UNIVERSITY
OF OREGON

CHEMICAL HYGIENE PLAN

ENVIRONMENTAL HEALTH AND SAFETY
72 ONYX BRIDGE
541-346-3192

Environmental Health and Safety

Staff and Services

Consult SRS/EHS webpage for the current contact information for the following by scanning the code:

EHS Main Phone
Waste Collection Request
Director of EHS
EHS FAX
Laboratory Safety Officer
Chemical Safety Officer
Hazardous Waste Specialist
Indoor Air Quality
Radiation Safety Officer
Biosafety Officer
Fire Marshal

OTHER CONTACT NUMBERS

EMERGENCY ---------- ---------- 911
UOPD, Non-Emergency ---------- 541-346-2919

CHEMICAL HYGIENE PLAN

11th Edition ◆ 2023

PREVIOUS EDITIONS ARE OBSOLETE.

CHEMICAL HYGIENE PLAN

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Purpose:

The purpose of the Chemical Hygiene Plan is to set forth policies and procedures in accordance with the federal Occupational Safety and Health Administration (OSHA) 1910.1450 standard and the Oregon-Occupational Safety and Health Administration (OR-OSHA) standard for Occupational Exposure to Hazardous Chemicals in Laboratories (Appendix A of this document). The information contained within this plan explains general safety and safe work practices for employees in contact with hazardous chemicals in the laboratory. The provisions defined in this plan can protect employees from health hazards associated with hazardous chemicals in the laboratory and are also capable of keeping exposures below the permissible exposure limit for OR-OSHA regulated substances.

Scope:

This Chemical Hygiene Plan applies to all employees of the University of Oregon engaged in the laboratory use of hazardous chemicals and working with these chemicals on a laboratory scale in which there is potential for exposure.

Responsibilities:

Chemical Hygiene Officer (CHO):

The Chemical Hygiene Officer for the University of Oregon will work with administrators and other employees to develop and implement appropriate chemical hygiene policies and practices. This person will assist faculty, supervisors, laboratory managers and employees to develop precautions and design adequate facilities and will know the current legal requirements concerning hazardous chemicals.

Departments:

Departments are responsible for costs incurred through the need for medical evaluations and exposure monitoring. Departments are responsible for their members' enaction of this Plan.

Employee:

Each laboratory employee is responsible for attending safety training sessions, following safety guidelines applicable to the procedures being carried out, assuring that required safety precautions are in place before work is started, and reporting hazardous conditions as they are discovered. Employees who have significant responsibility for directing their own laboratory work are responsible for assuring that potential hazards of specific projects have been identified and addressed before work is started.

Environmental Health and Safety (EHS):

Environmental Health and Safety is responsible for preparing and updating the Chemical Hygiene Plan. It also distributes the plan to applicable departments and

participates in providing resources for departments in the development of their individual Health and Safety Programs.

Laboratory Safety Advisory Committee:

The Laboratory and Studio Safety Advisory Committee (LSAC), in conjunction with Environmental Health and Safety, is responsible for implementing the Chemical Hygiene Plan. It is also responsible for review of reports regarding laboratory safety practices and recommending appropriate changes to improve employee safety.

Supervisor:

The laboratory supervisor or principal investigator is responsible for enforcing safe work practices. The supervisor will schedule time for the employee to attend designated training sessions and will provide the employee with adequate safety equipment and personal protective equipment as is needed for specific projects. The supervisor identifies potential hazards of specific projects before work is started. The supervisor will inform the employee as to the location of the Chemical Hygiene Plan and make sure that the employee has read and understands the plan. The supervisor, or their designee, shall perform regular, formal chemical hygiene and housekeeping inspections.

University:

The University of Oregon is responsible for developing and supporting a broad-based Chemical Hygiene Program that will protect laboratory employees from health effects associated with hazardous chemicals.

Standard Operating Procedures:

Safe Work Practices with Hazardous Chemicals in the Laboratory at the University of Oregon will include the following:

- Assist support personnel who may have to enter laboratories by removing hazardous materials from equipment/facilities to be serviced and forewarning them of the need for protective equipment or work practices, etc.

- Avoid the release of toxic substances in workspaces, especially in cold rooms and warm rooms, since they have recirculated atmosphere. Laboratory fume hoods shall be used for work with toxic substances in quantities where general laboratory ventilation is insufficient for hazard.

- Conduct all work within the hood at a distance of at least six inches behind the face opening, assure that airflow baffles at the back of the hood are not blocked by stored items, and position the vertical sliding sash at the height specified on the certification sticker. By following these steps, the hood provides adequate containment for most chemical operations.

- Employees with life threatening or serious injuries or exposures should immediately call **911**. Also contact University of Oregon Police Department (UOPD) dispatch at **541-346-2919**.

- Ensure unimpeded access to safety showers and eyewash stations.

- Follow the established procedures for the decontamination and safe movement of scientific and medical equipment.

- Follow established procedures for the decontamination and decommissioning of laboratory workspaces when space use changes

- When transporting hazardous material between UO spaces secondary containment or securing of the primary container is required.

- Follow hazardous material spill procedures immediately in the event of a hazardous chemical spill.

- Operate laboratory in a manner that keeps air supply and exhaust properly balanced. Open laboratory doors can adversely affect hood performance.

- Keep food, beverages, cosmetics, and medications outside the area where laboratory chemicals are immediately present.

- Keep the work area clean and uncluttered. Properly label and store chemicals (see Appendix D) and equipment; cleanup work area on completion of an operation or at the end of each day.

- Minimize hazardous chemical exposures and avoid underestimation of risks due to familiarity.

- Never mouth pipet.

- Protect your clothes and exposed skin by wearing laboratory coats. Open-toed shoes, sandals, shorts, and other apparel that leave skin exposed are not appropriate when handling potentially hazardous chemicals. ***Laboratory coats should be removed immediately if they become contaminated. EHS provides rental lab coats and cleaning of rental lab coats free of charge to the departments.***

- Refer to the (Material) Safety Data Sheet ((M)SDS) before working with a chemical. Pay particular attention to route of entry, protective measures, spill response, and symptoms of exposure.

- Remove your gloves carefully and thoroughly wash your hands and forearms upon completion of work and before leaving the laboratory.

- Use a chemical fume hood when opening, pouring or handling hazardous chemicals. Do not exceed the PELs (Permissible Exposure Limits of OR-OSHA, equivalent to Chapter 29 Code of Federal Regulations Part 1910, Subdivision Z). See Appendix B of this document.

- Wear gloves and eye/face protection whenever handling hazardous chemicals. Select PPE based upon risk assessment and manufacturer's guidance on material properties.

Additional information is available in a National Research Council publication entitled *Prudent Practices in the Laboratory, Handling and Management of Chemical Hazards*. (Washington D.C.: National Academy Press, 2011). *Prudent Practices PDF* is available online and free of charge through NIH NCBI Bookshelf website.

Control Measures:

Engineering Controls:

Engineering controls are physical structures used to minimize the hazards of a substance to the user.

Use of Fume Hoods:

A fume hood is a protective device used for manipulations which may result in the release of toxic chemical vapors, dust, or aerosols. The fume hood draws air from the laboratory to prevent or minimize the escape of air contaminants from the inside of the hood to the general laboratory area. Chemical manipulations are conducted in the enclosure without insertion of any portion of the employee's body other than hands and arms.

Characteristics to be considered in requiring fume hood use are the physical state, volatility, toxicity, flammability, eye and skin irritation, odor, and the potential for producing aerosols.

A fume hood should be used when one of following occurs during a chemical procedure:

- Emits airborne concentrations which might approach the action level (or permissible exposure limit, PEL).

- Emits flammable vapors which might approach one tenth (10%) of the lower explosion limit. Flammable vapors must not exceed one quarter (25%) of the lower explosion limit (OMSC 510.2). Refer to chemical SDS section 9.

- When materials of unknown toxicity are used or generated.

- When toxic vapors, gases, fumes, mist, or dust from substances with a health hazard rating of 1, 2, 3, or 4 are generated. The concentration of toxic vapors,

gases, fumes, mist, or dusts must not exceed 1% of the median lethal concentration for acute inhalation toxicity (OMSC 510.2). Refer to chemical SDS section 11.

- Produces an odor that is annoying to laboratory occupants or adjacent units.

***Safety Shields or Other Containment Devices**:*

Safety shielding, such as the sliding sash of a fume hood and benchtop safety shielding, is advised for a chemical procedure when the following occurs:

- Working with any substance that has a potential for splattering or explosion. This includes highly concentrated acids, bases, oxidizers or reducing agents.
- Working under non-ambient pressure (vacuum or high pressure).
- Working with a reaction for the first time.
- Working with a sealed-up reaction.

Other containment devices such as glove boxes and vented gas cabinets are used when the following occurs:

- An inert atmosphere for the chemical procedure is needed.
- Capture of any chemical emission is needed.
- A standard laboratory fume hood does not provide adequate assurance that overexposure to a hazardous chemical will not occur.
- Toxic compressed gases are stored and used at volumes greater than that of a laboratory lecture cylinder.
- There are special containment requirements for certain biological or radioactive materials.

Highly localized exhaust ventilation (snorkel tubes) may be required for equipment that exhausts toxic or irritating materials to the laboratory environment.

Personal Protective Equipment:

***Eye and Face Protection**:*

Eye protection is required for all personnel and any visitors whose eyes may be exposed to liquid chemicals or physical hazards. Any personal protective equipment (PPE) designated for eye and face protection should meet the requirements listed in ANSI Z87.1 and OR-OSHA 1910.133 regulations.

General eye and face protective guidelines include the following:

- Safety glasses with side shields are required in any operation where there is limited potential for eye exposure to hazardous liquids or projectiles.

- Safety goggles are recommended for operations where there is significant potential for hazardous material splashes or projectiles.

- Face shields are recommended in operations where there is high potential for high-risk hazardous material splashes or projectiles. Face shields provide maximum protection to the face and throat. Face shields should not be used as a substitute for eye protection; safety glasses or chemical goggles are required whenever using a face shield.

***Foot Protection**:*

Bare feet, sandals, perforated shoes, or open-toed shoes are not allowed as working attire within laboratories where chemicals are used or stored.

***Hand and Body Protection**:*

Hand and body protection is required when working with chemicals that can cause significant exposure through skin contact. Appropriate gloves, lab coats, and other personal protection should be selected to meet the specific chemical work environment's needs. General requirements for hand and body protection include the following:

- Lab coats should be worn by personnel in any area where chemicals are routinely used or stored. Lab coats are required when working with carcinogens, reproductive toxins, substances which have a high degree of acute toxicity, strong acids and bases, and any substance on the OR-OSHA list for Limits of Exposure to Toxic and Hazardous Substances that carries a "skin" notation. See Appendix B web link for chemical listings.

- **Lab coats will <u>not</u> be taken home to be laundered. Lab coats and lab coat laundering are available through EHS lab coat rental at no cost to departments.**

- Gloves made of appropriate material are necessary to protect the hands and arms from thermal burns, cuts, or chemical exposure that may result in absorption through the skin or reaction on the surface of the skin.

- Glove materials must be chosen with the specific chemical use in mind (type of material, thickness, breakthrough time and permeation rate). A glove reference chart is available from each specific glove manufacturer.

- Gloves are required for work involving pure or concentrated solutions of select carcinogens, reproductive toxins, substances which have a high degree of acute toxicity, strong acids and bases, cryogens, and any substance on the OR-OSHA PEL list carrying a "skin" notation. See Appendix B web link for chemical listings.

- Inspect gloves for defects or tears before each use. Double glove when working with particular hazardous materials, or when there are poor warning properties of glove breakthrough.

Hygiene Practices:

Laboratory workers should not eat, drink, smoke, chew gum, or apply cosmetics in areas where laboratory chemicals are present. Laboratory workers should wash their hands before conducting these activities.

Laboratory workers should not store or prepare food or beverages in storage areas or refrigerators used for laboratory operations; in glassware which is used for laboratory operations; or in any other device used for laboratory operations (e.g., microwaves or ovens). Food and beverages should not be handled with laboratory utensils.

Keep the laboratory work area clean and uncluttered. Clean up the work area on completion of an operation or at the end of each day. Maintain required clearances around safety equipment, electrical equipment, and other areas as required by code.

Laboratory workers should wash their hands thoroughly after removing PPE and before exiting the laboratory. Gloves should not be worn on both hands when traveling building corridors, or at any point when activating door hardware is necessary.

Respirators:

In certain situations where engineering controls cannot effectively control the amount of chemical air contaminants within the work environment, personnel may be required to wear respiratory protective equipment. Personnel designated to use respiratory equipment must first have appropriate approvals and training via the University Respiratory Protection Program offered by EHS. Availability of respiratory protection for emergency situations may be required when working with chemicals that are highly toxic and highly volatile or gaseous. If an experimental protocol creates exposure above the permissible exposure limit that cannot be reduced, respiratory protection will be required.

Performance Management

Monitoring:

Fume hoods should be monitored upon every use by the user to ensure that air is moving into the hood. The hood should have a continuous reading device, such as a pressure gauge, to indicate that air is moving correctly. Hood users should also attach a strip of tissue or thin tape to the bottom of the vertical sliding sash as a visual indicator of air flow. To ensure adequate capture, users must also ensure that the hood and baffles are not blocked by equipment or storage containers.

Eye washes should be flushed weekly by the user. Should emergency use become necessary, this will ensure that the eye wash is working and that the water is clean.

***Performance Verification**:*

Environmental Health and Safety will measure the average face velocity of each fume hood annually, and upon maintenance impacting the fume hood exhaust rate. Hood alarms and automatic sash positioning systems will also be tested. Performance will be verified and documented according to EHS procedure.

Environmental Health and Safety will ensure that the emergency showers and eye washes are checked for operation annually.

Equipment that does not meet the requirements of the performance check shall have a request for servicing submitted to Campus Operations. Nonfunctional equipment shall be labeled as such and should not be used until repairs are complete. EHS will recheck performance upon notification of repair.

Information and Training

Information:

Oregon - Occupational Safety and Health Administration Laboratory Standard: "Occupational Exposure to Hazardous Chemicals in Laboratories" and its Appendices (Oregon Administrative Rule Chapter 437 Division 2 Part 1910.1450), a copy of which is found in Appendix A of this Chemical Hygiene Plan.

Reference Materials:

Safety Data Sheets (SDS) for laboratory chemicals are readily available online from the chemical manufacturer. Departments that receive SDSs directly with chemical shipments will make such information available to the employees using the chemicals. Employees must be informed of the location and availability of all chemical reference materials.
Links to web based SDS files are also accessible on the Environmental Health and Safety website through contract with MSDS Online. Links are also available directly via the Environmental Health and Safety Assistant (EHSA) materials inventory database for those laboratories recording inventory within the database.

Signs and Symptoms:

The signs and symptoms associated with exposure to hazardous chemicals may be found in the following references: Laboratory Chemical Safety Summaries (LCSS's) for 88 commonly encountered laboratory chemicals, are located in the Supplemental Materials on CD of Prudent Practices in the Laboratory, 2011 edition and are available online from NIH NLM NCBI. LCSS's are similar to Material Safety Data Sheets (MSDS) but are tailored to the hazards of laboratory use of those chemicals. A more extensive list of LCSS's are available online through NIH NLM NCBI PubChem.

University of Oregon Chemical Hygiene Plan:

The University of Oregon's Chemical Hygiene Plan is available to all employees and can be found on the Environmental Health and Safety website.

Training:

Each laboratory supervisor is responsible for ensuring that laboratory employees are provided with training about the hazards of chemicals present in their laboratory work area, and methods to control exposure to such chemicals. Such training must 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 potential exposure situations. Training shall include the following topics.

Chemical Hygiene Plans:
Details of the University Chemical Hygiene Plan and an individual laboratory's Standard Operating Procedures and Laboratory-Specific Plans.

Emergency Response:
Appropriate actions for emergency response within individual laboratories.

Information Available:
The use and location of Safety Data Sheets and Laboratory Chemical Safety Summaries, and other laboratory-specific references.

Methods to Detect the Presence of Hazardous Chemicals:
Hazardous chemicals are identified through the observation of labeling and information available, odors present, real-time monitoring, air sampling, etc.

Physical and Health Hazardous:
Hazards to be reviewed include toxicity, exposure levels, routes of entry, acute and chronic effects, dose-response relationship, LD_{50}, threshold limit values and permissible exposure limits, exposure time, and health hazards related to classes of chemicals manipulated within a laboratory.

Prior Approval:
The responsibility for approval of the acquisition and use of toxic chemical agent's rests with the laboratory supervisor. If there are questions concerning the need for university approvals, contact Environmental Health and Safety.

Protective Measures:
Laboratory practices intended to reduce personal exposure and to control physical hazards, as well as specific protective mechanisms and warning systems used in individual laboratories. Appropriate use of fume hoods and required PPE is to be specifically addressed.

Medical Consultation and Examination

Criteria for Consultation and Examination:

All University of Oregon employees who work with hazardous chemicals will have an opportunity to receive medical attention, including any follow-up examinations that the examining physician determines to be necessary under the following circumstances:

Whenever an employee develops signs or symptoms associated with a hazardous chemical to which the employee may have been exposed in the laboratory, the employee shall be provided an opportunity to receive appropriate medical attention.

Where exposure monitoring reveals an exposure level routinely above the action level (or in the absence of an action level, the PEL) for an OR-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 standard.

Whenever an event takes place in the work area such as a spill, leak, explosion, or other occurrence resulting in the likelihood of hazardous exposure, the affected employee shall be provided an opportunity for a medical consultation.

The Chemical Hygiene Officer shall be contacted whenever the need for medical consultation or examination occurs, or when there is uncertainty as to whether any of the above criteria have been met.

Documentation and Distribution of Medical Report:

The examining physician will provide the Office of Risk Management with information about the employee's physical restrictions that may affect the employee's performance or ability to be in contact with specific chemical. The Office of Risk Management, or Environmental Health and Safety, will notify the employees' department of these restrictions.

All employee medical information, such as diagnosis and prognosis will be kept on file by the health care provider.

Information for Examining Physician:

The employer shall provide the following information to the physician:

- The identity of the hazardous chemical(s) to which the employee may have been exposed. And, when available, specific written recommendations for treatment of chemical exposures (e.g. the UO Hydrofluoric Acid Hazard Alert).

- A description of the conditions under which the exposure occurred including quantitative exposure data, if available.

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

The above information will be collected and transmitted by the employee's supervisor or department and submitted to Environmental Health and Safety and the examining physician.

Medical Service Provider:

All medical examinations and consultation 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. The University of Oregon's Office of Risk Management will coordinate those services for university employees.

For problems from exposures, the employee can contact a physician of his/her choice, including providers at an urgent care clinic or emergency room.

Written Report from the Examining Physician:

For examination or consultation, the examining physician will provide a written report that shall include the following:

- Any recommendation for further medical follow-up.

- Fitness for work based upon the results of the medical examination and any associated tests.

- Any medical condition which may be revealed during the examination which may place the employee at increased risk as a result of exposure to a hazardous workplace.

- A statement that the employee has been informed by the physician of the results of the consultation or medical examination and any medical condition that may require further examination or treatment.

The written opinion shall not reveal specific findings or diagnoses unrelated to occupational exposure.

Particularly Hazardous Substances

Protective Provisions:

Laboratory supervisors are responsible for assuring that laboratory procedures involving particularly hazardous chemicals have been evaluated for the level of employee protection required. It is important to understand that the OR-OSHA permissible exposure limits (PELs) and substance-specific standards do not include all hazardous chemicals. It is the laboratory supervisor's responsibility under the Laboratory Standard and the "general duty" clause to apply scientific knowledge in safeguarding workers against risks, even though there may be no specifically applicable OR-OSHA standard.

When Additional Protection is Needed:

Additional employee protection will be considered for work with particularly hazardous substances. These include select carcinogens, reproductive toxins, and substances that have a high degree of acute toxicity (see Appendix B with link to materials).

Before working with a particularly hazardous substance or with materials approaching 25% of lower explosion limit, consideration should be given to the need for inclusion of the following special provisions:

- Establishment of a designated area.
- Use of containment devices such as fume hoods or glove boxes.
- Written Standard Operating Procedures (SOPs)
- Procedures for safe removal of contaminated waste.
- Decontamination procedures.

Evaluate, assess, and implement these special provisions as appropriate.

Review and Documentation of Chemical Hygiene Plan

Documentation

Documentation associated with the Chemical Hygiene Plan shall be maintained as follows.

Accident Records:
Records of accidents and near-misses will be written, retained, and reviewed by the Laboratory Safety Advisory Committee. Lessons-learned from incident investigations will be written and distributed among laboratory supervisors.

Hazardous Materials Inventories:
Inventory records of chemicals and other hazardous materials purchased and stored will be maintained by laboratories and will be provided to Environmental

Health and Safety for centralized data warehousing and reporting. Employee usage records should also be maintained for materials of known high hazard.

Facility Design:
Facility design records should be retained to indicate compatibility of design with knowledge and regulation current at the time of design.

Exposure Evaluation*:*
Any records of exposure evaluation carried out by individual departments (including continuous monitoring systems) should be retained by the department and a copy sent to Environmental Health and Safety. Results of exposure evaluations carried out by EHS will be kept by EHS and copies sent to the employee, the employee's supervisor, and the University Health Center. The evaluation report data collected by EHS will be retained for the term of employment plus 30 years.

Fume Hood Monitoring*:*
Data on annual fume hood monitoring will be kept at Environmental Health and Safety. Fume hood monitoring data are considered maintenance records and as such the data will be retained for five years.

Medical Consultation and Examination**:**
Results of medical consultations and examinations will be kept by the health care provider for a length of time specified by the appropriate medical records standard. This time will be at least 30 years as required within OR-OSHA 1910.1020.

Training*:*
Individual employee training should be recorded on a Lab Specific Training form available through EHS (or equivalent) and should be kept in the individual department for five years. Training records shall be available for inspection. Training conducted by Environmental Health and Safety (EHS) will be retained by EHS.

Periodic Review

On an annual basis, this Chemical Hygiene Plan will be reviewed and evaluated for effectiveness by Environmental Health and Safety and the Laboratory Safety Advisory Committee. It will be updated as necessary. Any changes in the Chemical Hygiene Plan will be transmitted to all departments in possession of hazardous chemicals.

References

Oregon Administrative Rules, Chapter 437 Division 2 Subdivision Z Part 1910, Toxic and Hazardous Substances, 1996

Office of the Federal Register National Archives and Records Administration, *Code of Federal Regulations, Title 29 Labor* (Washington D.C.: United States Government Printing Office, 1992)

National Research Council, *Prudent Practices for Handling Hazardous Chemicals in Laboratories* (Washington D.C.: National Academy Press, 1981)

National Research Council, *Prudent Practices in the Laboratory, Handling and Disposal of Chemicals* (Washington D.C.: National Academy Press, 1995)

National Research Council, *Prudent Practices in the Laboratory, Handling and Management of Chemical Hazards* (Washington D.C.: National Academy Press, 2011)

Oregon Mechanical Specialty Code, Chapter 5 Section 510.2 (2014)

University of Oregon, Office of Environmental Health and Safety
https://safety.uoregon.edu/environmental-health-and-safety

University of Oregon, EHS, Chemical Safety
https://safety.uoregon.edu/chemical-safety

SDS for UO Employees
https://safety.uoregon.edu/safety-data-sheets

Appendices to the UO Chemical Hygiene Plan
Appendix A
https://www.osha.gov/laws-regs/regulations/standardnumber/1910/1910.1450
Appendix B
https://osha.oregon.gov/OSHARules/div2/div2Z-437-002-0382-air-cont.pdf
Appendix C
https://safety.uoregon.edu/sites/safety1.uoregon.edu/files/lab_specific_training_guide_2020-f.pdf
Appendix D

Documentation:

Original Preparation Date: 12/01/98
Latest Revision Number: 10
Latest Revision Date: 5/11/2023

Appendix A: OSHA Laboratory Standard

29 CFR 1910.1450—Occupational Exposure to Hazardous Chemicals in Laboratories

(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 29 CFR 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 designated in 29 CFR part 1910 for a specific substance, calculated as an eight (8)-hour time-weighted average, which initiates certain required activities such as exposure monitoring and medical surveillance.

"Assistant Secretary" means the Assistant Secretary of Labor for Occupational Safety and Health, U.S. Department of Labor, or designee. "Carcinogen" (see "select carcinogen").

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

"Chemical Hygiene Plan" means a written program developed and implemented by the employer which sets forth procedures, equipment, personal protective equipment and work practices that (i) are capable of protecting employees from the health hazards presented by hazardous chemicals used in that particular workplace and (ii) meets the requirements of paragraph (e) of this section. "Combustible liquid" means any liquid having a flashpoint at or above 100 deg. F (37.8 deg. C), but below 200 deg. F (93.3 deg. C), except any mixture having components with flashpoints of 200 deg. F (93.3 deg. C), or higher, the total volume of which make up 99 percent or more of the total volume of the mixture.

"Compressed gas" means: (i) A gas or mixture of gases having, in a container, an absolute pressure exceeding 40 psi at 70 deg. F (21.1 deg. C); or (ii) A gas or mixture of gases having, in a container, an absolute pressure exceeding 104 psi at 130 deg. F (54.4 deg. C) regardless of the pressure at 70 deg. F (21.1 deg. C); or (iii) A liquid having a vapor pressure exceeding 40 psi at 100 deg. F (37.8 deg. 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, such as a laboratory hood.

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

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

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

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

(i) "Aerosol, flammable" means an aerosol that, when tested by the method described in 16 CFR 1500.45, yields a flame protection exceeding 18 inches at full valve opening, or a flashback (a flame extending back to the valve) at any degree of valve opening;

(ii) "Gas, flammable" means: (A) A gas that, at ambient temperature and pressure, forms a flammable mixture with air at a concentration of 13 percent by volume or less; or (B) A gas that, at ambient temperature and pressure, forms a range of flammable mixtures with air wider than 12 percent by volume, regardless of the lower limit.

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

(iv) "Solid, flammable" means a solid, other than a blasting agent or explosive as defined in 1910.109(a), that is liable to cause fire through friction, absorption of moisture, spontaneous chemical change, or retained heat from manufacturing or processing, or which can be ignited readily and when ignited burns so vigorously and persistently as to create a serious hazard. A chemical shall be considered to be a flammable solid if, when tested by the method described in 16 CFR 1500.44, it ignites and burns with a self-sustained flame at a rate greater than one-tenth of an inch per second along its major axis.

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

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

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

(iii) Setaflash Closed Tester (see American National Standard Method of Test for Flash Point by Setaflash Closed Tester (ASTM D 3278-78)). 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 movable sash or fixed partial enclosed on the remaining side; constructed and maintained to draw air from the laboratory and to prevent or minimize the escape of air contaminants into the laboratory; and allows chemical manipulations to be conducted in the enclosure without insertion of any portion of the employee's body other than hands and arms. Walk-in hoods with adjustable sashes meet the above definition provided that the sashes are adjusted during use so that the airflow and the exhaust of air contaminants are not compromised and employees do not work inside the enclosure during the release of airborne hazardous chemicals.

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

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

(ii) Multiple chemical procedures or chemicals are used;

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

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

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

"Organic peroxide" means an organic compound that contains the bivalent —O—O— structure and which may be considered to be a structural derivative of hydrogen peroxide where one or both of the hydrogen atoms have 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 chemicals which affect the reproductive capabilities including chromosomal damage (mutations) and effects on fetuses (teratogenesis).

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

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

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

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

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

animals in accordance with any of the following criteria: (A) After inhalation exposure of 6-7 hours per day, 5 days per week, for a significant portion of a lifetime to dosages of less than 10 mg/m(3); (B) After repeated skin application of less than 300 (mg/kg of body weight) per week; or (C) After oral dosages of less than 50 mg/kg of body weight per day.

"Unstable (reactive)" means a chemical which in 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

(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 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 1910.120)

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) Record-keeping.

(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.

(l) 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.

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

Table Of Contents

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 (e) of the standard. It indicates those sections of this appendix which are most pertinent to each of the sections of paragraph (e) and related paragraphs.

Paragraph and topic in laboratory standard appendix section	Relevant
(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. (References 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
   (b) Monitor procurement, use, and disposal of chemicals used in the lab (8);
   (c) See that appropriate audits are maintained (8);
   (d) Help project directors develop precautions and adequate facilities (10);
   (e) Know the current legal requirements concerning regulated substances (50); and
   (f) Seek ways to improve the chemical hygiene program (8, 11).
4. Laboratory supervisor, who has overall responsibility for chemical hygiene in the laboratory (21) including responsibility to:
   (a) Ensure that workers know and follow the chemical hygiene rules, that protective equipment is available and in working order, and that appropriate training has been provided (21, 22);
   (b) Provide regular, formal chemical hygiene and housekeeping inspections including routine inspections of emergency equipment (21, 171);
   (c) Know the current legal requirements concerning regulated substances (50, 231);
   (d) Determine the required levels of protective apparel and equipment (156, 160, 162); and
   (e) Ensure that facilities and training for use of any material being ordered are adequate (215).
5. Project director or director of other specific operation, who has primary responsibility for chemical hygiene procedures for that operation (7).
6. Laboratory worker, who is responsible for:
   (a) Planning and conducting each operation in accordance with the institutional chemical hygiene procedures (7, 21, 22, 230); and
   (b) Developing good personal chemical hygiene habits (22).

C. The Laboratory Facility

1. Design. The laboratory facility should have:
   (a) An appropriate general ventilation system (see C4 below) with air intakes and exhausts located so as to avoid intake of contaminated air (194);
   (b) Adequate, well-ventilated stockrooms/storerooms (218, 219);
   (c) Laboratory hoods and sinks (12, 162);
   (d) Other safety equipment including eyewash fountains and drench showers (162, 169); and
   (e) Arrangements for waste disposal (12, 240).
2. Maintenance. Chemical-hygiene-related equipment (hoods, incinerator, etc.) should undergo continual appraisal and be modified if inadequate (11, 12).
3. Usage. The work conducted (10) and its scale (12) must be appropriate to the physical facilities available and, especially, to the quality of ventilation (13).
4. Ventilation—
   (a) General laboratory ventilation. This system should: Provide a source of air for breathing and for input to local ventilation devices (199); it should not be relied on for protection from toxic substances released into the laboratory (198); ensure that laboratory air is continually replaced, preventing increase of air concentrations of toxic substances during the working day (194); direct air flow into the laboratory from non-laboratory areas and out to the exterior of the building (194).
   (b) Hoods. A laboratory hood with 2.5 linear feet of hood space per person should be provided for every 2 workers if they spend most of their time working with chemicals (199); each hood should have a continuous monitoring device to allow convenient con-

firmation of adequate hood performance before use (200, 209). If this is not possible, work with substances of unknown toxicity should be avoided (13) or other types of local ventilation devices should be provided (199). See pp. 201-206 for a discussion of hood design, construction, and evaluation.

(c) Other local ventilation devices. Ventilated storage cabinets, canopy hoods, snorkels, etc. should be provided as needed (199). Each canopy hood and snorkel should have a separate exhaust duct (207).

(d) Special ventilation areas. Exhaust air from glove boxes and isolation rooms should be passed through scrubbers or other treatment before release into the regular exhaust system (208). Cold rooms and warm rooms should have provisions for rapid escape and for escape in the event of electrical failure (209).

(e) Modifications. Any alteration of the ventilation system should be made only if thorough testing indicates that worker protection from airborne toxic substances will continue to be adequate (12, 193, 204).

(f) Performance. Rate: 4-12 room air changes/hour is normally adequate general ventilation if local exhaust systems such as hoods are used as the primary method of control (194).

(g) Quality. General air flow should not be turbulent and should be relatively uniform throughout the laboratory, with no high velocity or static areas (194, 195); airflow into and within the hood should not be excessively turbulent (200); hood face velocity should be adequate (typically 60-100 lfm) (200, 204).

(h) Evaluation. Quality and quantity of ventilation should be evaluated on installation (202), regularly monitored (at least every 3 months) (6, 12, 14, 195), and reevaluated whenever a change in local ventilation devices is made (12, 195, 207). See pp. 195-198 for methods of evaluation and for calculation of estimated airborne contaminant concentrations.

D. Components of the Chemical Hygiene Plan

1. Basic Rules and Procedures (Recommendations for these are given in section E, below.)

2. Chemical Procurement, Distribution, and Storage

(a) Procurement. Before a substance is received, information on proper handling, storage, and disposal should be known to those who will be involved (215, 216). No container should be accepted without an adequate identifying label (216). Preferably, all substances should be received in a central location (216).

(b) Stockrooms/storerooms. Toxic substances should be segregated in a well-identified area with local exhaust ventilation (221). Chemicals which are highly toxic (227) or other chemicals whose containers have been opened should be in unbreakable secondary containers (219). Stored chemicals should be examined periodically (at least annually) for replacement, deterioration, and container integrity (218-19). Stockrooms/storerooms should not be used as preparation or repackaging areas, should be open during normal working hours, and should be controlled by one person (219).

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

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

3. Environmental Monitoring

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

4. Housekeeping, Maintenance, and Inspections

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

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

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

Procedures to prevent restarting of out-of-service equipment should be established (25).
(d) Passageways. Stairways and hallways should not be used as storage areas (24). Access to exits, emergency equipment, and utility controls should never be blocked (24).

5. Medical Program
(a) Compliance with regulations. Regular medical surveillance should be established to the extent required by regulations (12).
(b) Routine surveillance. Anyone whose work involves regular and frequent handling of toxicologically significant quantities of a chemical should consult a qualified physician to determine on an individual basis whether a regular schedule of medical surveillance is desirable (11, 50).
(c) First aid. Personnel trained in first aid should be available during working hours and an emergency room with medical personnel should be nearby (173). See pp. 176-178 for description of some emergency first aid procedures.

6. Protective Apparel and Equipment
These should include for each laboratory:
(a) Protective apparel compatible with the required degree of protection for substances being handled (158-161);
(b) An easily accessible drench-type safety shower (162, 169);
(c) An eyewash fountain (162)
(d) A fire extinguisher (162-164);
(e) Respiratory protection (164-9), fire alarm and telephone for emergency use (162) should be available nearby; and (f) Other items designated by the laboratory supervisor (156, 160).

7. Records
(a) Accident records should be written and retained (174).
(b) Chemical Hygiene Plan records should document that the facilities and precautions were compatible with current knowledge and regulations (7).
(c) Inventory and usage records for high-risk substances should be kept as specified in section E3e below.
(d) Medical records should be retained by the institution in accordance with the requirements of state and federal regulations (12).

8. Signs and Labels
Prominent signs and labels of the following types should be posted:
(a) Emergency telephone numbers of emergency personnel/facilities, supervisors, and laboratory workers (28);
(b) Identity labels, showing contents of containers (including waste receptacles) and associated hazards (27, 48);
(c) Location signs for safety showers, eyewash stations, other safety and first aid equipment, exits (27) and areas where food and beverage consumption and storage are permitted (24); and
(d) Warnings at areas or equipment where special or unusual hazards exist (27).

9. Spills and Accidents
(a) A written emergency plan should be established and communicated to all personnel; it should include procedures for ventilation failure (200), evacuation, medical care, reporting, and drills (172).
(b) There should be an alarm system to alert people in all parts of the facility including isolation areas such as cold rooms (172).
(c) A spill control policy should be developed and should include consideration of prevention, containment, cleanup, and reporting (175).
(d) All accidents or near accidents should be carefully analyzed with the results distributed to all who might benefit (8, 28).

10. Information and Training Program
(a) Aim: To assure that all individuals at risk are adequately informed about the work in the laboratory, its risks, and what to do if an accident occurs (5, 15).
(b) Emergency and Personal Protection Training: Every laboratory worker should know the location and proper use of available protective apparel and equipment (154, 169). Some of the full-time personnel of the laboratory should be trained in the proper use of emergency equipment and procedures (6). Such training as well as first aid instruction should be available to (154) and encouraged for (176) everyone who might need it.
(c) Receiving and stockroom/storeroom personnel should know about hazards, handling equipment, protective apparel, and relevant regulations (217).
(d) Frequency of Training: The training and education program should be a regular, continuing activity-not simply an annual presentation (15).
(e) Literature/Consultation: Literature and consulting advice concerning chemical hygiene should be readily available to laboratory person-

nel, 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 on 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 those mentioned above, for work with substances of known high chronic toxicity (in quantities above a few milligrams to a few grams, depending on the substance) (47). (Procedure A of "Prudent Practices" pp. 47-50.)

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

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

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

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

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

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

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

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

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

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

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

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

5. Animal Work with Chemicals of High Chronic Toxicity

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

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

(c) Aerosol suppression: Devise procedures which minimize formation and dispersal of contaminated aerosols, including those from food, urine, and feces (e.g., use HEPA filtered vacuum

equipment for cleaning, moisten contaminated bedding before removal from the cage, mix diets in closed containers in a hood) (55, 56).
(d) Personal protection: When working in the animal room, wear plastic or rubber gloves, fully buttoned laboratory coat or jumpsuit and, if needed because of incomplete suppression of aerosols, other apparel and equipment (shoe and head coverings, respirator) (56).
(e) Waste disposal: Dispose of contaminated animal tissues and excreta by incineration if the available incinerator can convert the contaminant to non-toxic products (238); otherwise, package the waste appropriately for burial in an EPA-approved site (239).

F. Safety Recommendations

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

1. Corrosive agents: (35-6)
2. Electrically powered laboratory apparatus: (179-92)
3. Fires, explosions: (26, 57-74, 162-4, 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
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)
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)

29 CFR 1910.1450 App. B References (Non-Mandatory)
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 nonmandatory 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 Labora-

tory, 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.812385, GPO, Washington, DC 20402, 1981.
7. National Research Council, Prudent Practices for Disposal of Chemicals from Laboratories, National Academy Press, Washington, DC, 1983.
8. National Research Council, Prudent Practices for Handling Hazardous Chemicals in Laboratories, National Academy Press, Washington, DC, 1981.
9. Renfrew, Malcolm, Ed., Safety in the Chemical Laboratory, Vol. IV, J. Chem. Ed., American Chemical Society, Easlon, PA, 1981.
10. Steere, Norman V., Ed., Safety in the Chemical Laboratory, J. Chem. Ed. American Chemical Society, Easlon, PA, 18042, Vol. I, 1967, Vol. II, 1971, Vol. III, 1974.
11. Steere, Norman V., Handbook of Laboratory Safety, the Chemical Rubber Company, Cleveland, OH, 1971.
12. Young, Jay A., Ed., Improving Safety in the Chemical Laboratory, John Wiley & Sons, Inc., New York, 1987.

(b) HAZARDOUS SUBSTANCES INFORMATION:

1. American Conference of Governmental Industrial Hygienists, Threshold Limit Values for Chemical Substances and Physical Agents in the Workroom Environment with Intended Changes, 6500 Glenway Avenue, Bldg. D-7, Cincinnati, OH 45211-4438.
2. Annual Report on Carcinogens, National Toxicology Program U.S. Department of Health and Human Services, Public Health Service, U.S. Government Printing Office, Washington, DC (latest edition).
3. Best Company, Best Safety Directory, Vols. I and II, Oldwick, 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).
8. NIOSH/OSHA Pocket Guide to Chemical Hazards. NIOSH Pub. No. 85-114, U.S. Government Printing Office, Washington, DC, 1985 (or latest edition).
9. Occupational Health Guidelines, NIOSH/OSHA. NIOSH Pub. No. 81-123, U.S. Government Printing Office, Washington, DC, 1981.
10. Patty, F.A., Industrial Hygiene and Toxicology, John Wiley & Sons, Inc., New York, NY (Five Volumes).
11. Registry of Toxic Effects of Chemical Substances, U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, Revised Annually, for sale from Superintendent of Documents, U.S. Govt. Printing Office, Washington, DC 20402.
12. The Merck Index: An Encyclopedia of Chemicals and Drugs. Merck and Company Inc., Rahway, NJ, 1976 (or latest edition).
13. Sax, N.I. Dangerous Properties of Industrial Materials, 5th edition, Van Nostrand Reinhold, NY, 1979.
14. Sittig, Marshall, Handbook of Toxic and Hazardous Chemicals, Noyes Publications, Park Ridge, NJ, 1981.

(c) Information on Ventilation:

1. American Conference of Governmental Industrial Hygienists. Industrial Ventilation (latest edition), 6500 Glenway Avenue, Bldg. D-7, Cincinnati, OH 45211-4438.
2. American National Standards Institute, Inc. American National Standards Fundamentals Governing the Design and Operation of Local Exhaust Systems ANSI Z 9.2-1979, American National Standards Institute, NY 1979.
3. Imad, A.P. and Watson, C.L. Ventilation Index: An Easy Way to Decide about Hazardous Liquids, Professional Safety, pp. 15-18, April 1980.
4. National Fire Protection Association, Fire Protection for Laboratories Using Chemi-

cals NFPA-45, 1982. Safety Standard for Laboratories in Health Related Institutions, NFPA, 56c, 1980. Fire Protection Guide on Hazardous Materials, 7th edition, 1978. National Fire Protection Association, Batterymarch Park, Quincy, MA 02269.

5. Scientific Apparatus Makers Association (SAMA), Standard for Laboratory Fume Hoods, SAMA LF7-1980, 1101 16th Street, NW, Washington, DC 20036.

(d) INFORMATION ON AVAILABILITY OF REFERENCED MATERIAL

1. American National Standards Institute (ANSI), 1430 Broadway, New York, NY 10018.

2. American Society for Testing and Materials (ASTM), 1916 Race Street, Philadelphia, PA 19103.

(Approved by the Office of Management and Budget under control number 1218-0131)
[55 FR 3327, Jan. 31, 1990]

Department of Consumer and Business Services

Oregon Occupational Safety and Health Division - Chapter 437

Division 2
GENERAL OCCUPATIONAL SAFETY AND HEALTH RULES

437-002-0382
Oregon Rules for Air Contaminants

An employee's exposure to any substance listed in Oregon Tables Z-1, Z-2, or Z-3 of this section shall be limited in accordance with the requirements of the following paragraphs of this section.
(1) Oregon Table Z-1.
(a) Substances with limits preceded by "C" – Ceiling Values. An employee's expo- sure to any substance in Oregon Table Z-1, the exposure limit of which is preceded by a "C", shall at no time exceed the exposure limit given for that substance. If instantaneous monitoring is not feasible, then the ceiling shall be assessed as a 15-minute time weighted average exposure which shall not be exceeded at any time during the working day.
(b) Other substances – 8-hour Time Weighted Averages. An employee's exposure to any substance in Oregon Table Z-1, the exposure limit of which is not preceded by a "C", shall not exceed the 8-hour Time Weighted Average given for that substance in any 8-hour work shift of a 40-hour work week.
(c) Other Substances – Excursion Limits. Excursions in worker exposure levels may exceed 3 times the PEL-TWA for no more than a total of 30 minutes during a workday, and under no circumstances should they exceed 5 times the PEL-TWA, provided that the PEL-TWA is not exceeded.
(d) Skin Designation. To prevent or reduce skin absorption, an employee's skin exposure to substances listed in Oregon Table Z-1 with an "X" in the Skin Designation column following the substance name shall be prevented or reduced to the extent necessary in the circumstances through the use of gloves, coveralls, goggles, or other appropriate personal protective equipment, engineering controls or work practices.
(2) Oregon Table Z-2. An employee's exposure to any substance listed in Oregon Table Z-2 shall not exceed the exposure limits specified as follows:
(a) 8-hour time weighted averages. An employee's exposure to any substance listed in Oregon Table Z-2, in any 8-hour work shift of a 40-hour work week, shall not exceed the 8-hour time weighted average limit given for that substance in Oregon Table Z-2.
(b) Acceptable ceiling concentrations. An employee's exposure to a substance listed in Oregon Table Z-2 shall not exceed the acceptable ceiling concentration for the given substance in the table at any time during an 8-hour shift except: Acceptable maximum peak above the acceptable ceiling concentration for an 8-hour shift. An employee's exposure to a substance listed in Oregon Table Z-2 shall not exceed the acceptable maximum peak above the acceptable ceiling concentration, and shall not exceed the maximum duration for the given substance during an 8-hour shift.
(c) Example. During an 8-hour work shift, an employee exposed to benzene may be exposed to an 8-hour time weighted average (TWA) of 10 ppm. Concentrations of benzene during the 8-hour work shift may not exceed 25 ppm, unless that exposure is no more than 50 ppm and does not exceed 10 minutes during an 8-hour work shift. Such exposures must be compensated by exposures to concentrations below 10 ppm so that the 8-hour time-weighted average is less than 10 ppm.

[Example]

(d) Skin Designation. To prevent or reduce skin absorption, an employee's skin exposure to substances listed in Oregon Table Z-2 with an "X" in the Skin Designation column following the substance name shall be prevented or reduced to the extent necessary in the circumstances through the use of gloves, coveralls, goggles, or other appropriate personal protective equipment, engineering controls or work practices.
(3) Oregon Table Z-3. An employee's exposure to any substance listed in Oregon Table Z-3, in any 8-hour work shift of a

40-hour work week, shall not exceed the 8-hour time weighted average limit given for that substance in the table.
(4) Computation formulae. The computation formula which shall apply to employee exposure to more than one substance for which 8-hour time weighted averages are included in OAR 437, Division 2/Z, Toxic and Hazardous Substances, in order to determine whether an employee is exposed over the regulatory limit is as follows:
(a) Cumulative exposures.
(A) The cumulative exposure for an 8-hour work shift shall be computed as follows:

E = (CaTa + CbTb + ...CnTn) ÷ 8
Where:
E is the equivalent exposure for the working shift.
C is the concentration during any period of time T where the concentration remain constant.
T is the duration in hours of the exposure at the concentration C.
The value of E shall not exceed the 8-hour time weighted average specified in subpart Z of 29 CFR part 1910 for the substance involved.

(B) To illustrate the formula prescribed in paragraph (4)(a)(i) of this section, assume that Substance A has an 8-hour time weighted average limit of 100 ppm (Oregon Table Z-1). Assume that an employee is subject to the following exposure:

Two hours exposure at 150 ppm
Two hours exposure at 75 ppm
Four hours exposure at 50 ppm
Substituting this information in the formula, we have
[(2 x 150) + (2 x 75) + (4 x 50)] ÷ 8 = 81.25 ppm
Since 81.25 ppm is less than 100 ppm, the 8-hour time weighted average limit, the exposure is acceptable.

(b) Mixtures.
(A) In case of a mixture of air contaminants an employer shall compute the equivalent exposure as follows:

Em = (C1 ÷ L1) + (C2 ÷ L2) + . . .(Cn ÷ Ln)
Where:
Em is the equivalent exposure for the mixture.
C is the concentration of a particular contaminant.
L is the exposure limit for that substance specified in Subpart Z of 29 CFR Part 1910.
The value of Em shall not exceed unity (1).

(B) To illustrate the formula prescribed in paragraph (4)(b)(i) of this section, consider the following exposures:

[Table Z 2.1]
Substituting in the formula, we have:
Em = (500 ÷ 1000) + (45 ÷ 200) + (40 ÷ 200)
Em = 0.500 + 0.225 + 0.200
Em = 0.925
Since Em is less than unity (1), the exposure combination is within acceptable limits.

(5) To achieve compliance with paragraphs (1) through (4) of this section, administrative or engineering controls must first be determined and implemented whenever feasible. When such controls are not feasible to achieve full compliance, protective equipment or any other protective measures shall be used to keep the exposure of employees to air contaminants within the limits prescribed in this section. Any equipment and/or technical measures used for this purpose must be approved for each particular use by a competent industrial hygienist or other technically qualified person. Whenever respirators are used, their use shall comply with 1910.134.

[Table Z-1, Notes, Footnotes; Table Z-2, Note, Footnotes; Table Z-3, Note, Footnotes.]

[ED. NOTE: To view attachments referenced in rule text, click here for PDF copy.]

Statutory/Other Authority: ORS 654.025(2), 654.035 & 656.726(4)
Statutes/Other Implemented: ORS 654.001 through 654.295
History:
OSHA 11-2021, amend filed 09/01/2021, effective 09/01/2022
OSHA 3-2017, f. 7-7-17, cert. ef. 3-12-18
OSHA 5-2016, f. 9-23-16, cert. ef. 7-1-18
OSHA 6-2008, f. 5-13-08, cert. ef. 7-1-08
OSHA 6-2006, f. & cert. ef. 8-30-06
OSHA 4-2001, f. & cert. ef. 2-5-01
OSHA 6-1997, f. & cert. ef. 5-2-97
OSHA 5-1997, f. & cert. ef. 4-22-97
OSHA 6-1994, f. & cert. ef. 9-30-94
OSHA 17-1993, f. & cert. ef. 11-15-93

Lab Specific Training Guide

This checklist should be used to assist PIs/supervisors with recording lab-specific training for new lab members. Training records should be updated as new areas become relevant; **initial and date** next to checkboxes for training provided after initial date. Maintain this document with personnel training files.

PI:		Department:
Building:		Room:
Y / N	Initial	Basic laboratory safety
		Review **UO Safety Policy** and **UO Laboratory Safety Manual**
		Review safe lab practices (proper attire, handwashing, no pets allowed etc.)
		Identify designated areas for food consumption/storage outside of the lab
		Review procedures for working after hours
		Review procedures for incident/accident first aid, reporting and applicable **Workplace Injury forms**.
		Emergency information: spills, injury, fire, and power failure
		Fire extinguisher and first aid kit
		Evacuation plans and Fire alarm pull stations
		Safety shower and eyewash locations and use
		Lab spill kit and Emergency procedures (wall flip-chart and **Lab Incident Response Guidelines)**
		Waste handling procedures (labeling, packaging, **requesting pick-up)**
		Chemical Waste here
		Radioactive Waste
		Pathogenic/Biohazard and Carcasses
		Sharps (e.g., needles/razor blades), and uncontaminated glass waste
		Work involving chemical hazards
		Review of UO and lab-specific **Chemical Hygiene Plans** (CHP)
		Review location of Safety Data Sheets (SDSs)
		Review Chemical Inventory
		Review procedures for chemical procurement and distribution
		Storage (compatible storage, corrosives cabinet, flammable liquid storage cabinet, flammable liquid storage refrigerator, etc.)
		Location where certain procedure(s) may be performed (e.g., fume hood)
		Personal protective equipment
		Discuss required PPE for various lab work, plus additional PPE for specific tasks
		Review selection and proper use of gloves (& manufacturer's guidance)
		If a respirator is required for work, arrange for **evaluation, training, and fit testing**

Y,N	Initial	Housekeeping, maintenance, and inspections
		Discuss materials stored or frequently present on the floor
		Discuss maintenance of scientific equipment
		Review maintenance of lab's safety equipment: weekly flushing of eyewash, monitoring gauges on fume hoods, biosafety cabinets, keeping safety showers and electrical panels accessible, etc.
		Exposure monitoring/medical surveillance
		Discuss PEL and TLV for chemicals in use and how to reduce employee exposure
		Discuss use of fume hoods, biological safety cabinets or other mechanical ventilation systems
		Review criteria for medical surveillance, per the UO Chemical Hygiene Plan
		Instruct employee to inform health care provider of hazardous substances used in the lab, particularly in instances of immunocompromised status
		Working with pathogenic or recombinant/synthetic materials
		Review standard microbiological practices; use of biosafety cabinet at BSL2
		If work involves human blood, other human-derived or non-human primate derived materials, contact EHS to enroll in **Bloodborne Pathogens Program**
		If recombinant or synthetic DNA is used, review procedures for reporting requirements
		Review **UO Biosafety Manual** and lab-specific biosafety manual for BSL-2 labs
		Working with radioisotopes
		Contact Radiation Safety Officer for enrollment into program
		Review **Radiological Safety Manual; Review Dosimetry Program**
		Working with animals
		Contact Animal Care Services for animal handler training
		Contact Biosafety Officer for occupational health training
		Complete and submit Medical Questionnaire to University Health Center
		Additional lab-specific topics
		Review applicable topics -liquid nitrogen, **lasers, controlled substances**
		Discuss ongoing laboratory training (e.g., review of incidents/accidents/injuries and how to prevent recurrence)

I certify the above items have been reviewed with me and I agree to take responsibility for maintaining a safe laboratory environment.

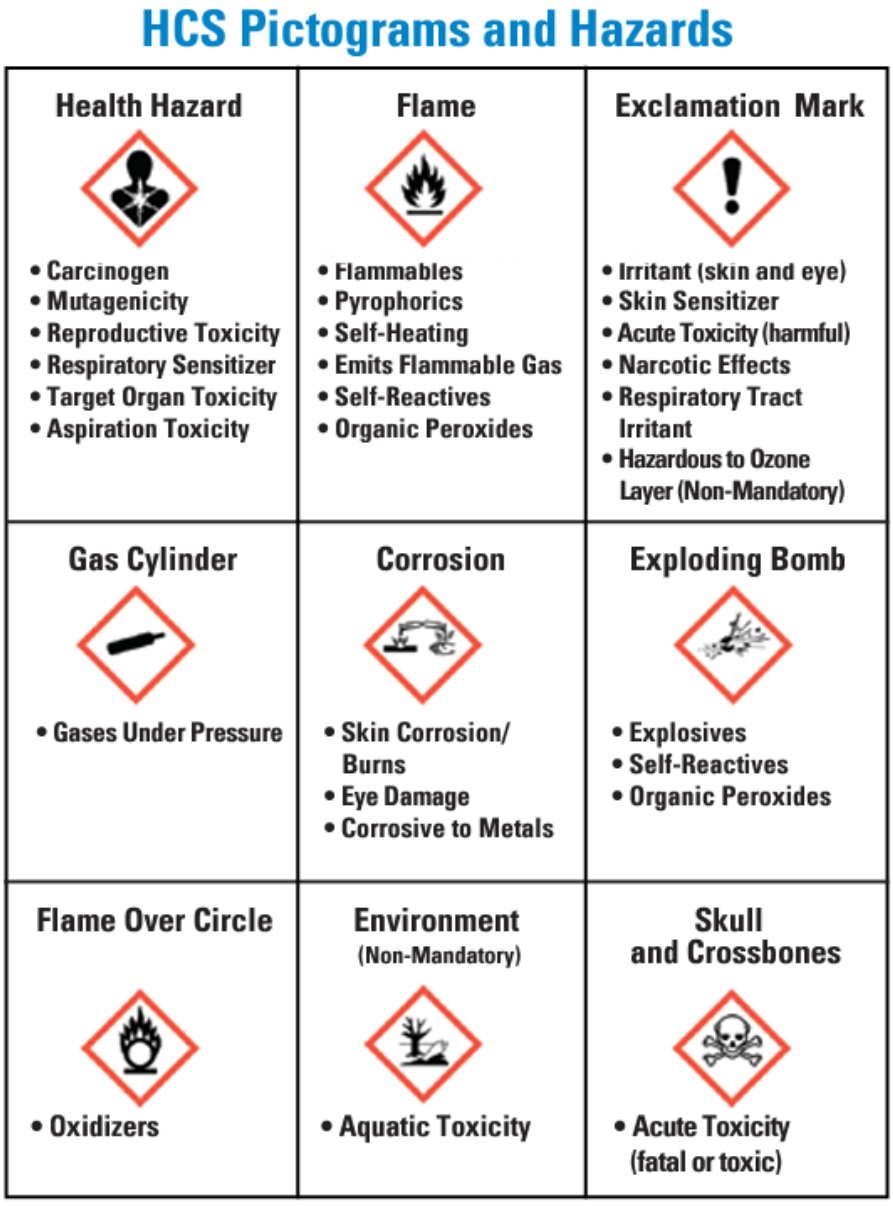
Lab member's signature: _____ Date: _____

Supervisor's signature: _____ Date: _____

Appendix D. Guidance for Chemical Labeling and Chemical Waste Labeling

Hazard Communication

Hazard pictograms are important components of labeling containers and workplace hazards under the Globally Harmonized System (GHS). These pictograms are classified based on the type of hazard they represent. Each pictogram consists of a symbol on a white background framed within a red border and represents a distinct hazard(s). The chemical hazard classification determines the pictogram on the label.



Chemical Labeling

It is crucial to adhere to GHS and OSHA standards in a laboratory environment by properly labeling every chemical found in the laboratory. This labeling system allows for identifying the chemical contents and their associated hazards, ensuring a safe workspace. The manufacturer labels must only be removed or defaced once the chemical is fully utilized. If the original container is to be reused, the original label must be defaced or removed, and a new label indicating the chemical or mixture must be attached. If small containers or vials are difficult to label, they may be numbered or coded as long as an associated log that identifies the chemical constituents is available. A group of small containers or vials may be labeled together and stored in the same location. The original chemical containers should have a label that indicates the date they were received and opened. All chemical and waste containers must display full chemical names (no abbreviations or formulas) and appropriate hazard warnings. Storage areas for hazardous materials, such as refrigerators and cabinets, should be labeled to indicate the hazardous nature of the chemicals stored within them.

Labeling best practices for all hazardous substances are summarized as follows:

- All containers of hazardous materials MUST be labeled with the identity of the hazardous substance and ALL applicable hazard warning statements.
- Labels on incoming containers of hazardous substances shall be removed or defaced once the container is completely empty.
- The name and address of the chemical manufacturer or other responsible party must be included.
- Laboratories should have a posting with a list of abbreviations used for chemical names and associated hazards.
- Labels should be easy to read, written in English, and displayed prominently.
- When a chemical is moved from its original container to another container, such as a solvent wash bottle for future use, it is called a secondary container.
- Secondary containers must have the name of the chemical (as it appears on the SDS) and appropriate hazard warnings on the label.
- Immediate-use secondary containers used by the person who made the transfer are exempt from these requirements.

- Newly synthesized compounds must be labeled with appropriate hazard warnings based on their chemical and physical properties.
- The PI is responsible for ensuring compliance with container labeling regulations.

Labeling Chemical Waste Containers

Labeling is an essential and obligatory requirement to safely store hazardous waste that cannot be overlooked. When waste is added to a container, a laboratory waste label should be immediately attached, with ALL waste constituents listed including percentages of each component totaling to 100%. The University has established specific labeling requirements and guidelines to adhere to. The waste generation “Start Date" field must be completed promptly when waste is added to the container. Waste containers must undergo inspection to ensure they have visible labels, are suitable for the generated waste stream, and have reliable closures. All chemical waste components must be spelled out in English on the label, and molecular formulas nor abbreviations cannot be the sole form of identification. All components, including trace contaminants, must be listed for both liquid and solid waste. Listing "Organic Solvents" or "Contaminated Solids" is insufficient for proper waste classification.