate even though a PEL is not designated for a chemical. In such cases other guidelines to exposure, such as NIOSH or ACGIH recommended exposure limits may be available.

b. Periodic Monitoring

If the initial monitoring shows employee exposure over the action level or the PEL for a chemical, then follow-up monitoring will be immediately begun as required by the regulations for that particular chemical agent. Remedial actions will be taken to lower the concentrations below the PEL or action level. Termination of monitoring may be done only in compliance with the appropriate regulations.

c. Monitoring Results

The results of this monitoring shall be distributed to employees working in the affected area, in writing, within 15 days after the results are obtained. The results will either be given to individual workers or posted in an appropriate location readily accessible to the workers.

5.2 Monitoring for Exposure to Physical Agents

a. Initial Monitoring

If any employee has a concern regarding exposure to physical agents (noise, heat, cold, non-ionizing radiation) this must be reported to the Office Environmental Health and Safety. A qualitative assessment will be done to determine if quantitative measurements must be taken.

b. Periodic Monitoring

If the initial monitoring shows employee exposure above acceptable exposure limits for the physical agent, then follow-up monitoring will be immediately begun as required by the regulations for that agent. Remedial actions will be taken to bring the exposure to an acceptable level. Termination of monitoring may be done only in compliance with the appropriate regulations.

c. Monitoring Results

The results of this monitoring shall be distributed to employees working in the affected area, in the affected area, in writing, within 15 days after the results are obtained. The results will either be given to individual workers or posted in an appropriate location readily accessible to the workers.

6. Hazard Warnings

6.1 Signs Warning of Dangers are Required

Prominent signs should be posted to warn of equipment or areas that present special or unusual hazards. Contact the Chemical Hygiene Officer or the appropriate safety offices (Biosafety, Environmental Health and Safety or Radiation Safety) to obtain signs for laboratories using radioactive materials, biohazards, or other hazardous materials. Areas using lasers, X-ray sources or OSHA regulated carcinogens (such as formaldehyde or ethylene oxide) must be posted within the laboratory where the hazard exists or on the laboratory door, as appropriate.

6.2 Labeling of Chemical Containers

Secondary containers (flasks, bottles, beakers, Petri dishes, etc.) must be labeled with the identity of the contents.

Examples of chemical containers that must be labeled are:

- Flasks, beakers, Petri dishes, or bottles containing chemicals or biological (solids or solutions)
- Compounds synthesized in the laboratory
- Biological media
- Samples submitted to analytical laboratories
- Chemical reactions
- Commercial chemicals and solvents in original bottles:
(Note: Do not remove or deface or cover any hazard warning label on any commercial chemical container while the original contents are still in it.)

Chemical containers must be labeled so that others can identify the contents. Labels must contain:

1. The chemical identity.
 - a) A laboratory notebook reference is required if the sample or solution is identified in a laboratory notebook, or for reactions which are written up in a notebook.
 - b) Chemical names or structures may optionally be added if a laboratory notebook reference is used.
 - c) Chemical names and/or structures must be used if a laboratory notebook reference is not used. (examples: 10% NaOH in water; 25% methanol in water)

2. The owner's identity (name or initials) if the container is in an area shared with other workers (such as common laboratory bench, storage cabinet, or refrigerator).
3. Additionally, if a chemical container is being shared with or used by other researchers, than any known hazards must also be identified on the label. Examples of such containers would be shared HPLC solvent mixtures, or samples sent out for analysis. The hazard warning may be in the form of hazard code numbers on an appropriate label or written out (e.g., caustic, flammable, carcinogen). Hazards to be considered are:
 - a. Health
 - b. Flammability
 - c. Reactivity
4. Collections of small vials of similar chemical samples with similar hazardous properties may have the hazard warning label on the box of samples or on a sheet of paper associated with the samples, rather than on each individual vial

6.3 Hazard Classification Systems used in Labeling

a. General

The researcher and staff are likely to encounter two hazard classification systems in their work with chemicals at the University of Cincinnati. The National Fire Protection Association and the HHMI hazard classification system. Some commercial chemical suppliers in labeling the containers use the NFPA system. Both system are used by

b. National Fire Protection Association (NFPA) Hazard Classification System

The NFPA 704M labeling system shows at a glance the type and degree of a chemical hazard. The labeling system is concerned with the health, flammability, reactivity, and other related hazards of chemicals as they behave in a fire situation. The labeling system is used on some chemical containers, but is most often found at entrances to laboratories and chemical storage areas. The labels are spatially arranged on a label in a diamond shape, with a different color used for each category. Health hazards are indicated in a blue field, fire hazards in red, and reactivity hazards in yellow. The fourth field in the diamond is white and gives special information, such as water or oxidizer incompatibility. In each field, the degree of the hazard is indicated by a number between 0 and 4, with 4 indicating the greatest hazard and 0 indicating no significant hazard. Below is a schematic.

**F-Flammability Hazard (Red)**

- 4 Very flammable gases or very volatile flammable liquids.
- 3 Can be ignited at all normal temperatures.
- 2 Ignites if moderately heated.
- 1 Ignites after considerable preheating.
- 0 Will not burn.

H-Health Hazard (Blue)

- 4 Can cause death or major injury despite medical treatment.
- 3 Can cause serious injury despite medical treatment.
- 2 Can cause injury. Requires prompt treatment.
- 1 Can cause irritation if not treated.
- 0 No hazard.

R-Reactivity (Stability) Hazard (Yellow)

- 4 Readily detonates or explodes.
- 3 Can detonate or explode but requires strong initiating force or heating under confinement.
- 2 Normally unstable but will not detonate.
- 1 Normally stable. Unstable at high temperature and pressure. Reacts with water.
- 0 Normally stable. Not reactive with water.

S/N Special Notice Key (White)

W- water reactive	ACID- acid	COR- corrosive
OX- oxidizing agent	ALK- alkali	RAD-radioactive

c. University of Cincinnati System

The University of Cincinnati labeling system is concerned with health, flammability, and reactivity hazards of chemicals. Numerical ratings, from 0 to 4, are

used to denote the degree of hazard severity. The rating descriptors for flammability and reactivity are identical in the UC and NFPA systems. The descriptors for health, however, are somewhat different: Both short-term and long-term exposures are considered in the UC system, whereas that distinction is not spelled out in the NFPA system. Below are the health descriptors in the UC hazard

7. Personal Protective Equipment

The following personal protective equipment must be available for laboratory personnel who are working with hazardous materials. The Principal Investigator/Researcher will supply personal protective equipment to all employees as needed. However, the Office of Environmental Health and Safety at 556-4968 will assist with recommendations on specific types and uses of protective equipment.

7.1 Safety Glasses

Either safety glasses with side shield, or goggles, must be worn at all times by all workers and visitors in the laboratories. Both prescription and non-prescription safety glasses must meet the ANSI Z87.1 standard and must have side shields. Ordinary prescription glasses do not provide adequate protection. Prescription safety glasses may be obtained through an outside vendor.

7.2 Goggles

Goggles should be worn when carrying out operations in which there is an increased danger from splashing chemicals or flying particles, as they provide better protection than safety glasses.

7.3 Face Shields

Face shields that protect the face and throat should be worn when maximum protection from flying particles and harmful liquids is needed. This is especially desirable when handling caustic or corrosive solutions and the possibility of chemical splashes exists. **Safety glasses or goggles must be worn under a face shield, as a face shield is not considered eye protection.**

7.4 Laboratory coats

Laboratory coats and shoes (**open toed shoes, sandals, flip-flops, etc. are prohibited**) must be worn during work with any chemicals or biologicals. The Laboratory coats must be buttoned to ensure adequate protection. Do not wear laboratory coats into the office areas. Laboratory coats may **NOT** be worn outside of the laboratories. The exception is if the researcher is transporting chemicals or biologicals to another laboratory. In that case, be sure the coat is clean! Clean the coats frequently through a laundry service. Disposable laboratory coats may be required in certain biology laboratories, as determined by the laboratory supervisor or Principal Investigator. Impervious plastic aprons and sleeves (to be worn over the laboratory coats) are available to provide additional protection against liquids.

Some laboratories may be free of hazards as to not require the wearing of laboratory coats. This determination must be done by the Principal Investigator, laboratory supervisor and must be documented in writing and posted in the laboratory.

7.5 Gloves

Protective gloves that are appropriate for specific laboratory uses from safety supply houses. Do not wear latex gloves when working with formaldehyde solutions, liquid organic chemicals or solutions of organic chemicals, as latex gloves do not provide adequate protection against these substances. When using chemicals, consult chemical compatibility information that is provided in manufacturer's catalogs to help select the proper gloves and other protective clothing. More information on specific types and uses of personal protective apparel is available from the Office of Environmental Health and Safety at 556-4968.

Nitrile gloves are good for most chemical operations. The thin disposable nitrile gloves (for example the light blue N-Dex gloves or the purple MicroGrip gloves) offer adequate protection against most solvents and chemicals for brief exposures, such as intermittent splashes. When wearing these gloves blot them dry when a splash occurs.

To determine the appropriate glove for use with a particular chemical(s), consult the glove guides that are posted by NIOSH. If you need help in selecting the proper glove for your particular needs, contact the Chemical Hygiene Officer or Environmental Health and Safety at 556-4968.

Avoid rubbing your eyes or touching your face or skin when wearing gloves.

In order to prevent the spread of hazardous substances, always remove gloves before leaving the laboratory. Do not wear gloves when handling telephones, doorknobs, or keyboards in the laboratory. Gloves may not be worn outside of the laboratories. The exception is if you are transporting chemicals or biologicals to another laboratory and you feel that you need gloves for protection. In that case, be sure the gloves are clean!

7.6 Respirators

It is best to control respiratory hazards at the point of generation by using engineering controls (hoods and other local ventilation devices) and good work practices. In keeping with this goal, the use of respirators should be necessary only in certain situations, such as short-term temporary experiments where engineering controls are not feasible, and situations, in which respirators provide supplemental control. The use of respirators is strictly regulated by OSHA standards. Before anyone can wear a respirator, that person must receive medical clearance and undergo fit testing and training. If you think you need of a respirator, contact the Chemical Hygiene Officer. If it is determined that you should wear a respirator, you will have to get medical approval through University Health Services and also undergo fit testing and training prior to wearing a respirator. Annual retraining and fit testing are required. Respirators are assigned to individuals for their

exclusive use. The Chemical Hygiene Officer must have a copy of the written Respiratory Protection Program that is available upon request.

8. Working Safely with Chemicals

8.1 General Rules and Procedures for Working in a Laboratory

a. Working Alone in the Laboratory

Student interns are never to work alone in the laboratories. It is recommended that other researchers working alone outside of normal working hours (7 AM to 6 PM, Monday through Friday) should confine their activities to relatively non-hazardous operations. Do not perform operations that involve:

1. High energy materials (e.g., explosives, pyrophorics)
2. Highly toxic chemicals
3. High Pressure systems
4. Cryogenic liquids
5. Working with unprotected (exposed) high-voltage electrical systems
6. Handling or transferring large quantities of flammable liquids
7. Any non-routine job function

Discuss the dangers and discuss the operations

b. Laboratory Coats

Laboratory Coats must be worn when working with any chemicals or biological agents. They must be buttoned to ensure adequate protection. Do not wear laboratory coats into the office areas of the building. Laboratory coats may not be worn outside of the Laboratories. The exception is if you are transporting chemicals or biological agents to another laboratory and it is necessary to have a coat for protection. In that case, be sure that it is clean! Clean the coats frequently through a laundry service. Disposable laboratory coats may be required in certain biology laboratories, as determined by the laboratory supervisor or the Principal Investigator. Impervious aprons and sleeves (to be worn over the laboratory coats) provide additional protection against liquids.

c. No Food or Drinks in the Laboratories, No Chemicals in Offices!

Absolutely no food or drinks are allowed in laboratories. Chemicals should **NOT** be brought into offices, except for situations where it is necessary to transport chemicals through an office area. In this case use the precautions noted below. If it necessary to deliver a chemical to another researcher, deliver it to that person's laboratory and inform the researcher that the material has been delivered.

- d. **Gloves must be worn when working with hazardous chemicals or hazardous biologicals.**
See section 7.5 for a discussion of different types of gloves and what to use them for.
- e. **Eye Protection – Goggles, Safety Glasses, Face Shields**
Either safety glasses with side shields, or goggles, must be worn at all times by all workers and visitors in the laboratories. Safety glasses must be available for use by visitors. It is the responsibility of the laboratory occupants to ensure that such eye protection is available and used. **While safety glasses with side shields provide some protection against flying particles, they offer only limited protection against splashed liquids. Goggles are the eye protection of choice when working with liquids where the possibility of splash exists.**
Some laboratories may be so free of hazards as to not require the wearing of safety glasses. This determination must be made by the Principal Investigator and the laboratory supervisor and must be documented in writing and posted in the laboratory.

Contact Lenses: If chemicals get in your eyes, make sure that the contacts are washed out of your eyes during the washing process! Contact lens wearers must also wear safety glasses or goggles.

GOGGLES MUST BE WORN when:

1. Working with EXPLOSIVES (diazomethane, acryl azides, picric acid, peroxides, etc.)
2. Working with pressurized reactions (including hydrogenations)
3. Working with materials that can damage your eyes. These materials include:
 - a. Liquid pyrophorics (butyl lithium, ethyl aluminum, etc.)
 - b. Solid pyrophorics (sodium, potassium, sodium hydride, etc.)
 - c. Chemicals that react violently with water (thionyl chloride, chlorosulfonic acid, titanium tetrachloride, etc.)
 - d. Highly reactive or corrosive liquids (Sodium Hydroxide or Hydrochloric Acid less than or equal to 0.01 molar, solutions of bromine or iodine, acid chlorides, hydrogen peroxide, etc.)
 - e. Pouring greater than 1 liter of hot liquids (hotter than 65 C.)
 - f. Transferring greater than 100 milliliters of liquid nitrogen or helium.
 - g. Pouring solvents or waste solutions of greater than 4 Liters.

Note: If you work in a fume hood with these materials and keep the sash pulled down with the windows closed so that your eyes are protected by the sash, there may not be a need to wear goggles. YOU must assess the situation to determine whether there is a chance of these materials entering your eyes. If there is, you must wear goggles.

Note also: For the best eye and face protection, wear both goggles and a face shield. Face shields are **NOT** considered eye protection, and goggles or safety glasses must be worn also.

- f. **Personal Clothing Warnings:** Do **NOT** wear sandals, open-toed shoes, or perforated shoes in the laboratory. Confine long hair and loose clothing to avoid entanglement in equipment and contamination with chemicals.
- g. **Never use mouth suction for pipetting or to start a siphon.** Use a pipette bulb or vacuum hose instead.
- h. **Housekeeping:** keep the work area clean and uncluttered, with chemicals properly labeled and stored. Make sure the floors are clean and uncluttered. If the floor is in need of cleaning contact maintenance at 66404/82500. Refrigerators should be cleaned periodically and not allowed to become overcrowded.
- i. **Horseplay and practical jokes** are unsafe and are not appropriate for the laboratory.
- j. **Vent pump exhausts into hoods** if pumps are being used with volatile hazardous chemicals.
- k. **Gas cylinders must be securely fastened** to walls or benches with chains. While belts may be used additionally, chains are required in order to provide security in case of fire. Cylinders not in use must have the protective cap in place.
- l. **Transport of Gas Cylinders:** Transport must be done only using carts designed for that purpose, with the cylinder chained to the cart. The protective cap must be in place while transporting the cylinder, and before loosening the cylinder from the wall/bench and moving it onto the cart. At
- m. **Correct all unsafe conditions** when they are detected. Call Facilities Management to get things fixed.
- n. **Correct all unsafe behaviors.** If coworkers are working in an unsafe manner, bring it to their attention. It may be appropriate to contact their supervisor or the Chemical Hygiene Officer about the situation. This must be done if their behavior or work habits endanger the safety of others.

8.2 General Principles for Working with Chemicals

- a. Know the Hazards Involved! A cardinal rule of laboratory research is that workers must determine the potential hazards associated with an experiment before beginning it. **Before working with any chemical, it is the responsibility of the researcher to determine what physical and health hazards are associated with the substance.** This determination may require consulting library references and material safety data sheets and could involve discussions with the Principal Investigator and/or the Chemical Hygiene Officer. It may be beneficial to conduct a job hazard analysis, where you:
 1. Identify the steps involved in the work procedure.
 2. Identify the hazards associated with each step.
 3. Identify corrective actions to be taken to reduce/eliminate those hazards.Contact the Office of Environmental Health and Safety for help with this process.
- b. Minimize all chemical exposure. Since few chemicals are without hazard, it is important to minimize all exposure. Eye and skin contact and breathing gases, vapors or dusts should be avoided. All work with chemicals should be avoided. **All work with chemicals should be done in a fume hood or vented cabinet whenever possible.**
- c. **Do not underestimate the risk of a chemical.** Mixtures may be more toxic than any one of their components. Solutions may be more rapidly absorbed through the skin than the pure chemical. All new compounds and substances of unknown toxicity should be treated as hazardous substances.
- d. **Wear gloves when working with hazardous chemicals or hazardous biological agents.**
- e. **Neither taste nor smell chemicals.**
- f. **Wash your hands with soap and water immediately after working with hazardous chemicals.**
- g. **Use ventilation controls.** The use of hoods, vented balance enclosures, and other ventilation devices which are ventilated to the outside of the building is the best way to prevent exposure to airborne substances in the work place.
- h. **Choose or substitute chemicals with reduced hazards** for use in laboratory operations whenever possible.

- i. **Purchase only the quantity of chemical required.** Storage and disposal of excess chemicals is expensive and poses safety hazards.
- j. **Do not exceed Permissible Exposure Limits or Threshold Limit Values.** The Permissible Exposure Limits (PELs) of OSHA and the Threshold Limit Values (TLVs) of the American Conference of Governmental Industrial Hygienists should not be exceeded. These values are usually available on Material Safety Data Sheets (MSDS) or may be obtained from the Chemical Hygiene Officer. Contact the Chemical Hygiene Officer or Environmental Health and Safety to arrange for monitoring of exposure levels if you have any reason to believe the PEL or TLV of a hazardous substance is being exceeded, or if you smell the odor of chemicals in your work area.
- k. **Be prepared for accidents** Before beginning an experiment, know what specific action you will take in the event of an accidental release of a hazardous substance. Know the location and proper use of all safety equipment, including fire extinguishers, eyewashes, safety showers, and spill control materials. Have an emergency phone number sticker (911) on all phones.
- l. **Transporting Chemicals:** All chemicals and solvents must be tightly sealed and carried in either the original shipping container (box) or in a secondary container such as rubber or plastic bucket (with handle) when being moved from a stockroom to laboratory or between laboratories. A sturdy cart may be used as long as the shelves have lips to prevent items from sliding off. Even when a cart is used, breakable containers must still be placed in a secondary container such as a bucket or the original shipping container or shaped Styrofoam blocks. Ziplock bags are appropriate secondary containment for small items such as vials and nmr tubes. As much as possible, avoid crossing office areas when transporting chemicals.
- m. **Plastic coated solvent bottles are required.** All solvents, except for water and DMSO, that are purchased in plastic coated bottles whenever technically feasible. That is, whenever the required solvent purity/grade is available for purchase in plastic coated bottles.
- n. **Pyrophorics.** Before working with any pyrophorics, read the Safe Practice. Note – need a reference
- o. **Pressure Reactions.** Before running any reaction under pressure, or any sealed reaction, read the “Safe Reactions”
- p. **Radioactive materials.** Special procedures and regulations are in effect for working with radioactive materials. If you have questions on this

subject or a need to work with radioactive materials, contact the **Radiation Safety Office (558-4110)**.

- q. **Follow this chemical hygiene plan**, a mandatory program designed to minimize exposure to hazardous substances.

8.3 Safe Use of a Laboratory Fume Hood

- a. **Ensure that the airflow is sufficient for safe operation** prior to working with hazardous chemicals in the hood. Do not use the hood if the airflow monitor indicates low flow (red light and/or audible alarm). If you have any reason to believe the airflow is insufficient call Facilities Management to get it fixed. If the fume hood does not have a certification label less than one year old contact the Chemical Hygiene Officer or the Office of Environmental Health and Safety.
- b. **Keep the laboratory fume hood free of clutter.** Excessive clutter inhibits the airflow. Only materials actively in use should be in the fume hood. Do not block the vents in the back of the hood.
- c. **Keep the hood clean.** Clean up all chemical spills promptly.
- d. **Elevate large items to avoid restricting airflow.** Large items that restrict air flow should be raised off the fume hood floor by means of a platform or laboratory jack in such a manner as to allow air flow underneath the equipment.
- e. **Always work with hazardous chemicals at least six inches behind the sash.** Working closer than that to the front of the hood increases the risk of chemical dust and vapors coming out at you due to turbulence. Keep the first six inches free of all open chemicals, including dirty spatulas. Keep the area free of anything larger than a pint-sized bottle, to reduce the amount of turbulence near the front of the fume hood. Keep the fume hood apron (the metal platform under the sash) clean and free of all items.
- f. **Never put your head into the laboratory fume hood** to check an experiment. The plane of the sash is the barrier between contaminated and uncontaminated air.
- g. **Work with the laboratory fume hood sash in the lowest practical position.** You are less likely to be exposed to chemicals due to turbulence, and the sash will act as a barrier in case of an explosion. Keep the sash panels closed when not working in the hood.

9. Working Safely with Particularly Hazardous Substances

9.1 Particularly Hazardous Substances: What are they?

Some substances are so highly hazardous as to require further regulations in addition to the general guidelines for working with chemicals that are listed in Section 8. These particularly hazardous materials include allergens (sensitizers), compounds with high acute toxicity, reproductive toxins (abortifacients and teratogens), and carcinogens. Some of these are listed in the sections below.

a. Allergens (Sensitizers)

An allergen (sensitizer) is a substance that causes a person to develop an allergic reaction after repeated exposure to the substance. Examples of natural allergens are poison ivy and bee stings. The allergic reaction may range from a mild rash to anaphylactic shock, depending on the substance, the exposure and the individual. Examples of allergens include:

benzoyl peroxide	formaldehyde
diazomethane	isocyanates
dicyclohexylcarbodiimide (DCC)	penicillins
chromium salts	arylhydrazines
nickel salts	benzylic and allylic halides
enzymes	

b. Compounds with High Acute Toxicity

Compounds that have a high degree of acute toxicity comprise a second category of particularly hazardous substances as defined by the OSHA Lab Standard. These chemicals may cause toxic manifestations after only a single short exposure to small quantities of the compound. Some such compounds are:

acrolein	1,2-dibromoethane	nickel carbonyl
acrylic acid	dimethyl sulfate	nicotine
acrylonitrile	ethylene oxide	nitrogen dioxide
allyl alcohol	hydrazine	osmium tetroxide
allyl amine	hydrogen cyanide	ozone
bromine	hydrogen fluoride	phosgene
chlorine	hydrogen sulfide	sodium azide
diazomethane	methyl fluorosulfonate	sodium cyanide
diborane (gas)	methyl iodide	

The above is only a very limited list of compounds exhibiting high acute toxicity. It is the responsibility of the researcher (in consultation with the lab supervisor) to evaluate compounds being worked with and to determine whether they are substances with a high degree of acute toxicity. If so, then the procedures in Section 9.2 must be followed. In some cases, however, as

when very small quantities or the material are being used, it may not be necessary to implement all of those procedures.

c. Reproductive Toxins

Reproductive toxins act during pregnancy and may cause effects such as embryo lethality (death of the fertilized egg or fetus) or teratogenic effects (malformations of the fetus). They can also act on the reproductive systems of males or females causing sterility, reduced fertility, etc. Examples of embryo toxins include thalidomide and tetracycline. Embryo toxins can affect the fetus at anytime during its development but often have caused damage during the first trimester, the period when many organs and systems are developing. Because a woman may not know that she is pregnant during some or all of this period caution is advised. Reproductive toxins that may result in an adverse response to the male reproductive system (damaged sperm or testicular damage) include heavy metals (lead, cadmium, nickel and methyl mercury), glycol ethers, halogenated pesticides, and chemotherapy agents. As minimal precautions, the procedures in Sections 8 and 9.2 should be followed for work with such compounds. The compounds below are highly suspected to be reproductive toxins.

acrylic acid	hexachlorobenzene
aniline	iodoacetic acid
benzene	lead compounds
cadmium	mercury compounds
carbon disulfide	nitrobenzene
N,N-dimethylacetamide	nitrous oxide
dimethylformamide (DMF)	phenol
dimethylsulfoxide (DMSO)	polychlorinated and polybrominated phenols
diphenylamine	prostaglandin E2
estradiol	toluene
formaldehyde	vinyl chloride
formamide	xylene
2-ethoxyethyl acetate	

The above list is not intended to be complete, and it is the responsibility of the researcher (in consultation with the laboratory supervisor and/or the Chemical Hygiene Officer) to evaluate each compound he/she works with to determine whether it should be handled as a reproductive toxin. MSD sheets (see Section 3.4) and the sources of information listed in Section 3.2 should help provide this knowledge.

d. Carcinogens

Carcinogens are compounds that have varying levels of evidence for their potential to cause cancer in animals or humans. The following tables of carcinogens come from the Tenth Report on Carcinogens (2002), which was created by the National Toxicology Program within the U.S. Dept. of Health and Human Services of NIH.

The Tenth Report on Carcinogens may be found on the Internet at:

<http://ehis.niehs.nih.gov/roc>

Further details on the listed carcinogens may be obtained at that site.

d.1 Known Human Carcinogens

Names and Synonyms of Carcinogens. This list includes agents, substances, mixtures, and medical treatments that are known to be carcinogenic in humans.

Aflatoxins	Ethylene Oxide
4-Aminobiphenyl (4-Aminodiphenyl)	MeCCNU [See 1-(2-Chloroethyl)-(4-methylhexyl)-nitrosourea]
2-Aminonaphthalene (2-Naphthylamine)	
Analgesic Mixtures Containing Phenacetin	Melphalan
Arsenic compounds, Inorganic	Methoxsalen with UV A therapy
Asbestos	Mineral Oils
Azathioprine	Mustard Gas
Benzene	Myleran(r) (1,4-Butanediol Dimethylsulfonate)
Benzidine	2-Naphthylamine (b-Naphthyllamine; 2-Aminonaphthalene)
Beryllium and beryllium compounds	Nickel compounds
Bis(chloromethyl) Ether	Radon
Busulfan (1,4-Butanediol Dimethylsulfonate)	Silica, crystalline (Respirable Size)
1,3-Butadiene	- cristobalite
1,4-Butanediol Dimethylsulfonate (Myleran(r); Busulfan)	- quartz
Cadmium and cadmium compounds	- tridymite
Chlorambucil	Smokeless tobacco
1-(2Chloroethyl)-(4-methylcyclohexyl)- nitrosourea (MeCCNU)	Solar Radiation and Exposure to Sunlamps
Chloromethyl Methyl Ether	Soots
Chromium Hexavalent compounds	Strong Inorganic Acid Mists containing Sulfuric Acid
Coal Tar	Tamoxifen
Coke Oven emissions	2,3,7,8-Tetrachlorogibenzo-p-dioxin (Dioxin)
Cyclophosphamide	Thiotepa
Cyclosporin A(Cyclosporine A; Ciclosporin)	Thorium Dioxide
Diethylstilbestrol	Tobacco smoke
Dioxin (2,3,7,8-Tetrachlorogibenzo-p-dioxin)	Tris(1-aziridinyl)phosphine Sulfide (Thiotepa)
Dyes that Metabolize to Benzidine	Vinyl Chloride
Erionite	Ultraviolet radiation
Estrogens, steroidal	Wood dust

d.2 Compounds Reasonably Anticipated To Be Human Carcinogens

Names and Synonyms of Carcinogens. The list includes agents, substances, and mixtures that have been shown to cause cancer or tumors in animals, and therefore are reasonably anticipated to be human carcinogens.

Acetaldehyde	Cupferron
2-Acetylaminofluorene	Dacarbazine
Acrylamide	Danthron [1,8-Dihydroxyanthraquinone]
Acrylonitrile	DDT [Dichlorodiphenyltrichloroethane]
Adriamycin® [Doxorubicin hydrochloride]	2,4-Diaminoanisole Sulfate

2-Aminoanthraquinone	Diaminodiphenyl Ether [4,4-Oxydianiline]
<i>o</i> -Aminoanthraquinone	2,3-Diaminotoluene
1-Amino-2-methylantraquinone	Dibenz[a,h]acridine
2-Amino-3-methylimidazo[4,5-f]quinolone	Dibenz[a,j]acridine
Amitrole	Dibenz[a,h]anthracene
<i>o</i> -Anisidine Hydrochloride	7H-Dibenzo[c,g]carbazole
Azacitidine [5-Azacytidine]	Dibenzo[a,e]pyrene
Benz[a]anthracene	Dibenzo[a,h]pyrene
Benzo[b]fluoranthene	Dibenzo[a,i]pyrene
Benzo[j]fluoranthene	Dibenzo[a,l]pyrene
Benzo[k]fluoranthene	1,2-Dibromo-3-chloropropane
Benzo[a]pyrene	1,2-Dibromoethane [Ethylene dibromide]
Benzotrichloride	2,3-Dibromo-1-propanol
bis(Chloroethyl)nitrosourea	tris(2,3-Dibromopropyl) Phosphate
Bromodichloromethane	1,4-Dichlorobenzene [p-Dichlorobenzene]
2,2-bis-(Bromoethyl)-1,3-propanediol	3,3'-Dichlorobenzidine
Butylated Hydroxyanisole [BHA]	3,3'-Dichlorobenzidine Dihydrochloride
Carbon Tetrachloride	2,4-Dichlorophenyl-p-nitrophenyl ether [Nitrofen]
Ceramic Fibers	Dichlorodiphenyltrichloroethane [DDT]
Chloramphenicol	1,2-Dichloroethane [Ethylene Dichloride]
Chlorendic Acid	Dichloromethane [Methylene Chloride]
Chlorinated Paraffins	1,3-Dichloropropene (Technical Grade)
1-(2-Chloroethyl)-3-cyclohexyl-1-nitrosourea	Diepoxybutane
bis(Chloroethyl)nitrosourea	N,N-Diethyldithiocarbamic acid 2-chloroallyl ester [Sulfallate]
2-Chloro-1,3-butadiene [Chloroprene]	Diethylnitrosamine [N-Nirosodiethylamine]
Chloroform	Diethyl Sulfate
3-Chloro-2-methylpropene	Diglycidyl Resorcinol Ether
4-Chloro- <i>o</i> -phenylenediamine	1,8-Dihydroxyanthraquinone [Danthon]
Chloroprene [2-chloro-1,3-butadiene]	3,3-Dimethoxybenzidine
<i>p</i> -Chloro- <i>o</i> -toluidine	4-Dimethylaminoazobenzene
<i>p</i> -Chloro- <i>o</i> -toluidine Hydrochloride	4,4-(Dimethylamino)benzophenone [Micher's Ketone]
Chlorozotocin	3,3-Dimethylbenzidine
C.I. Basic Red 9 Monohydrochloride	Dimethylcarbamoyl Chloride
Cisplatin	1,1-Dimethylhydrazine
<i>p</i> -Cresidine	
Dimethylnitrosamine [N-Nitrosodimethylamine]	
Mirex	
Dimethyl Sulfate	Nickel (metallic)
Dimethylvinyl Chloride	Nitrilotriacetic Acid
1,6-Dinitropyrene	<i>o</i> -Nitroanisole
1,8-Dinitropyrene	6-Nitrochrysene
1,4-Dioxane	Nitrofen [2,4]Dichlorophenyl-p-nitrophenyl ether]
Disperse Blue 1	Nitrogen Mustard Hydrochloride
Doxorubicin hydrochloride [Adriamycin®]	2-Nitropropane
Epichlorohydrin	1-Nitropyrene
Ethyl Carbamate [Urethane]	4-Nitropyrene
Ethylene Dibromide [1,2-Dibromoethane]	N-Nitroso-n-butyl-N-(3-carboxypropyl)amine
Ethylene Dichloride [1,2-Dichloroethane]	N-Nitroso-n-butyl-N-(4-hydroxybutyl)amine
Ethylene Thiourea	N-Nitrosodi-n-butylamine
di(2-Ethylhexyl) Phthalate	N-Nitrosodiethanolamine

Ethyl Methanesulfonate	N-Nitrosodiethylamine [Diethylnitrosamine]
N-Ethyl-N-nitrosourea [N-Nitroso-N-ethylurea]	
N-Nitrosodimethylamine [Dimethylnitrosamine]	
Formaldehyde (gas)	N-Nitrosodi-n-propylamine
Furan	N-Nitroso-N-ethylurea [N-Ethyl-N-nitrosourea]
Glasswool (respirable size)	4-(N-Nitrosomethylamino)-1-(3-pyridyl)-1-butanone
Glycidol	
Hexachlorobenzene	N-Nitroso-N-methylurea [N-Methyl-N-nitrosourea]
Hexachlorocyclohexane isomers	N-Nitrosomethylvinylamine
Hexachloroethane	N-Nitrosomorpholine
Hexamethylphosphoramide	N-Nitrosornicotine
Hydrazine	N-Nitrosopiperidine
Hydrazine Sulfate	N-Nitrosopyrrolidine
Hydrazobenzene	N-Nitrososarcosine
Indeno[1,2,3-cd]pyrene	Norethisterone
Iron Dextran Complex	Ochratoxin A
Isoprene [2-methyl-1,3-butadiene]	4,4'-Oxydianiline
Kepone® [Chlordecone]	Oxymetholone
Lead Acetate	Perchloroethylene (Tetrachloroethylene)
Lead Phosphate	Phenacetin
Lindane	Phenazopyridine Hydrochloride
2-Methylaziridine [Propylenimine]	Phenolphthalein
2-Methyl-1,3-butadiene [Isoprene]	Phenoxybenzamine Hydrochloride
5-Methylchrysene	Phenytoin
4,4'-Methylenebis [2-chloraniline]	Polybrominated Biphenyls (PBBs)
4,4'-Methylenebis(N,N-dimethylbenzenamine)	Polychlorinated Biphenyls (PCBs)
Methylene Chloride [Dichloromethane]	Polycyclic Aromatic Hydrocarbons (PAHs)
4,4'-Methylenedianiline	Procarbazine Hydrochloride
4,4'-Methylenedianiline Dihydrochloride	Progesterone
Methyleugenol	1,3-Propane Sultone
Methyl Methanesulfonate	b-Propiolactone
N-Methyl-N-nitro-N-nitrosoguanidine	Propylene Oxide
N-Methyl-N-nitrosourea [N-Nitroso-N-methylurea]	Propylenimine (2-Methylaziridine)
Metronidazole	Propylthiouracil
Micher's Ketone [4,4-(Dimethylamino)benzophenone]	Reserpine
Streptozotocin	Safrole
Styrene-7,8-oxide	Selenium Sulfide
Sulfallate	Toxaphene
Tetrachloroethylene (Perchloroethylene)	Trichloroethylene
Tetrafluoroethylene	2,4,6-Trichlorophenol
Tetranitromethane	1,2,3-Trichloropropane
Thioacetamide	UDMH (See 1,1-Dimethylhydrazine)
Thiourea	Ultraviolet Radiation (A,B and C)
Toluene Diisocyanate	Urethane (Urethan; Ethyl carbamate)
o-Toluidine	Vinyl Bromide
o-Toluidine Hydrochloride	4-Vinyl-1-cyclohexene Diepoxide
	Vinyl Fluoride

9.2 Additional Rules for Working with Particularly Hazardous Substances

In addition to the earlier mentioned guidelines for working with chemicals (Section 8), the following rules apply to working with the chemicals listed in Section 9.1 and with allergens, carcinogens, neurotoxins, reproductive toxins, or possessing a high degree of acute toxicity.

a. Approval Needed for Working with Highly Hazardous Chemicals

Before working with a highly hazardous material, be sure that you are familiar with its chemical and physical properties and the health hazards associated with it. If you have not worked with the material before, consult with your supervisor on how to handle it, and gain her/his approval to work with it prior to doing so. The supervisor must understand the hazards of the material and must be confident in your ability to handle it safely before granting approval to use it.

Some chemicals are so toxic and/or have such low permissible exposure limits as to require additional safeguards on their use that approval is required from both the Department Head and the Chemical Hygiene Officer before working with them. If you have a need to use one of the chemicals listed below, contact the CHO *before ordering them*.

Bis(chloromethyl) ether
Hydrogen cyanide (gas)
Hydrogen fluoride (gas)
Nickel carbonyl
Phosgene (gas)
Vinyl Chloride (gas)
Dimethyl mercury and other dialkyl mercury compounds

b. Work Only in Designated Areas

A key requirement of the OSHA Laboratory Standard is that all work with particularly hazardous substances be confined to designated areas. A designated area is defined as a laboratory, an area within a laboratory, or a device such as a fume hood, which is posted with warning signs to ensure that all employees working in the area are informed of the hazardous substances in use there. The lab supervisor should determine the need for designating the lab or areas of it for work with highly hazardous chemicals. In the event that such need is found, those designated areas must be posted with conspicuous signs warning of the hazard. All workers in designated areas should be made aware of the identity of the especially hazardous chemicals being used in the area, and of the hazards associated with them.

c. Eliminate Skin Contact

Many toxic chemicals are readily absorbed through the skin. Avoid all skin contact with particularly hazardous chemicals by always wearing a lab coat and appropriate gloves when working with these materials. Avoid touching exposed skin (e.g. face) with your gloved hands. Always wash hands and arms with soap and water immediately after working with these chemicals. Be sure to wash your face and neck

also if you think you have been exposed to a hazardous substance. Impervious plastic aprons and sleeves (to be worn over lab coats) are available for use when working with solutions of hazardous chemicals.

d. Work Only in Hoods

All synthesis operations with the above highly hazardous materials must be carried out in fume hoods. Weighing and transfers should be done only in fume hoods or in vented balanced enclosures. Analytical work should be performed in hoods and vented balance enclosures as much as practical.

e. Spills

If a spill occurs outside a hood, evacuate the area and notify the emergency response team (9511). If you are not confident of your ability to safely clean up a spill (large or small, outside a hood or in a hood), call the emergency response team (9511). Inform the response team of the identity and hazards of the spill. Provide a MSDS for the material spilled to the Hazmat team.

f. Do Not Contaminate the Environment

Clean up all spills promptly, including particles from weighing operations. Cleaned up materials should be disposed of as hazardous waste (see Section 11). Volatile toxic substances should never be disposed of by evaporation in the hood. Vapors from experiments using particularly hazardous chemicals should be trapped or condensed. Dispose of as in Section 11, being especially careful in handling and storage of these wastes before disposal. Be explicit in labeling the dangers of these materials. Write on the label appropriate information such as: *Caution! Cancer Suspect Agent*.

Use traps, scrubbers, or filters, as appropriate, to protect vacuum pumps against contamination. Decontaminate pumps, glassware, and other equipment in the hood before removing them from the controlled area.

Thoroughly decontaminate any contaminated clothing or shoes. If this cannot be done, dispose of in properly labeled impervious containers.

Decontaminate the work area following use of highly toxic agents. Wipe down surfaces in the work area with soap and water or use solvents, as appropriate.

g. Storage

Store these highly hazardous chemicals in ventilated cabinets. Liquids should be stored in plastic trays sufficient to contain spills in the event a bottle breaks. All containers must be appropriately labeled with identity and warning labels. The outside of the storage cabinet (or refrigerator) should have a sign warning of the storage of particularly hazardous chemicals.

h. Inventory Records

Highly hazardous chemicals must be inventoried for all labs. This inventory record should include: Location, amount on hand, who is responsible for it, and the nature of the hazard. The ChemSW Inventory & Tracking System is being used to maintain this inventory. A convenient chemical inventory form is attached to this Generic Chemical Hygiene Plan.

i. Diazomethane

Before working with diazomethane or related compounds, read the Safe Practice entitled "Diazomethane". Abide by the rules in that Safe Practice.

j. Phosgene and Phosgene-like Chemicals

Before working with phosgene, diphosgene, or triphosgene, read and adhere to the Safe Practice entitled "Phosgene and Phosgene-like Materials".

10. Storage of Chemicals

10.1 Eye-Level Rule

Large bottles of hazardous chemicals should be stored at or below eye level. Bottles of 1 liter or 1 kg size or larger of hazardous chemicals must not be stored above eye level.

10.2 Refrigerators and Freezers

Do not store flammable liquids in a refrigerator or freezer unless the refrigerator/freezer is rated explosion proof or rated for storage of flammable liquids. Units that are not so rated should be labeled. "Danger! Do not store flammable solvents in this refrigerator [freezer]. An explosion may result". The use of plastic trays is recommended to reduce contamination in case of breakage. Maintain refrigerators in a clean and uncrowded state. All materials placed in a refrigerator must be properly labeled. Do not store food or drinks in laboratory refrigerators or freezers!

10.3 Solvents

All bottles of organic solvents greater than (>) 100 milliliters must be stored in flame resistant solvent cabinets. If smaller sized bottles of solvents are stored outside a solvent cabinet, the total volume per laboratory area or personal work area must not exceed 500 ml. Limits for the storage of solvents are based on fire hazards associated with the liquid solvent and defined by the State of Ohio Fire Code. Consult University Fire Safety at 556-4934 for more information. Keep the doors to the solvent storage cabinets' tightly closed and latched at all times. **A safety storage cabinet with the doors open provides little fire protection.** In no case should solvents be left out on bench tops, shelves, or on the floor when not in use. Plastic squirt bottles of solvents may be on the bench top during the day if being used, but at night they must be stored in a hood or in a flammable solvent cabinet.

10.4 Chemicals on Bench Tops

Do not place chemical containers (beakers, flasks, bottles, vials, petri dishes, etc.) where they might be brushed into and knocked onto the floor. Keep containers at least 3 inches back from the edge of the bench top. If flasks are not sitting directly on the bench surface, make sure the supports (e.g. cork rings) are the proper size for the flask (to prevent tipping). Do not pile bottles or flasks on top of each other.

10.5 No Open Chemicals

All chemical containers outside of fume hoods must be covered. While screw caps or solid stoppers are preferred, aluminum foil, parafilm, or covered petri dishes are acceptable for nonvolatile chemicals.

10.6 Particularly Hazardous Chemicals

Highly toxic chemicals should be stored in vented cabinets in plastic trays. These cabinets should have a sign warning of the presence of highly toxic substances within.

10.7 Acids and Bases

Acids and bases greater 2 N should not be stored together. The preferred method of storage is in secondary containers (such as plastic trays or rubber acid buckets) large enough to contain a spill in the case of breakage. If this is done, then acids and bases may be in the same cabinet in separate trays or buckets. If secondary containers are not used, then the acids and bases must be stored in separate cabinets. Inorganic acids should be stored separately from organic acids using the above guidelines.

10.8 Reactive Metals, Hydrides and Other Pyrophorics

Butyl lithium, sodium, potassium, lithium, magnesium and other reactive metals and the associated hydrides, and other pyrophorics must be segregated from other chemicals and must be stored in cabinets.

10.9 Ethers and Other Peroxide Formers

Peroxide formation in ethers and certain other chemicals occurs on exposure to air and can pose a severe hazard. In extreme cases peroxide content can build up to the point where an explosion may occur when the container is handled. Instances have been reported where solid peroxides have formed around the cap of a bottle, and the friction of removing the cap caused the peroxide to explode. Peroxide content may become so high as to form a solid in the bottle, as when a container of ether is left sitting for a long time with a loose cap. **If solids are observed in a bottle of ether or tetrahydrofuran, do not handle the bottle!** Contact the Chemical Hygiene Officer or the Office of Environmental Health and Safety (**556-4968**) to determine how best to handle the material.

Do not store more ether, tetrahydrofuran, or other peroxide-formers than can be used within a year. Check the caps when a bottle is received to ensure that they are tightly sealed. If the cap on the container is loose, test the chemical for peroxide-formers before using. The most common way to check peroxide-formers for concentration levels. The most common procedure is to use peroxide test strips available from chemical suppliers <http://www.labsafety.com> and <http://www.fishersafety.com>.

Label all ethers and other peroxide formers with the date when the bottles are first opened. Discard these bottles according to the schedule below. Check for peroxides before discarding. If peroxide content is low, the solvent may be added to the general solvent waste container. If peroxide content is high (above 100ppm) consult with Environmental Health and Safety for proper disposal procedure.

Due to its unusual tendency to form peroxides, unstabilized diisopropyl ether should be discarded within 1 month after opening.

- a. **Category A: Severe peroxide hazard on storage with exposure to air. Discard 3 months after opening.**

Butadiene	Vinylidene chloride (1,1-dichloroethyl)
Chloroprene (2-chloro 1,3-butadiene)	Potassium amide
Diisopropyl ether (isopropyl ether)	Sodium amide (sodamide)
Divinylacetylene (DVA)	Potassium metal

Any unstabilized (e.g. HPLC grade) solvent on Category B list

- b. **Category B: Severe peroxide hazard on concentration. Discard 6 months after opening. Test for peroxides before using in any process in which distillation or concentration occurs.**

Acetaldehyde diethyl acetal (acetal)	Ethylene glycol monoethers
Chloroprene (2-chloro-1,3-butadiene)	Furan
Cumene (isopropylbenzene)	Methylacetylene
Cyclohexene	Methylcyclopentene
Cyclopentene	Methyl isobutyl ketone
Decalin (decahydronaphthalene)	Styrene (monomer)
Dicyclopentadiene	Tetrahydrofuran (THF)
Diethyl ether (ethyl ether)	Tetralin (tetrahydronaphthalene)
Diethylene glycol dimethyl ether	Vinyl acetate (monomer)
Dioxane	Vinyl ethers
Ethylene glycol dimethyl ether	Vinylpyridine
Ethylene glycol ether acetates	

- c. **Category C: Peroxide hazard on concentration. Test for peroxides before using in any process in which distillation or concentration occurs.**

Secondary alcohols, some ketones and aldehydes (not a complete list)

Acetaldehyde	Cyclopentanol
Benzyl alcohol	Cyclopentanone
2-butanol	Isopropanol
Cyclohexanol	2-pentanol
Cyclohexanone	3-pentanone

11. Chemical Waste Disposal Program

11.1 General Rules

Order only the quantities of chemicals you need. It often costs more to dispose of excess chemicals than it costs to purchase them.

Before a worker's employment in a laboratory ends, chemicals for which that person was responsible should be discarded or transferred to another researcher. Refer to Advisory 7.1.1 – "Laboratory Faculty, Staff, and Student Departure Procedures" for more detailed information.

Consider sending a "free chemicals" notice to other researchers when getting rid of quantities of unopened or "good" chemicals.

Do not dispose of solvents or other organic chemicals down the sink drains. All solvents must be collected and disposed of as described in Section 11.4.

Organic chemicals must be disposed of as hazardous waste (see Sec 11.5).

Heavy metal salts and highly toxic inorganics (e.g. azides, cyanides) must be disposed of as hazardous waste (see Sec 11.5).

11.2 Check the Drug Enforcement Agency List before Disposing of Chemicals

The Drug Enforcement Agency (DEA) regulates the shipment of certain chemicals that are potential intermediates in the synthesis of controlled drugs. These chemicals **CAN NOT** be sent off site for (not even for disposal!) unless the site is licensed to do so. Check the DEA chemical list below. All controlled substances must be properly destroyed/disposed of in accordance with DEA. The Returns Industry Association <http://returnsindustry.com> lists a number of companies that can provide disposal services based on the schedule of the substance. If the chemical is on the list, Contact the Office of Environmental health and Safety to determine what to do with the material for disposal.

1. N-Acetylanthranilic acid, its esters and its salts
2. Anthranilic acid, its esters, and its salts (Note: anthranilic acid = 2-aminobenzoic acid)
3. Benzaldehyde
4. Benzyl cyanide
5. Ephedrine, its salt, optical isomers, and salts of optical isomers (Note: ephedrine = 2-(methylamino)-1-phenylpropan-1-ol)
6. Ergonovine and its salts
7. Ergotamine and its salts
8. Ethylamine and its salts

9. Hydriotic acid (Hydriodic Acid)
10. Insosafrole (Insosafrole) (Note: Insosafrole = 1,2-(methylenedioxy)-4-propenylbenzene)
11. Methylamine and its salts
12. 3,4-Methylenedioxyphenyl-2-propanone
13. N-Methylephedrine, its salts, optical isomers, and salts of optical isomers
14. N-Methylpseudoephedrine
15. Nitroethane
16. Norpseudoephedrine, its salts, optical isomers, and salts of optical isomers (Note: Norpseudoephedrine = 2-amino-1-phenylpropan-1-diol)
17. Phenylacetic acid, its esters, and its salts
18. Phenylpropanolamine, its salts, optical isomers, and salts of optical isomers
19. Piperidine and its salts
20. Piperonal (Note piperonal = 3,4-(methylenedioxy)benzaldehyde)
21. Propionic anhydride
22. Pseudoephedrine, its salts, optical isomers, and salts of optical isomers (Note: pseudoephedrine = 2-(methylamino)-1-phenylpropan-1-ol)
23. Safrole (Note safrole = 4-allyl-1,2-methylenedioxybenzene)

11.3 What may I dispose of in the sink?

Only non-hazardous water soluble inorganic solids and the associated aqueous solutions may be disposed of in the sink drains. No azides, cyanides, sulfides, heavy metal salts, heated solutions, oils or odorous chemicals are allowed down the drain. No organic solvents or organic chemicals may drain disposed. Acids and bases should be “neutralized” to a pH of 6 to 8. Conduct neutralizations slowly and with constant stirring to avoid exothermic splashing. If you have questions about what may be disposed of in this manner, contact the Chemical Hygiene Officer or the Office of Environmental Health and Safety (556-4968). Refer to Safety Advisory 7.3 “Management of Chemical Wastes for more information.

11.4 Solvent waste pickup from laboratories

Solvent waste in approved containers is collected from our laboratories every week on a regular schedule. Fill out the Chemical Recycle/Disposal label online and attach the label to each container.

Plastic one-gallon jugs are acceptable for used pump oil. Attach a label listing the contents of the solvent waste can as soon as possible to collect waste in the container. List identity and approximate volumes or percentages.

11.5 Disposal of Hazardous Waste Chemicals (other than solvents)

Chemical wastes, both solids and liquids, will be picked up from the laboratories every week. All waste chemicals require a chemical recycle/disposal label. Consult Environmental Health and Safety (556-4968) if you have any questions about labeling your chemical wastes. The labels are available online at <http://ehs.uc.edu/chemical>.

11.6 Disposal of Sharp Objects

Any objects that are capable of penetrating the skin are termed “sharps” and may **not** be disposed on in the waste trash. Examples are syringe needles, Pasteur pipettes, and broken glassware. Sharps must be disposed of as below:

1. Biologically Contaminated Sharps

Must be placed in one of the red plastic “Sharps” containers marked with the Biological Hazard sign. When no more than $\frac{3}{4}$ filled, these “Sharps” containers should be sealed prior to pickup and disposal.

Syringes and Needles

Needles and syringes must be placed in the red plastic “Sharps” containers. The needles and syringes may not be disposed of in the broken glass containers or in the trash. Ohio State Law considers needles and sharps to be contaminated with biological waste (whether they are or not) and requires that they be disposed of in the “Sharps” containers. This is also required of scalpel blades. Needles should not remain attached to disposable syringes. If needed, rinse out excess chemicals before placing syringes/needles into the waste. Do not autoclave chemically contaminated wastes.

Broken Glass and Other Sharps (not biologically contaminated)

Other than syringes and needles, all other sharp objects that have not been used with biological materials should be disposed of in broken glass containers. Broken glass containers are available by calling work control. Do not fill the containers more than $\frac{3}{4}$ full, or the containers become too heavy to move, and bottom on the container tends to open up spilling the contents. When $\frac{3}{4}$ full (or less), seal the box and label it for pickup and disposal.

APPENDIX A

THE OSHA LABORATORY STANDARD

(a) *Scope and application.* (1) This section shall apply to all employers engaged in the laboratory use of hazardous chemicals as defined below.

(2) Where this section applies, it shall supersede, for laboratories, the requirements of all other OSHA health standards in 29CFR part 1910, subpart Z, except as follows:

(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.

(ii) Prohibition of eye and skin contact where specified by any OSHA health standard shall be observed.

(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.

(3) This section shall not apply to:

(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.

(ii) Laboratory uses of hazardous chemicals which provide no potential for employee exposure.

Examples of such conditions might include:

(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

(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.

(b) *Definitions--*

Action level means a concentration designed in 29 CFR part 1910 for a specific substance, calculated as an eight (i)-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°F (37.8°C), but below 200°F (93.3°C), except any mixture having components with flashpoints of 200°F (93.3°C), or higher, the total volume of which make up 99 percent or more of the total volume of the mixture.

Compressed gas means:

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

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

(iii) A liquid having a vapor pressure exceeding 40 psi at 100°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°F (37.8°C), except any mixture having components with flashpoints of 100°F (37.8°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 Tagliabue Closed Tester, Z11.24-1979 (ASTM D 56-79))-for liquids with a viscosity of less than 45 Saybolt Universal Seconds (SUS) at 100°F (37.8°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 Flash Point 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°F (37.8°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)).

Organic peroxides, which undergo autoaccelerating 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 safely 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 moveable 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 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 air-borne 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 that 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 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/m³;

(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.

(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.

(d) *Employee exposure determination--*

(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).

(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.

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

(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.

(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.)

(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:

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

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

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

(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:

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

(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;

(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;

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

(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;

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

(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

(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:

(A) Establishment of a designated area;

(B) Use of containment devices such as fume hoods or glove boxes;

(C) Procedures for safe removal of contaminated waste; and

(D) Decontamination procedures.

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

(f) *Employee information and training.*

(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.

(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.

(3) *Information.* Employees shall be informed of:

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

(ii) The location and availability of the employer's Chemical Hygiene Plan;

(iii) The permissible exposure limits for OSHA regulated substances or recommended exposure limits for other hazardous chemicals where there is no applicable OSHA standard;

(iv) Signs and symptoms associated with exposures to hazardous chemicals used in the laboratory; and

(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.

(4) *Training.* (i) Employee training shall include:

(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.);

(B) The physical and health hazards of chemicals in the work area; and

(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.

(ii) The employee shall be trained on the applicable details of the employer's written Chemical Hygiene Plan.

(g) *Medical consultation and medical examinations.* (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:

(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.

(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.

(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.

(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.

(3) *Information provided to the physician.* The employer shall provide the following information to the physician:

(i) The identity of the hazardous chemical(s) to which the employee may have been exposed;

(ii) A description of the conditions under which the exposure occurred including quantitative exposure data, if available; and

(iii) A description of the signs and symptoms of exposure that the employee is experiencing, if any.

(4) *Physician's written opinion.* (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:

(A) Any recommendation for further medical follow-up;

(B) The results of the medical examination and any associated tests;

(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 chemical found in the workplace; and

(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.

(ii) The written opinion shall not reveal specific findings of diagnoses unrelated to occupational exposure.

(h) *Hazard identification.* (1) With respect to labels and material safety data sheets:

(i) Employers shall ensure that labels on incoming containers of hazardous chemicals are not removed or defaced.

(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.

(2) The following provisions shall apply to chemical substances developed in the laboratory:

(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.

(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.

(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.

(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.

(j) *Recordkeeping.* (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.

(2) The employer shall assure that such records are kept, transferred, and made available in accordance with 29 CFR 1910.20.

(k) *Dates - (1) Effective date.* This section shall become effective May 1, 1990.

(2) *Start-up dates.* (i) Employers shall have developed and implemented a written Chemical Hygiene Plan no later than January 31, 1991.

(ii) Paragraph (a)(2) of this section shall not take effect until the employer has developed and implemented a written Chemical Hygiene Plan.

(1) *Appendices.* The information contained in the appendices is not intended, by itself, to create any additional obligations not otherwise imposed or to detract from any existing obligation.

[55 FR 3327, Jan. 31, 1990, 55 FR 7967, Mar. 6, 1990, 55 FR 12111, Mar. 30, 1990]

APPENDIX A TO §1910.1450--NATIONAL RESEARCH COUNCIL RECOMMENDATIONS CONCERNING CHEMICAL HYGIENE IN LABORATORIES (NON-MANDATORY)

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Foreword

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" deals 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.

Corresponding Sections of the Standard and this Appendix

The following table is given for the convenience of those who are developing a Chemical Hygiene Plan which will satisfy the requirements of paragraph (3) 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 continuing 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, 299).

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 tested routinely (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) Identify 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 prevent 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 identify 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, 162-4, 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 (107)

*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 (96)
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 TO §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, Blvd., D-7 Cincinnati, OH 45211-4438 (latest edition.)
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, NJ, 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).

APPENDIX B

TABLE Z-1. OSHA Permissible Exposure limits (PELS)
for Air Contaminants

Substance	CAS No. (c)	ppm (a) ¹	mg/m ³ (b) ¹	Skin entry (g)
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-Acetylaminofluorine; 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	

Substance	CAS No. (c)	ppm (a) ¹	mg/m ³ (b) ¹	Skin entry (g)
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	71-43-2	1 (note i)	3	
See Table Z-2 for the limits applicable in the operations or sectors excluded in 1910.1028 ^d				
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	
Berllium 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)	106-99-0	1000	2200	
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)	1189-85-1	.....	(C)0.1	X
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			

Substance	CAS No. (c)	ppm (a) ¹	mg/m ³ (b) ¹	Skin entry (g)
Calcium carbonate	1317-65-3			
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	
α-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

Substance	CAS No. (c)	ppm (a) ¹	mg/m ³ (b) ¹	Skin entry (g)
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 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), res- pirable fraction.			(3)	
Coal dust (greater than or equal to 5% SiO ₂), respirable fraction			(3)	
Coal tar pitch volatiles (benzene solu-ble 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; 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	
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 (Dichlorophenoxyacetic 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-meth-yl-2- pentanone)	123-42-2	50	240	
1,2-Diaminoethane; see Ethylene-diamine				
Diazomethane	334-88-3	0.2	0.4	
Diborane	19287-45-7	0.1	0.1	

Substance	CAS No. (c)	ppm (a) ¹	mg/m ³ (b) ¹	Skin entry (g)
1,2-Dibromo-3-chloropropane (CBCP); 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	
Dichlorodiphenyltrichloroethane (DDT)	50-29-3	.....	1	X
1,1-Dichloroethane	75-34-3	100	400	
1,2-Dichloroethane; see Ethylene di-chloride				
1,2-Dichloroethylene	540-59-0	200	790	
Dichloroethyl ether	111-44-4	(C) 15	(C)90	X
Dichloromethane (Methylene chloride)	75-09-2	25 (note h)	88	
Dichloromonofluoromethane	75-43-4	1000	4200	
1,1-Dichloro-1-nitroethane	594-72-9	(C)10	(C)60	
1,2-Dichloropropane; see Propylene di-chloride				
Dichlorotetrafluoroethane	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-Dimethylaminoazobenzene; 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	

Substance	CAS No. (c)	ppm (a) ¹	mg/m ³ (b) ¹	Skin entry (g)
Dimethyl sulfate	77-78-1	1	5	X
Dinitrobenzene (all isomers)			1	X
(ortho)	528-29-0			
(meta)	99-65-0			
(pera)	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	
Endosulfan	115-29-7	.....	0.1	X
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 ace-tate)	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			

Substance	CAS No. (c)	ppm (a) ¹	mg/m ³ (b) ¹	Skin entry (g)
Ethylene oxide; see 1910.1047	75-21-8			
Ethylidene chloride; see 1,1-Dichloroethane				
N-Ethylmorpholine	100-74-3	20	94	X
Ferbam	14484-64-1			
Total dust			15	
Ferrovandium dust	12604-58-9		1	
Fluorides (as F)	(4)		2.5	
Fluorine	7782-41-4	0.1	0.2	
Fluorotrchloromethane (Trichlorofluoromethane)	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	

Substance	CAS No. (c)	ppm (a) ¹	mg/m ³ (b) ¹	Skin entry (g)
Iodine	7553-56-2	(C)0.1	(C)1	
Iron oxide fume	1309-37-1	.....	10	
Isoamyl acetate	123-92-2	100	525	
Isoamyl alcohol (primary and second-ary)	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. (Liquefied 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	

Substance	CAS No. (c)	ppm (a) ¹	mg/m ³ (b) ¹	Skin entry (g)
Methyl acetylene-propediene 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-Trichloroethane)	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 bisphenyl isocyanate (MDI)	101-68-8	(C)0.02	(C)0.2	
Methylene chloride (Dichloromethane)	75-09-2	25 (note h)	88	
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	
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	

Substance	CAS No. (c)	ppm (a) ¹	mg/m ³ (b) ¹	Skin entry (g)
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; 1910-42-5; 2074-50-2	.....	0.5	X
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	

Substance	CAS No. (c)	ppm (a) ¹	mg/m ³ (b) ¹	Skin entry (g)
Perlite	93763-70-3			
Total dust			15	
Respirable fraction			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-Propiolactone; 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				

Substance	CAS No. (c)	ppm (a) ¹	mg/m ³ (b) ¹	Skin entry (g)
Rhodium (as Rh), metal fume and in-soluble 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), respirable 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)	

Substance	CAS No. (c)	ppm (a) ¹	mg/m ³ (b) ¹	Skin entry (g)
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 pyrophosphate)	107-49-3		0.05	X
Terphenyls	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-Tetrachloroethane	79-34-5	5	35	X
Tetrachloroethylene; see Perchloroethylene				
Tetrachloromethane; see Carbon tetra-chloride				
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-Trinitrophenylmethylnitramine)	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 ox-ides) (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				

Substance	CAS No. (c)	ppm (a) ¹	mg/m ³ (b) ¹	Skin entry (g)
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-Trinitrophenyl; see Picric acid				
2,4,6-Trinitrophenylmethylnitramine; 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			0.05	
Vanadium	1314-62-1			
Respirable dust (as V ₂ O ₅)			(C)0.5	
Fume (as V ₂ O 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	

- 1 The PELs are 8-hour TWAs unless otherwise noted; a (C) entry (g) 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°C and 760 torr.
 - (b) Milligrams of substance per cubic meter of air. When entry (g) is in this column only, the value is exact; when listed with a ppm entry (g), it is approximate.
 - (c) The CAS number is for information only. Enforcement is based on the substance name. For an entry (g) 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 gmetting. 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.
 - (g) An "X" under Skin Entry indicates that absorption through the skin, mucous membranes, and eyes may contribute significantly to the overall exposure to a compound. This may be through contact with vapors, or probably of greater significance through direct skin contact with the compound or with solutions containing it. (Other compounds in this table possibly can also be absorbed through the skin, and should be handled as though that were the case, even though an "X" may not be present.)
 - (h) OSHA Standard 1910.1052 establishes an 8 hour PEL of 25 ppm and a 15 minutes STEL of 125 ppm for methylene chloride (dichloromethane).
 - (i) OSHA Standard 1910.1028 establishes an 8 hour PEL of 1 ppm and a 15 minutes STEL of 5 ppm for benzene.
- 2 See Table Z-2
- 3 See Table Z-3
- 4 Varies with compound

TABLE Z-2. OSHA Permissible Exposure Limits (PELs) for Air Contaminants

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 (note c)	25 ppm	50 ppm	10 minutes
Benzene <u>CURRENT LIMITS</u> (From 29CFR 1910.1028)	1 ppm	5 ppm		
Beryllium and beryllium compounds (Z37.29-1970)	2 µg/m ³	5 µg/m ³	25 µg/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 4 hrs.
Chromic acid and chromates (Z37.7-1971) ..	.....	1 mg/10m 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 min.s once, only if no other measurable exposure 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 (Z37.23-1969)	500 ppm (note d)	1,000 ppm ..	2,000 ppm	5 mins. in any 2 hrs.
Methylene chloride <u>CURRENT VALUES</u> (From 29CFR 1910.152)	25 ppm	125 ppm		
Organo (alkyl) mercury (Z37.30-1969)	0.01 mg/m ³	0.04 mg/m ³ ..	.....
Styrene (Z37.15-1969)	100 ppm	200 ppm	600 ppm	5 mins. in any 3 hrs.
Tetrachloroethylene (Z37.22-1967)	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.

- 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.
- b. This standard applies to any operations or sectors for which the Cadmium standard, 1910.1027, is stayed or otherwise not in effect.
- c. OSHA Standard 1910.1028 establishes an 8 hour PEL of 1 ppm and a 15 minutes STEL of 5 ppm for benzene. HCRC researchers are expected to abide by these lower limits.
- d. OSHA Standard 1910.1052 establishes an 8 hour PEL of 25 ppm and a 15 minutes STEL of 125 ppm for methylene chloride (dichloromethane). HCRC researchers are expected to abide by these lower limits.

APPENDIX C

Special Handling Procedures for Some Common Particularly Hazardous Substances

This section outlines special handling procedures for some specific particularly hazardous substances that may be encountered in the laboratories. The information presented in this Section or the list of chemicals is not meant to be complete, and researchers should consult the appropriate literature and their Principal Investigator before working with these particularly hazardous substances.

Acrylonitrile

Acrylonitrile is regulated as a human carcinogen by OSHA and is also listed as a substance with a high degree of acute toxicity. **The PEL (permissible exposure limit) is 2 ppm as an 8-hour time-weighted average (TWA) or 10 ppm as averaged over any 15-minute period.** Skin and eye protection from liquid acrylonitrile is mandatory. *Work involving acrylonitrile should be conducted using the procedures outlined in Sections 8 and 9.2.* Laboratory hoods that have been demonstrated to provide sufficient protection must be used, and closed systems are recommended for laboratory operations.

Benzene

In humans, acute inhalation exposure to benzene can produce acute delirium, characterized by excitement, euphoria, and restlessness. If the exposure is significantly high, the symptoms may progress to depression, drowsiness, stupor, and even unconsciousness. The concentration required to produce these symptoms is 1000 ppm or higher. These concentrations will also produce irritation of the eye, nose, and respiratory tract. Chronic inhalation exposure to 25-50 ppm of benzene can produce changes in the blood that include macrocytosis, decrease in the total red blood count, decrease in platelets, decrease in the hemoglobin concentration, and/or decrease in leukocytes. Any or all of these hematologic effects may be seen in any individual. Usually, the worker will be asymptomatic while these effects are observed in the blood. Continued exposure to higher concentrations (more than 100 ppm) can result in more severe blood disorders that include leukopenia or even aplastic anemia, with symptoms of headaches, dizziness, loss of appetite, nervousness, irritability and perhaps bleeding manifestations, (i.e. nosebleeds, easy bruisability, or hematuria). Severe cases may have fatal outcomes.

The current OSHA PEL for benzene is 1 ppm as an 8-hour time-weighted average, with a 15-minute, short-term exposure limit (STEL) of 5 ppm. Benzene is a flammable liquid and should not be exposed to heat or flame. An explosion hazard also exists when the vapors are exposed to a flame. Benzene may react vigorously with oxidizing agents such as bromine, pentafluoride, chlorine, chromic acid, nitryl-perchlorate, oxygen, ozone, perchlorates, aluminum chloride plus fluorine perchlorate,

sulfuric acid plus permanganates, potassium peroxide, silver perchlorate plus acetic acid, and sodium peroxide.

Experiments involving the use of significant quantities of benzene should be conducted employing the procedures outlined in Sections 8 and 9.2. All operations in which there is the possibility of the accidental release of harmful quantities of benzene should be carried out in a designated area.

Bis(chloromethyl)ether (BCME) and Chloromethyl Methyl Ether

Because of the high volatility of bis(chloromethyl)ether (BCME), exposure through inhalation presents the greatest hazard to humans. BCME vapors are severely irritating to the skin and mucous membranes and can cause corneal damage that heals slowly. The substance is known to cause cancer in humans. BCME is highly toxic to animals via inhalation: LD₅₀ (rats, oral) = 280 mg/kg; LD₅₀ (rabbits, skin) = 368 mg/kg. The vapors are strongly irritating to the eyes of rats. Rats and hamsters subjected to 10 or 30 6-hour exposures of 1 ppm BCME showed evidence of tracheal and bronchial hyperplasia, as well as effects on the central nervous system. BCME is carcinogenic to mice following inhalation, skin application, or subcutaneous administration. In newborn mice, it is carcinogenic by inhalation and subcutaneous administration. BCME is a known lung carcinogen in humans.

The TLV for BCME is 0.001 ppm (1 ppb; 0.0047mg/m³). **The substance is classified by the American Conference of Governmental Industrial Hygienists (ACGIH) as a human carcinogen. OSHA has classified BCME as a cancer-suspect agent and has stringent regulations (29 CFR 1910.1008) for its use if its concentration in a material exceeds 0.1%. Work involving chloromethyl ether derivatives must be carried out using the procedures outlined in Sections 8 and 9.2.** Additionally, work with this substance in an open system is prohibited, including a fume hood. If transfers of material are done via any means other than in a completely closed system (glove box), or if the system is opened while BCME is suspected to be present, then the researcher must wear a full-face respirator with a supplied air source.

Carbon Monoxide

Carbon monoxide is a direct and cumulative poison. It combines with the hemoglobin of the blood to form a relatively stable compound (carboxyhemoglobin) rendering it useless as an oxygen carrier. When approximately one-third of the hemoglobin has entered into such a combination, the victim dies. The gas is a treacherous poison because of its odorless character and insidious action. Exposure to 1500-2000 ppm CO in air for 1-hour is dangerous, and exposure to 4000 ppm is fatal in less than 1-hour. Headache and dizziness are the usual symptoms of CO poisoning, but occasionally the first evidence of poisoning is the collapse of the individual. **The current PEL for carbon monoxide is 50 ppm (55mg/m³).**

Carbon monoxide should be used only in fume hoods with adequate ventilation employing the procedures outlined in Sections 8 and 9.2. A trap should be used to prevent impurities from being sucked back into a CO cylinder.

Carbon Tetrachloride

The current OSHA PEL for carbon tetrachloride is 10 ppm as an 8-hour time-weighted average, 25 ppm as a ceiling for any period of time provided the 8-hour average is not exceeded, and 200 ppm for 5 minutes in a 4 hour period. Carbon tetrachloride is a suspected human carcinogen. The American Conference of Governmental Industrial Hygienist also states that skin contact may account for a substantial part of the toxic response.

The carcinogenic potency of carbon tetrachloride is low and for most laboratory it need not be treated as a particularly hazardous substance. In cases where large quantities of carbon tetrachloride are in frequent use, then the general procedures outlined in Section 8 should provide adequate protection. All operations should be carried out in a fume hood, not only because of the carcinogenicity of the substance, but also because of its other toxic effects and its volatility. Nitrile rubber is the recommended material for gloves and other protective clothing.

Chlorine

Chlorine is classified as a substance with a high degree of acute toxicity. Humans can generally detect the odor of chlorine at about 0.3 ppm. Minimal irritation of the throat and nose are noticed at about 2.6 ppm and painful irritation at about 3.0 ppm; at a range of 2.6 - 41.0 ppm, a group of "trained industrial hygienists" noted "strong irritation." The subjective response to chlorine is less pronounced with prolonged exposure.

Experimentally determined responses to chlorine by humans are not very consistent. Throat irritation occurs at about 6.6 - 15 ppm. However, an exposure for medical purposes of a large number of humans to 5 - 7 ppm for 1 hour did not result in serious or long-term consequences. Exposure to about 17 ppm causes coughing, and levels as low as 10 ppm may cause lung edema. Chronic effects on humans from long-term low-level exposures have been well documented. Animal exposures have indicated that prolonged exposure to approximately 1.7 ppm for 1 hour per day can cause deterioration in the nutritional state, blood alteration and decreased resistance to disease. **The OSHA PEL is 1 ppm (3mg/m³) as a ceiling limit. NIOSH has recommended a ceiling limit of 0.5 ppm over any 15-minute period. The ACGIH 15-minute exposure limit is 3 ppm.**

Chlorine should be kept away from easily oxidized materials. Chlorine reacts readily with many organic chemicals, sometimes with explosive reactions. Because of its high toxicity, *laboratory operations using chlorine must be carried out in a fume hood employing the procedures outlined in Sections 8 and 9.2.*

Chloroform

Inhalation exposure to chloroform at concentrations greater than 1000 ppm can produce dizziness, nausea, and headaches. At higher concentrations, disorientation and delirium progressing to unconsciousness can occur. Such high exposure can also produce liver and possible kidney damage. It is believed that chloroform can sensitize the heart to adrenaline, so it may cause cardiac arrhythmias and possibly death. High concentrations of the vapor can produce conjunctivitis. Liquid chloroform in the eyes will produce a painful corneal injury that usually heals in several days. Chronic exposure to chloroform at concentrations of 100 – 200 ppm has been reported to produce enlarged livers. Continued contact with the skin can produce drying, fissuring, and inflammation. In experimental studies, prolonged ingestion of high levels of chloroform by mice resulted in liver cancer and in rats, kidney tumors.

Although the fire hazard posed by chloroform is slight, exposure to heat or flame can result in the generation of phosgene gas. Chloroform reacts violently with acetone in the presence of a base, and also with aluminum, disilane, lithium, magnesium, nitrogen tetroxide, potassium, perchloric acid plus phosphorus pentoxide, potassium hydroxide plus methanol, potassium tert-butoxide, sodium, sodium hydroxide plus methanol, sodium methylate, and sodium hydride.

The current OSHA PEL for chloroform is 50 ppm (240 mg/m³) as a ceiling level that should not be exceeded for any 15-minute period (as a time-weighted average). The ACGIH currently recommends that chloroform be treated as a suspect human carcinogen and recommends an 8-hour time-weighted average exposure limit of 10 ppm.

Although chloroform has caused tumors in animals, its potency is low. *In most of its uses in laboratory chloroform need not be treated as a particularly hazardous substance.* In cases where significant quantities of chloroform are in frequent use, the general procedures outlined in Section 8 should provide adequate protection. The high volatility of chloroform emphasizes the importance of using a fume hood for such operations. Polyvinyl alcohol gloves provide the best skin/hand protection.

Dimethyl and Diethyl Sulfate

Many cases of dimethyl sulfate (DMS) poisoning have been reported. The common initial symptoms are headaches and giddiness, with burning of the eyes. The patient's condition may worsen, with painful eyes, nose and throat irritation, loss of voice, coughing, difficulty in breathing and swallowing, vomiting, and diarrhea possible. The onset of the symptoms may be delayed for up to 10 hours. Skin contact causes blistering and necrosis. DMS can be absorbed through the skin in sufficient quantity to cause systemic intoxication. In worst cases, there is severe inflammation of the mucous membranes and pulmonary injury that may be fatal; several deaths have been documented. Exposure to 97 ppm for 10 minutes was found to be fatal. During a 4-hour exposure, 30 ppm DMS killed 5 out of 6 rats, but 15 ppm was not lethal. DMS is

moderately toxic to animals via the oral route LD_{50} (rats) = 440 mg/kg. DMS does not cause skin sensitization in animals.

DMS has been shown to be carcinogenic in the rat by inhalation, subcutaneous injection, and following 1-hour per day exposures to 10 ppm DMS for 130 days. **The OSHA PEL for DMS is 1 ppm (5 mg/m³) as an 8-hour time-weighted average. DMS is classified as a suspect carcinogen in humans by the ACGIH.** Skin absorption may contribute to the overall exposure.

The general procedures outlined in Sections 8 and 9.2 should be used when handling DMS due to the highly carcinogenic potency in rats by inhalation and the ability of the agent to penetrate the skin. It is particularly important to avoid skin contact by the appropriate use of butyl rubber gloves, a rubber apron and other protective equipment. Inhalation of even low concentrations of vapor should be avoided by working in a laboratory fume hood.

Ethylene Dibromide (1,2-Dibromoethane)

Ethylene dibromide (EDB) is classified as a compound with a high degree of acute toxicity. The oral lethal dose of EDB for humans is 5 milliliters. Skin absorption of EDB can also cause death, and inhalation of the vapor can produce pulmonary edema. EDB can cause severe irritation to all exposed tissues, respiratory tract, skin, and eye. Systemic effects include central nervous system depression, kidney injury, and severe liver necrosis. Ethylene dibromide is highly toxic to animals via inhalation. The maximum survival exposure of rats to EDB vapors in air is 3000 ppm for 6 minutes, 400 ppm for 30 minutes, and 200 ppm for 2-hours. It is moderately toxic via the oral and skin routes: LD_{50} (rats, oral) = 140 mg/kg; LD_{50} (rabbits, skin) = 300 mg/kg. EDB is irritating to skin, and a 10% solution has been known to cause serious but reversible corneal injury in rabbit eyes.

The PEL for EDB is 20 ppm (155 mg/m³) as an 8-hour time-weighted average with a ceiling limit of 30 ppm over any 15-minute period. These limits include a warning about the potential contribution of skin absorption to the overall exposure. **In 1980 the ACGIH classified EDB in category A1b (human carcinogen) confirmed animal carcinogen. Currently the ACGIH classifies EDB as an A3 (confirmed animal carcinogen). The ACGIH recommends that those working with type A classified carcinogens should be properly equipped to ensure virtually no contact with the carcinogen occurs.**

On the basis of the carcinogenicity data for EDB, *the procedures described in Section 8 and 9.2 should be followed when handling this substance.* Serious skin injury can occur from direct exposure to EDB. The substance can penetrate neoprene and several other types of plastic; therefore, gloves and other protective apparel made of these materials do not provide protection if EDB is spilled on them. Use polyvinyl alcohol, Teflon, or Viton gloves, apron and other protective equipment.

Hydrazine

Hydrazine is classified as a compound with a high degree of acute toxicity. Exposure to its vapors can cause respiratory tract irritation, excitement, convulsion, cyanosis, and decrease in blood pressure. The chemical can severely burn the eyes and skin. Hydrazine can cause fatty degeneration of the liver, nephritis, and hemolysis. Hydrazine also poses a dangerous fire and explosion risk and can explode during the distillation if traces of air are present. Hydrazine is moderately toxic to animals via the inhalation, oral, and skin routes: LC₅₀ (rats, 4-hour inhalation) = 570 ppm; LD₅₀ (rat, oral) = 60 mg/kg; LD₅₀(rabbits, skin) = 283 mg/kg (hydrazine hydrate). It is a strong skin and mucous membrane irritant and a strong skin sensitizer. Hydrazine hydrate produced moderately severe irritation when applied to rabbit eyes. After repeated oral, skin or injection exposure, the effects noted included weight loss, weakness, vomiting, and convulsions. The chief histological finding is fatty degeneration of the liver.

Hydrazine and hydrazine salts have been shown to be carcinogenic in mice after oral and intraperitoneal administration and in rats following oral dosing. By the oral route, effects were found at doses of 24 – 36 (mg/kg)/day in mice and 20 (mg/kg)/day in rats. No tumors were observed in Syrian golden hamsters after oral administration. The ACGIH has classified hydrazine as a suspected carcinogen. **The OSHA PEL is 1.0 ppm (1.3 mg/m³) as an 8-hour time-weighted average.** These limits include a warning about the potential contribution of skin absorption to the overall exposure. NIOSH has (1978) recommended a ceiling limit of 0.03 ppm in any 2-hour period.

When hydrazine is used in the laboratory, the general procedures outlined in Sections 8 and 9.2 should be followed since hydrazine is carcinogenic in animal tests, quite volatile, and readily absorbed through the skin. Nitrile rubber is recommended for gloves and other protective apparel. Prompt washing with water effectively removes hydrazine from skin that it is splashed on. Hydrazine should not be used in the vicinity of a flame or under conditions where sparks can occur, as an explosion or fire can result.

Hydrogen Bromide and Hydrogen Chloride Gases

Both hydrogen bromide (HBr) and hydrogen chloride (HCl) are toxic gases that are severely irritating to the upper respiratory tract. The acids formed neutralize the alkali in the tissues and can cause death as a result of edema or spasm of the larynx and inflammation of the upper respiratory system. Concentrations of 0.13 – 0.2% are lethal for human beings in exposures lasting a few minutes. However, because of their odor, usually these gases provide adequate warning for prompt voluntary withdrawal from contaminated atmospheres. These gases are also corrosive to the skin and mucous membranes and can cause severe burns. Exposure to high concentrations may also result in dermatitis. Contact with the eyes rapidly causes severe irritation of the eyes and eyelids.

Hydrogen bromide and hydrogen chloride are corrosive gases that have pungent, irritating odors. Although both chemicals are colorless, the agents fume in moist air

because of their high solubility in water. In a cylinder under pressure, both exist in the form of a gas over a liquid. Under such conditions, the cylinder pressure is equal to the vapor pressure of the substance contained; at 25°C, this is 613 lb/in² for HCL and 320 lb/in² for HBr. As long as liquid is present in the cylinder, the pressure will remain fairly constant. Although neither HBr nor HCL is combustible, both react with common metals to form hydrogen, which in turn may form explosive mixtures with air. *Operations involving significant quantities of hydrogen bromide and hydrogen chloride should be conducted using the general procedures outlined in Section 8.* Laboratory workers should wear protective apparel including rubber gloves, suitable gas-tight chemicals safety goggles and clothing such as rubber or plastic aprons. Proper respiratory equipment should be available. These gases should be handled only in adequately ventilated areas. A check valve, vacuum break, or trap should always be used to prevent foreign materials from being sucked back into the cylinder because this can cause the development of dangerous pressures. Leaks of HBr or HCl will be evident by the formation of dense white fumes upon contact with the atmosphere. Small leaks of HCl can be detected by holding an open bottle of concentrated ammonium hydroxide near the site of the suspected leak. The formation of dense white fumes confirms the presence of a leak. Cylinder-valve leaks can usually be corrected by tightening the valve-packing nut (by turning it clockwise as viewed from above).

Hydrogen Cyanide

Prior approval from the Principal Investigator and the Chemical Hygiene Officer is required before using hydrogen cyanide (See Section 9.2).

Hydrogen cyanide (HCN) is among the most toxic and rapidly acting of all known substances. Exposure to high doses may be followed by almost instantaneous collapse, cessation of respiration and death. At lower dosages, the early symptoms include weakness, headache, confusion, nausea, and vomiting. In humans the fatal dose is 40 mg via the oral route. Exposure to 3,000-ppm hydrogen cyanide is immediately fatal, while 200 to 480 ppm can be fatal after 30 minutes. Exposure to 18 to 36 ppm HCN causes slight symptoms after several hours. The liquid is rapidly absorbed through the skin. **The OSHA PEL is 10 ppm (11 mg/m³) for an 8-hour time-weighted average. NIOSH recommends a ceiling limit of 4.5 ppm (5 mg/m³) for any 10-minute sampling period.**

Aside from its high toxicity, HCN has a low flash point and forms an explosive mixture with air over a wide range of concentrations. Moreover, traces of base can cause rapid spontaneous polymerization, sometimes resulting in detonation. Protective gloves and safety goggles must be worn when working with HCN. The procedures of Sections 8 and 9.2 must be followed.

Hydrofluoric Acid

The use of anhydrous hydrogen fluoride requires prior approval from your Principal Investigator and from the Chemical Hygiene Officer.

All forms – dilute or concentrated solutions or the vapor – of hydrofluoric acid (HF) cause severe burns. Inhalation of anhydrous HF or HF mist or vapors can cause severe respiratory tract irritation that may be fatal. Death by pulmonary edema occurred within 2-hours in three of six workers splashed with 70% HF solution despite prompt showering with water. Anhydrous HF is a clear, colorless liquid that boils at 19.5°C. Because of its low boiling point and high vapor pressure, anhydrous HF must be stored in pressurized containers. A 70% aqueous solution is a common form of HF. Hydrofluoric acid is miscible with water in all proportions and forms an azeotrope (38.3% HF) that boils at 112°C. Anhydrous or concentrated aqueous HF causes immediate and serious burns to any part of the body. Dilute solutions (<30%) and gaseous HF are also harmful, although several hours may pass before redness or a burning sensation is noticed. These burns may still be quite severe and progressively damaging to the skin and deeper tissues. *“Undissociated HF readily penetrates skin and deep tissues where as the corrosive fluoride ion causes necrosis of soft tissues and decalcification of bone; the destruction produced is excruciating painful. Fluoride ion also attacks enzymes (e.g. of glycolysis) and cell membranes. The process of tissue destruction and neutralization of the hydrofluoric acid is prolonged for days, unlike other acids that are rapidly neutralized. Because of the manner of penetration, a relatively mild or minor exposure can cause a serious burn”* [Proctor, N.H. Hughes, J.P. Fischman, M.L. *Chemical Hazards in the Workplace*, Van Nostrand Reinhold 1991, p 335].

Occasionally workers fail to recognize the importance of seeking medical attention for HF burns *before* pain commences. By the time the victim is affected with progressively deep and more painful throbbing and burning, serious damage may have taken place. Exposures under fingernails can be a particularly painful problem if ignored. Wearing clothing (including leather shoes and gloves) that has absorbed small amounts of HF can result in serious delayed effects such as painful slow-healing skin ulcers.

When handling HF, it is crucial to ensure adequate ventilation by working only in a fume hood so that safe levels (3 ppm) are not exceeded. All contact with HF solutions or vapors with eyes, skin, respiratory system, or digestive system must be avoided by using protective equipment such as a face shield and neoprene or polyvinyl chloride gloves. The protective equipment should be washed after each use to remove any HF on it. Safety showers and eyewash fountains should be available nearby. Anyone working with HF should receive prior instructions about its hazards and proper protective measures and the recommended procedures for treatment in the event of an exposure.

Spills and leaks – Vapors of both anhydrous HF and aqueous 70% HF produce visible fumes when in contact with moist air. This characteristic can be useful in detecting leaks but cannot be relied on because of atmospheric variations. Spills of HF must be treated immediately to minimize the dangers of vapor inhalation, body contact, corrosion of equipment, and possible generation of hazardous gases. Spills should be contained and diluted with water. The resulting solution should be neutralized with lime before disposal.

Waste Disposal – Waste HF should be slowly added to a larger volume of a stirred solution of slaked lime (calcium hydroxide) to form a precipitate of calcium fluoride. Calcium fluoride is chemically inert and poses little toxic hazard (sodium fluoride is highly soluble and toxic). Alternatively, hydrofluoric acid can be diluted to about 2% concentration with cold water in a polyethylene vessel, neutralized with aqueous sodium hydroxide, and treated with excess calcium chloride solution to precipitate calcium fluoride.

In the event of exposure - Anyone who knows or even suspects that he or she has come into direct contact with HF should immediately flush the exposed area with large quantities of cool water. Exposed clothing should be removed as quickly as possible while flushing. Medical attention should be obtained promptly, even if the injury appears slight. On the way to the physician, the burned area should be immersed in a mixture of ice and water. If immersion is impractical, a compress made by inserting ice cubes between layers of gauze should be used. Make sure that the physician understands that the injury was caused by HF and requires treatment very different from other acid burns. Even in the case of very small exposure, washing alone may not be sufficient to completely prevent injury. For minor exposures such as a small hole in a glove, application of a calcium gluconate antidote gel can bind free fluoride ion not removed by washing.

If HF liquid or vapor has contacted the eyes, they should be flushed with large quantities of clean water while the eyelids are held apart. This flushing should be continued for 15 minutes. Medical attention should be obtained promptly.

Anyone who has inhaled HF vapor should be removed immediately to an uncontaminated atmosphere and kept warm. Medical help should be obtained promptly. Anyone who has ingested HF should drink a large quantity of water as quickly as possible. Do not induce vomiting. Again, medical help should be obtained promptly. After the acid has been thoroughly diluted with water, if medical attention is delayed, the person should be given milk or two fluid ounces of milk of magnesia to drink to soothe the burning effect.

Hydrogen Sulfide

Hydrogen sulfide is extremely dangerous. Human exposure to relatively low concentrations of hydrogen sulfide can cause corneal damage, headache, sleep disturbances, nausea, weight loss, and other symptoms suggestive of brain damage. Higher concentrations can cause irritation of the lungs and respiratory passages and even pulmonary edema. Exposure to 210 ppm for 20 minutes has been known to cause unconsciousness, arm cramps, and low blood pressure. Coma may occur within seconds after one or two breaths at high concentrations and may be followed rapidly by death. Hydrogen sulfide is moderately toxic to animals via the inhalation route: LC₅₀ (mice, 1-hour) = 673 ppm; LC₅₀ (mice, 7.5-hours) = 140 ppm. Exposure to 10-13 ppm for 4-7 hours has caused eye irritation. Skin absorption of hydrogen sulfide is slight and not considered significant. However, prolonged or repeated skin contact might cause mild irritation. **The TLV for hydrogen sulfide is 10 ppm (14 mg/m³) as an 8-hour time-**

weighted average. The short-term exposure limit (15 minute) is 15 ppm. The OSHA PEL has a ceiling limit of 20 ppm and a peak of 50 ppm over any 10-minute period. NIOSH (1977) recommended a 10-minute ceiling of 10 ppm.

The threshold for smelling hydrogen sulfide is 0.003 to 0.2 ppm. At low concentrations it has a “rotten egg” odor, while at concentrations of 30 ppm and above it has a sweet odor. High concentrations deaden the sense of smell.

Due to the toxic effects and the disagreeable odor of hydrogen sulfide, laboratory operations with the agent must be conducted in a laboratory fume hood. *Use the procedures outlined in Sections 8 and 9.2 when working with hydrogen sulfide.* Cylinders of the gas should not be stored in small, unventilated rooms.

Nickel Carbonyl

The use of nickel carbonyl requires prior approval from the Principal Investigator and from the Chemical Hygiene Officer (See Section 9.2).

Nitrogen Dioxide

Nitrogen dioxide (NO₂) is classified as a highly acute toxin; it is a primary irritant, acting principally on the lungs and to a lesser extent on the upper respiratory tract. It is certainly one of the most insidious of the gases. The inflammation of the lungs may cause only slight pain, but the edema that results several days later may cause death. One hundred ppm NO₂ in air is a dangerous concentration for even a short exposure, and 200 ppm may be fatal in a short time. **The OSHA ceiling level PEL (for a 15 minute period) is 5 ppm (9 mg/m³).** Nitrogen dioxide gas is reddish brown and has an irritating odor. It is a deadly poison and only personnel familiar with its handling and its toxic effects should work with the substance. *Nitrogen dioxide should be handled using the procedures outlined in Sections 8 and 9.2.*

Mercury

The element mercury is a liquid metal with a vapor pressure of 0.00185 mm at 25°C. This corresponds to a saturation concentration of 20 milligrams of mercury per cubic meter of air or 2.4 parts per million of mercury in air.

The American Conference of Governmental Industrial Hygienists has established a threshold limit for mercury vapor of 0.05 milligrams of mercury per cubic meter of air for continuous 40-hour per week exposures. Long-term chronic exposure to mercury vapor in excess of 0.05 mg of mercury per cubic meter of air may result in cumulative poisoning. The use of mercury in laboratory with small quantities in well-ventilated areas is fairly safe; however special precautions must be followed when working with large quantities of mercury.

Mercury poisoning from exposure through chronic inhalation produces a variety of symptoms. The characteristic effects are emotional disturbance, unsteadiness, inflammation of the mouth and gums, general fatigue, memory loss, and headaches. Kidney damage may result from poisoning by mercurial salts. In most cases of exposure by chronic inhalation, the symptoms of poisoning gradually disappear when the source of exposure is removed. However, improvement may be slow and complete recovery may take years. Skin contact with mercury compounds produces irritation and various degrees of corrosion. Soluble mercury salts can be absorbed through the intact skin and produce poisoning.

The general procedures outlined in Section 8 should be followed when working with liquid mercury. Every effort should be made to prevent spills of metallic mercury because the substance is extremely difficult and time consuming to pick up. Droplets get into cracks and crevices, under table legs and under and into equipment. If spills are frequent and Hg is added to the general air level, the combined concentration may exceed the allowable limits.

Storage – Containers of large quantities of mercury should be kept closed and stored in secondary containers in a well-ventilated area. When breakage of instruments or apparatus containing mercury is a possibility, the equipment should be placed in an enameled or plastic tray or pan that can be cleaned easily and is large enough to contain the mercury in the event of an accident. Transfer of Hg from one container to another should be carried out in a fume hood, over a tray or pan to confine any spills.

Cleanup of Spills See Section 1.3

Waste Disposal See Section 11.5

Phosgene

The use of phosgene requires prior approval of the Principal Investigator and of the Chemical Hygiene Officer (See Section 9.2)

Phosgene is classified as a substance with a high degree of acute toxicity. In humans, the symptoms of overexposure to phosgene are dryness or a burning sensation in the throat, numbness, vomiting, and bronchitis. An airborne concentration of 5 ppm may cause eye irritation and coughing within a few minutes. The substance can cause severe lung injury in 1-2 minutes at a concentration of 20 ppm. Exposure to concentrations above 50 ppm is likely to be fatal. Phosgene is extremely toxic to animals via inhalation. Liquid phosgene will cause severe burns and eye irritation. **The OSHA PEL for phosgene is 0.1 ppm (0.4 mg/m³) as an 8-hour time-weighted average. NIOSH has recommended a limit of 0.2 ppm over any 15-minute period.**

Laboratory operations involving phosgene require the use of the procedures outlined in Sections 8 and 9.2. Work with phosgene should always be carried out within a fume hood. Experiments should be designed in such a manner to ensure that excess phosgene

should always be carried out within a fume hood. Experiments should be designed in such a manner to ensure that excess phosgene is destroyed (e.g. by reaction with water or dilute alkali). Note that for many applications phosgene can be replaced by less hazardous reagents diphosgene and triphosgene.

Sodium Cyanide (and other cyanide salts)

Inorganic cyanide salts are classified as substances with a high degree of acute toxicity. Sodium cyanide is among the fastest acting of all known poisons. The lethal oral dose is 200 mg. The symptoms of cyanide overdose include weakness, headache, confusion, nausea, and vomiting. Higher doses may be followed by almost instantaneous death. Sodium cyanide is highly alkaline and is corrosive to the skin and the eyes. Sodium cyanide can also produce toxic symptoms via skin absorption and inhalation. **The OSHA PEL for air contamination by cyanide is 5 mg/m³ as an 8-hour time-weighted average. In 1976, NIOSH recommended that the 5-mg/m³ limit be retained but its basis be changed from an 8-hour TWA to a 10-minute ceiling.**

Proper gloves should be worn when handling dry sodium cyanide. Rubber gloves and splash proof goggles should be worn when substantial amounts of sodium cyanide solutions are used. Hydrolysis of sodium cyanide (and other cyanide salts) by water or acid generates HCN which is extremely hazardous. Consequently, *cyanide salts should always be handled using the procedures outlined in Sections 8 and 9.2.* All reaction equipment in which cyanides are used or produced should be placed in or over shallow pans so that spills or leaks will be contained. In the event of spills of HCN or cyanide solutions, the contaminated area should be evacuated promptly and it should be immediately determined whether anyone had been exposed to cyanide vapors or liquid splash. Consideration should be given to the need for evacuating other parts of the building or notifying other occupants that the spill has occurred. Call the emergency response team (911) if you have any doubt about your ability to safely clean up a spill.

Detection – Hydrogen cyanide has a characteristic odor that resembles bitter almonds, however, many people cannot smell the agent at low concentrations, and this method of detection should not be relied upon. Vapor-detector tubes sensitive to 1 ppm of HCN are available commercially. The presence of free cyanide ion in aqueous solution may be detected by treating an aliquot of the sample with ferrous sulfate and an excess of sulfuric acid. A precipitate of Prussian blue indicates the free cyanides ions are present.

Storage – Sodium cyanide (or other cyanide salts) and acids should not be stored or transported together. An open bottle of NaCN can generate HCN in humid air, and HCN may be liberated from spills of sodium cyanide solutions.

Waste Disposal – Waste solutions containing cyanides should be sealed in clearly marked bottles. Contact the Chemical Hygiene Officer to arrange for disposal of these containers.

Safe Practices - Pyrophoric Chemicals

Safe Practices are standard operating procedures (SOP) intended to provide the Principal Investigator with general guidance on how to safely work with a specific class of chemical or hazard. This SOP is generic in nature. It addresses the use and handling of substances by hazard class only. If you have questions concerning the applicability of item listed in this procedure – contact Office of Environmental Health and Safety (513-556-4968) or the Principal Investigator of your laboratory. Specific written laboratory procedures are the responsibility of the Principal Investigator.

If compliance with all the requirements of this standard operating procedure is not possible, the Principal Investigator must develop a written procedure that will be used in its place. This alternative procedure must provide the same level of protection as the SOP it replaces. The Office of Environmental Health and Safety is available to provide guidance during the development of alternate procedures.

Pyrophoric chemicals are liquids and solids that will ignite spontaneously in air at about 130 °F. Titanium dichloride and phosphorus are examples of pyrophoric solids; tributylaluminum and related compounds are examples of pyrophoric liquids.

Securing of gas cylinders

Not applicable

Decontamination procedures

Personnel: Wash hands and arms with soap and water immediately following any skin contact with pyrophoric chemicals.

Designated area

Not applicable

Emergency procedure

Emergency procedures which address response actions to fires, explosions, spills, injury to staff, or the development of sign and symptoms of overexposure must be developed. The procedure should address as a minimum the following:

Who to contact: (University police, the Office of Environmental Health and Safety, and the Principal Investigator of the laboratory including evening phone number)

The location of all safety equipment (showers, eye wash, fire extinguishers, etc.)

The method used to alert personnel in nearby areas of potential hazards

Special spill control materials required by the type of pyrophoric chemicals handled in the laboratory

Eye protection

Eye protection in the form of safety glasses must be worn at all times when handling pyrophoric chemicals. Ordinary prescription glasses do not provide adequate protection. Adequate safety glasses must meet the requirements of the Practice for Occupational and Educational Eye and Face Protection (ANSI Z.87.1, 1989) and must be equipped with side shields. Safety glasses with side shields do not provide adequate protection from splashes; therefore, when the potential for splash hazard exists other eye protection and/or face protection must be worn.

Eyewash

Where the eyes or body of any person may be exposed to pyrophoric chemicals, suitable facilities for quick drenching or flushing of the eyes and body shall be provided within the work area for immediate emergency use. Bottle type eyewash stations are not acceptable

Fume Hood

Many pyrophoric chemicals release noxious or flammable gases and should be handled in a hood. In addition, some pyrophoric materials are stored under kerosene or other flammable solvents; therefore the use of a fume hood is required to prevent the release of flammable vapors in the laboratory. Glove boxes may also be used.

Glove (dry) box

Glove boxes may be used to handle pyrophoric chemicals if inert or dry atmospheres are required.

Gloves

Gloves should be worn when handling pyrophoric chemicals. Disposable nitrile gloves provide adequate protection against accidental hand contact with small quantities of most laboratory chemicals. Lab workers should contact EH&S for advice on chemical resistant glove selection when directed or prolonged contact with hazardous chemicals is anticipated.

Hazard assessment

Hazard assessment for work involving pyrophoric chemicals should thoroughly address the issue of fire safety (including the need for Class D fire extinguishers), proper use and handling techniques, chemicals toxicity, storage, and spill response.

EH&S Notification

Not applicable

Protective apparel

Lab coats, closed toed shoes and long sleeved clothing should be worn when handling pyrophoric chemicals. Additional protective clothing should be worn if the possibility of skin contact is likely.

Safety shielding

Safety shielding is required any time there is a risk of explosion, splash hazard or a highly exothermic reaction. All manipulations of pyrophoric chemicals which pose this risk should occur in a fume hood with the sash in the lowest feasible position. Portable shields, which provide protection to all laboratory occupants, are acceptable.

Safety shower

A safety shower should be available in a nearby location where the pyrophoric chemicals are used.

Signs and labels

Containers: All pyrophoric chemicals must be clearly labeled with the correct chemical name. Handwritten labels are acceptable, chemical formulas and structural formulas are not acceptable.

Special storage

Pyrophoric chemicals should be stored under an atmosphere of inert gas or under kerosene as appropriate. Do not store pyrophoric chemicals with flammable materials or in a flammable-liquids storage cabinet. Store these materials away from sources of ignition. Minimize the quantities of pyrophoric chemicals stored in the laboratory.

Never return excess chemicals to the original container. Small amounts of impurities may be introduced into the container which may cause a fire or explosion.

Special ventilation

Always attempt to handle pyrophoric chemicals in a fume hood or glove box. If your research does not permit the handling of pyrophoric chemicals in a fume hood or glove box you must contact the Office of Environmental Health and Safety to review the adequacy of all special ventilation.

Spill response

Anticipate spills by having the appropriate clean up equipment on hand. The appropriate clean up supplies can be determined by consulting the material safety data sheet (MSDS). This should occur prior to the use of any pyrophoric chemicals. Spill control materials for pyrophoric chemicals are designed to be inert and will not react with the reagent.

In the event of a spill alert personnel in the area that a spill has occurred do not attempt to handle a large spill of pyrophoric chemicals. Turn off all ignition sources and vacate the laboratory immediately. Call for assistance:

- University Police at 911
- Office of Environmental Health and Safety 556-4968, remain on the scene, but at a safe distance, to receive and direct safety personnel when they arrive.

Vacuum protection

Evacuated glassware can implode and eject flying glass and splattered chemicals. Vacuum work involving pyrophoric chemicals must be conducted in a fume hood or isolated in an acceptable manner.

Mechanical vacuum pumps must be protected using cold traps and where appropriate filtered to prevent particulate release. The exhaust for the pumps must be vented into an exhaust hood. Vacuum pumps should be rated for use with pyrophoric chemicals.

Waste Disposal

All materials contaminated with pyrophoric chemicals should be disposed of as hazardous waste. Alert the Office of Environmental Health and Safety if you generate wastes contaminated with pyrophoric chemicals. These wastes may pose a flammability risk and should not remain in the laboratory overnight.