HARVARD
Campus Services
ENVIRONMENTAL HEALTH & SAFETY

Harvard University Chemical Hygiene Plan

Table of Contents

Harvard University Chemical Hygiene Plan

1.0 FORWARD

Harvard University encourages and supports all programs, which promote the safety, good health and well-being of University faculty, staff, students and visitors. The University is committed to providing a safe and healthful environment for all members of the Harvard community and to reducing injuries and illness to the lowest possible level. To assist academic institutions and businesses in enhancing the safety of laboratory personnel, the Occupational Safety and Health Administration (OSHA) published standard 29 CFR 1910.1450, "Occupational Exposure to Hazardous Chemicals in Laboratories". A copy of the standard and its appendices may be obtained by visiting the OSHA web site at osha.gov/SLTC/laboratories/standards.html. This regulation, known as the "Lab Standard", is designed to protect laboratory personnel from potential hazards associated with the use of laboratory chemicals. The key elements of the OSHA Lab Standard include the development and implementation of the following:

- Chemical Hygiene Plan (CHP)
- Employee Training and Information
- Hazard Identification
- Use and Management of Chemical Hazard Information
- Container Labeling
- Exposure Monitoring
- Medical Examinations and Consultation
- Methods of Exposure Control
- Personal Protective Equipment
- Laboratory Safety Equipment
- Chemical Waste Management
- Safeguards for Particularly Hazardous Substances
- Emergency Procedures
- Recordkeeping

The standard's intent is to ensure that laboratory personnel are apprised of the hazards of the chemicals in their work area, and that appropriate work practices and procedures are in place to protect laboratory personnel from chemical health and safety hazards. This Chemical Hygiene Plan has been prepared to provide guidance in safe laboratory operations for Harvard University laboratory personnel.

2.0 INTRODUCTION

2.1 Scope and Applicability

The policies and procedures set forth in this Chemical Hygiene Plan are applicable to all laboratory operations and personnel.

Laboratory operations are defined as handling or manipulation of hazardous chemicals in reactions, transfers, etc. in small quantities on a non-production basis.

Hazardous chemicals are defined as any chemical or mixture of chemicals which is classified as a physical hazard or health hazard, simple asphyxiant, combustible dust, pyrophoric gas, or hazard not otherwise as specified in Appendix A & B of the OSHA Hazard Communication Standard.

Laboratory personnel include faculty, staff, research associates and assistants, technicians, teaching assistants, post-doctoral fellows, graduate and undergraduate students.

2.2 Purpose

This Chemical Hygiene Plan is designed to identify the safety practices that should be implemented when working with common hazardous chemicals found in the laboratory. These safeguards will protect laboratory personnel from unsafe conditions in most situations.

There are instances, however, when the physical and chemical properties, the proposed use, the quantity used or the toxicity of a substance will be such that these controls may need to be modified. Professional judgment is essential in the interpretation and application of these procedures, and laboratories may modify or enhance these procedures to meet their specific uses and operational needs.

The Harvard University Laboratory Safety Program is based on the premise that every member of the research community shares the responsibility for safety. As part of the community, it is important for laboratory personnel to be familiar with the health and safety guidelines that apply to their work and to conduct that work in the safest possible manner. The Chemical Hygiene Plan is a resource to assist laboratory personnel in fulfilling these responsibilities.

2.3 Availability of Documents

This document identifies the ways in which Harvard University is complying with each portion of the OSHA Lab Standard. An official copy of the Harvard University Chemical Hygiene Plan is available at the EH&S web site. For laboratory-specific procedures, contact the Chemical Hygiene Officer or Principal Investigator (PI) for that laboratory.

The EH&S Lab Safety Offices are located at:

Cambridge/Allston Campus
46 Blackstone South
Cambridge, MA 02139
(617) 496-3797

Longwood Campus
107 Avenue Louis Pasteur
Boston, MA 02115
(617) 432-1720

An OSHA factsheet covering the key elements of the Lab Standard is available at
osha.gov/Publications/laboratory/OSHAfactsheet-laboratory-safety-osha-lab-standard.pdf

2.4 Plan Organization

Part I contains information regarding the general administrative components of the Chemical Hygiene Plan. This section outlines the purpose, scope and applicability of the plan. In addition, responsibilities, authority and resources are also defined. Training, medical surveillance, exposure monitoring, hazard identification, recordkeeping, plan evaluation and review and resources are detailed in this section.

Part II contains recommended general precautions for working with laboratory chemicals. These precautions address broad classes of chemicals and include information and guidance in the following areas:

- Common hazards
- General safe work practices
- Chemical storage
- Personal protective equipment
- Other safety equipment and engineering controls

- Work practices for particularly hazardous substances
- Chemical waste management
- Emergency procedures

Part III provides information and templates to enable individual laboratories to customize this Chemical Hygiene Plan for their operations. A Lab Standard Operating Procedure (SOP) Template is provided at www.ehs.harvard.edu/node/8620 to provide assistance to laboratory personnel generating specific safety procedures.

2.5 General Principles

To provide for the safety of the Harvard community and to protect Harvard University and surrounding property from damage, the following general principles apply to all faculty, staff and students performing work in laboratories:

1. **Perform Hazard Assessment:** Prior to initiation of new experiments or procedures, assessment of potential hazards must be performed. Appropriate protective measures, including personal protective equipment and engineering controls, must be identified and implemented. Laboratories should develop process- or experiment-specific guidelines and protective procedures.
2. **Minimize Chemical Exposures:** Since few laboratory chemicals are without hazards, general precautions for chemical handling, storage and disposal should be implemented in all laboratories. Use of less hazardous materials, implementation of engineering controls whenever feasible, and use of personal protective equipment to avoid skin contact with or inhalation of chemicals is encouraged.
3. **Avoid Underestimation of Risk:** Even for substances with no known significant hazard, exposure should be minimized. For work with particularly hazardous substances, special precautions must be taken (such as those contained in Part II and/or Part III). All substances of unknown toxicity should be considered toxic.
4. **Provide Adequate Ventilation:** The best way to prevent exposure to airborne substances is to prevent their escape into the working atmosphere by using chemical fume hoods or other ventilation devices.
5. **Observe Established Standards:** The permissible exposure limits and threshold limit values established by OSHA and other organizations should be observed. Where a regulatory standard does not exist, other recognized exposure limits should be followed.
6. **Follow the Chemical Hygiene Plan:** Procedures described in this Chemical Hygiene Plan are designed to minimize or prevent exposure to hazardous chemicals. Implementation of the CHP should be a regular, continuing effort.

Executive Summary

Chemical Hygiene Plan	The Harvard University Chemical Hygiene Plan addresses the general hazards of common chemicals that may be present in your laboratory, and describes work practices, procedures and controls which are in place to protect you from those hazards. It is your responsibility to participate in laboratory safety training and to plan and conduct each operation or experiment in accordance with the general safety procedures, or those safety procedures specific to your laboratory or experiment. You should consult with your supervisor, chemical hygiene officer or principal investigator regarding specific safety practices to be used in your laboratory.
OSHA Lab Standard	The Occupational Safety and Health Administration (OSHA) Lab Standard (29 CFR 1910.1450) is designed to enhance the safety of laboratory personnel through better information and work practices. As laboratory personnel, you already know that your technical skills are critical to your work. Knowing the hazards of the substances you work with and safe work practices is just as important. The key requirements of the Lab Standard that you should be aware of are as follows: ▪ You must have access to the Chemical Hygiene Plan. ▪ Chemical safety information, including Material Safety Data Sheets (MSDS) must be available to you. ▪ You must be informed of the hazardous chemicals present in your laboratory and the operations in which they are involved. ▪ You must receive adequate training in working with hazardous chemicals. ▪ Chemical containers and chemical waste must be labeled properly. ▪ You must know how to detect the presence or release of a hazardous chemical. ▪ You must be provided with personal protective equipment (safety glasses, gloves, lab coat, for example). ▪ You must be provided with engineering controls (fume hood, for example). ▪ You must receive training in the proper procedures for responding to emergencies. ▪ You are entitled to a medical consultation, whenever there is an event, such as a spill or leak that increases your risk of chemical exposure. ▪ If there is reason to believe that the airborne concentration of a hazardous chemical may exceed established exposure limits, air monitoring may be required. ▪ You must be notified of the results of any air monitoring conducted. ▪ You are entitled to a copy of established exposure limits for hazardous chemicals. ▪ You are entitled to a complete copy of the OSHA Lab Standard.

Harvard University Chemical Hygiene Plan

PART I: General Administration

1.0 ROLES AND RESPONSIBILITIES

1.1 Environmental and Safety Compliance Officers (ESCOs)

Under the authority delegated by the Deans and Senior University Administration, the ESCO for each school or administrative unit is responsible for promoting and maintaining a safe, healthful and environmentally responsible workplace. Specific responsibilities include:

- Ensuring the adequacy of technical and financial resources to conduct compliance programs in accordance with Harvard standards and regulatory requirements.
- Identifying personnel affected by specific compliance requirements.
- Communicating compliance program requirements to administration and faculty.
- Securing faculty and administration input for the development and implementation of compliance management programs.
- Communicating, periodically, compliance program status to the Harvard community, including program results, effectiveness and agendas.

1.2 Departments

Each department is responsible for supporting and promoting safe and compliant work practices in the laboratory. Department faculty and administration are responsible for facilitating the implementation of the Chemical Hygiene Plan within each department.

Department Chairs have overall responsibility for ensuring that all work performed within their departments complies with applicable health, safety and environmental requirements. The department chairs may implement this responsibility through delegation to principal investigators, other faculty, department administration or other departmental staff deemed appropriate.

The Department Faculty is responsible for:

- Collaborating with the administration, Environmental Health and Safety (EH&S) and others to identify effective means to implement the Chemical Hygiene Plan in the laboratory.
- Providing feedback to administration regarding compliance status.
- Ensuring that personnel receive required training, to implement the Chemical Hygiene Plan effectively.
- Coordinating and facilitating exchange of information regarding chemical hygiene issues with the research and teaching community.

Department Administration/Laboratory Directors are responsible for:

- Facilitating compliance with the Chemical Hygiene Plan requirements.
- Ensuring the appointment of a Chemical Hygiene Officer.
- Ensuring that compliance responsibilities are assigned and implemented for all areas and operations in the Department. These responsibilities include training, recordkeeping, reporting, program evaluation and plan revision.

Research Operations Managers (ROMs) at the Longwood Campus are responsible for:

- Communicating EH&S programs to the laboratories, Principal Investigators, and their appointed Safety Coordinators.
- Serving as the primary liaison between the EH&S Department and their basic science department.
- Monitoring compliance and safety issues within their department.

1.3 Principal Investigators (PIs)

Each Principal Investigator plays a critical role in the implementation of the Chemical Hygiene Plan. The PI has primary responsibility for chemical hygiene and EH&S compliance in his or her laboratory. These responsibilities include ensuring that:

- Laboratory personnel have adequate knowledge and information to recognize and control chemical hazards in the laboratory.
- Hazardous operations are defined and safe practices and protective equipment are designated and provided.
- Safe work practices, personal protective equipment and engineering controls are used to reduce the potential for exposure to hazardous chemicals.
- Laboratory personnel are informed of the potential hazards of the chemicals they use and are trained in safe laboratory practices, controls and emergency procedures.
- Laboratory personnel are informed of the signs and symptoms associated with exposures to hazardous chemicals used in their laboratory.
- Chemical waste is managed properly.
- Action is taken to correct work practices and conditions that may result in the release of hazardous chemicals.
- He or she grants approval, where required, prior to the use of particularly hazardous substances in the laboratory.
- Laboratory operations are supervised to ensure that the Chemical Hygiene Plan is being followed.
- Compliance with the CHP is maintained and documented.

1.4 Chemical Hygiene Officers (CHOs)

The Chemical Hygiene Officer (CHO) (e.g., Lab Supervisor, Safety Coordinator) is critical to the effective implementation of the Chemical Hygiene Plan. The CHO, working with the principal investigator is responsible for the adaptation and implementation of the Chemical Hygiene Plan in his or her laboratory, thus maintaining a safe work environment and ensuring compliance with regulatory requirements. The duties of the CHO include ensuring that:

- Appropriate training is provided to new and current laboratory personnel and is properly documented.
- Workers know and follow established safe work procedures and emergency procedures.
- Safety equipment and engineering controls are utilized.
- Appropriate personal protective equipment is utilized.
- Laboratory practices and safety and control equipment inspections are routinely conducted and properly documented.
- Copies of the up-to-date Chemical Hygiene Plan and chemical hazard reference material (e.g., MSDSs) are available to laboratory personnel.
- Procedures developed for new or particularly hazardous substances or operations are coordinated with input from the Chemical Hygiene Officer and the Environmental Health and Safety Department.

- Accidents and other potential exposure conditions are reported to the Chemical Hygiene Officer and the Environmental Health and Safety Department for further investigation, exposure monitoring or input regarding appropriate corrective action.
- Recommended actions are taken to correct any unsafe condition.

1.5 Laboratory Personnel

Laboratory personnel are responsible for:

- Participating in laboratory safety training sessions.
- Being aware of the hazards of the chemicals they are working around or with, and safe storage, handling and disposal procedures.
- Planning and conducting each operation or experiment in accordance with established chemical hygiene procedures.
- Using appropriate safe work practices, personal protective equipment and engineering controls at all times.
- Reporting unsafe conditions to their supervisor or Chemical Hygiene Officer.

Laboratory personnel and principal investigators share responsibility for chemical safety in their laboratory, as well as informing visitors entering their laboratory of the potential hazards and safety precautions to be taken.

1.6 Environmental, Health and Safety Department (EH&S)

The primary responsibility of the Environmental, Health and Safety Department is to provide technical support and guidance to laboratory personnel for the development and management of environmental, health and safety programs. EH&S is responsible for reviewing and updating the common (non-lab specific) portions of this Chemical Hygiene Plan on an annual basis and distributing any required changes to appropriate University personnel. The EH&S Department offers the following services relating to chemical hygiene:

- Development and evaluation of safety procedures.
- Laboratory inspection and audits.
- Fume hood evaluation and inspection.
- Training and information dissemination.
- Hazardous waste disposal.
- Hazard and exposure assessments.
- Accident investigation.
- Emergency assistance.

An overview of EH&S and its services may be obtained by visiting the EH&S web site at: ehs.harvard.edu.

2.0 INFORMATION AND TRAINING

Harvard University will provide laboratory personnel with information and training to ensure that they are apprised of the hazards of the chemicals present in their work area. The purpose of information and training is to ensure that all individuals at risk are adequately informed about the work being performed in the laboratory, associated hazards and actions to be taken to protect themselves during normal operations, as well as emergencies.

2.1 General Requirements

Information that must be provided or made available to laboratory personnel includes:

- How to obtain copies of the OSHA Lab Standard and Appendix A and Appendix B.
- The location and availability of the Chemical Hygiene Plan.
- How to obtain Permissible Exposure Limits (PELs) for OSHA-regulated substances and the AGCIH Threshold Limit Values (TLVs) (e.g., by contacting EH&S) for hazardous substances not given OSHA PELs.
- Resources and reference sources for signs and symptoms associated with exposure to hazardous substances used in the laboratory (see Section 5.2 below for a general overview).
- The location and availability of known reference materials on hazards, safe handling, storage and disposal of hazardous chemicals found in the laboratory (see Section 6.0 below).

Training includes coverage of the following topics:

- Methods and observations that may be used to detect the presence or release of a hazardous chemical.
- Determining physical and health hazards of chemicals in the work area.
- Measures laboratory personnel can take to protect themselves from these hazards.
- Specific procedures to provide protection, including engineering controls, work practices and personal protective equipment.
- Emergency procedures.
- Explanation of Material Safety Data Sheets and container labeling.
- How to obtain and use chemical hazard information.
- Review of the components and implementation of the Chemical Hygiene Plan.

The Harvard University safety training program for laboratory personnel consists of two parts:

General Laboratory Safety Training that is offered by EH&S and addresses general laboratory safety practices.

Specific Laboratory Safety Training that addresses specific chemicals, experiments or procedures provided by the principal investigator and/or the laboratory supervisor/chemical hygiene officer.

To assist laboratories in development and documentation of specific safety procedures and training, a template is provided at www.ehs.harvard.edu/node/8620.

Safety information and training must be provided to personnel initially, upon assignment to a laboratory where hazardous chemicals are present, and also prior to assignments involving new hazardous chemicals and/or new laboratory work procedures. The Principal Investigator, during annual review of laboratory-specific safety procedures in Part III, will determine whether refresher information and training is warranted at that time.

Records of training must be maintained for all workers, on a training attendance sheet that includes the course name and outline, trainer's name and affiliation, date, and attendees' names.

General and customized training, as well as individual consultation, is available on a regular schedule and upon request by checking the EH&S web site at: ehs.harvard.edu/training.

2.2 Chemical Safety Information Sources

The Laboratory Standard requires employers to provide chemical information to all laboratory personnel. Harvard University makes available numerous sources of chemical information for personnel working in laboratory settings.

Laboratory personnel can identify basic chemical hazards by means of the product *labeling* on incoming chemical containers as required by the OSHA's Hazard Communication Standard. Laboratory personnel are instructed to label temporary containers with the chemical name and hazard type. *Laboratory door placards/signs* such as those required by some local fire departments provide a visual indicator of the type and degree of hazards.

More detailed chemical hazard information is provided at the links below:

☐ CCOHS ChemInfo Sheets and other resources
A database system maintained by the Canadian Centre for Occupation Health & Safety that provides a comprehensive chemical hazard information resource and includes ChemInfo sheets and manufacturer Material Safety Data Sheets (MSDSs).
☐ Hazmat Navigator
Hazmat Navigator is a chemical safety database based on Bretherick's Handbook of Reactive Chemical Hazards that helps chemists and safety personnel quickly access critical, detailed chemical hazards information.
☐ ChemADVISOR MSDS Database

The lab safety staff is available to provide technical support regarding the use of hazardous chemicals laboratories. If laboratory personnel have questions regarding chemical safety, they can call EH&S at 6-3797 (Cambridge/Allston) or 2-1720 (Longwood Campus).

3.0 SIGNS AND SYMPTOMS OF CHEMICAL EXPOSURE

The hazards of laboratory chemicals can be ascertained by referring to labels and chemical hazard reference material such as MSDSs, ChemInfo sheets, etc. In addition, the ability to recognize the signs and symptoms of chemical exposure is important. Then, if adverse effects do arise despite all precautions taken to avoid exposure, those effects can be recognized early and appropriate action taken.

If chemical exposure has occurred you should:

- Seek prompt medical attention at University Health Services or a local hospital.
- Contact the principal investigator, Chemical Hygiene Officer and/or EH&S.

Some signs and symptoms of chemical exposure include:

- Skin that has become dried, whitened, reddened, swelled, blistered, and itchy or exhibits a rash.
- A chemical odor. Many chemicals can be smelled at concentrations well below harmful levels. On the other hand, a chemical may be present without a detectable odor.
- A chemical taste. Some chemicals have characteristic tastes.
- Tearing or burning of the eyes.
- Burning sensations of the skin, nose or throat.
- Cough.
- Headache or dizziness.

These general symptoms may also be associated with conditions other than chemical exposure. The signs and symptoms of exposure to specific chemicals are contained in the "Health Hazard Information" section of the MSDS or Section 11 of a GHS Safety Data Sheet. Laboratory personnel should be aware of the signs and symptoms of exposure to the chemicals they use.

4.0 MEDICAL EXAMINATION AND CONSULTATION

4.1 Examination/Consultation Determination

Harvard University is required to provide laboratory personnel who work with hazardous chemicals an opportunity to receive medical attention, including physician-determined follow-up examinations, when any of the following conditions are met:

- The worker develops signs or symptoms associated with a hazardous chemical used in the laboratory.
- Exposure monitoring reveals consistent worker exposure greater than the action level (or in the absence of an action level, the applicable OSHA exposure limit) for a chemical.
- Whenever a leak, spill, explosion or other occurrence results in the likelihood of hazardous exposure to the worker.
- When respiratory protective equipment is required.
- When medical surveillance requirements for OSHA regulated-substances must be met.
- At the discretion of the principal investigator, Chemical Hygiene Officer, or EH&S.

4.2 Exposure Information

A licensed physician providing care to a potentially exposed worker must be provided the following information:

- The identity of and MSDS(s) for the hazardous substance(s) to which the worker may have been exposed;
- The conditions that surrounded the exposure; and
- The signs and symptoms of exposure that the worker is experiencing, if any.

4.3 Examination Criteria and Frequency

Medical exam criteria will be determined by the licensed physician performing or directly supervising the exam. Where medical exam guidance exists, such as for OSHA-regulated substances, the EH&S or the will provide the information required by the substance-specific standard (e.g., 29 CFR 1910.1048(l) for formaldehyde) to the physician to be included in the physician's exam.

Frequency of medical examinations is at the discretion of the physician, if the examination resulted from a potential overexposure to hazardous substances. If the examination resulted from an exposure to an OSHA-regulated substance, examinations will be at least as frequent as the period set in the OSHA standard for each particular substance. Medical evaluations provided for required respirator use will be performed at a frequency determined by the physician.

4.4 Physician's Written Opinion

The physician is required to submit a written opinion to the principal investigator and the Chemical Hygiene Officer. This opinion should not reveal any specific findings or diagnoses unrelated to the chemical exposure. The written opinion must include the following information:

- Results of the medical examination, including any test results;
- Any medical condition, revealed during examination, which may place the worker at increased risk as a result of the chemical exposure or use of personal protective equipment;
- Recommendations for further medical follow-up; and
- A statement that the worker was informed of the medical examination results.

4.5 Cost and Scheduling

All required medical examinations and consultations must be provided to laboratory personnel at no cost, without loss of pay, and at a reasonable time and place.

5.0 EXPOSURE MONITORING

Regular environmental or worker exposure monitoring of airborne contaminants is not usually warranted or practical in laboratories, since chemicals are typically used for a relatively short period of time and in small quantities. However, air monitoring will be conducted if:

- There is reason to believe that exposure levels for a substance routinely exceed either the action level (AL) or permissible exposure level (PEL) set by OSHA.
- Workers suspect or report that they have been overexposed to a chemical in the laboratory.
- A particularly hazardous substance is used on a regular basis (several times per week), for an extended period of time (3-4 hours at a time) or in large quantities. Use of particularly hazardous substances in this manner should be reviewed with the principal investigator and Chemical Hygiene Officer. EH&S is available to provide technical assistance, upon request.

Monitoring will be conducted in accordance with established sample collection and analytical methodology for the chemical exposure being evaluated. If initial monitoring indicates that worker exposure is above the AL or PEL, the periodic monitoring provisions of the relevant OSHA standard will be met.

Upon receipt, results of personal monitoring will be made available to workers, in writing within 15 days, either individually or by posting in an appropriate location accessible to the affected workers.

6.0 RECORDKEEPING

6.1 Records

Harvard University will maintain accurate and complete records concerning the following:

- Medical examination and consultation;
- Exposure monitoring;
- Training;
- Fume hood evaluations; and
- Laboratory inspections.

6.2 Retention and Storage

Medical examination and consultation records, including test results and physician's written opinions, are to be maintained in an appropriate confidential manner by the laboratory's department. These records are to be kept, transferred and made available for at least the duration of the worker's employment plus thirty years. These records shall be maintained in accordance with 29 CFR 1910.1020. "Access to Employee Exposure and Medical Records".

Employee exposure records, including sampling results, MSDSs or other chemical-specific information, are to be maintained in the laboratory's department files. These records are to be kept, transferred and made available for at least 30 years. These records shall be maintained in accordance with 29 CFR 1910.1020. Exposure monitoring records generated by EH&S will be also maintained in the EH&S central files.

Training records are maintained in the laboratory's department files. Records of training conducted by EH&S will be maintained by EH&S.

Fume hood certification records for certifications conducted by department vendors are maintained in the laboratory's department files and updated annually. These records are maintained until the next certification is performed. Records of fume hood evaluations performed by EH&S are maintained by EH&S.

Laboratory inspection records are maintained in the laboratory's department files. These records are maintained until the next inspection is performed. Records of inspections conducted by EH&S will be maintained by EH&S.

7.0 PLAN EVALUATION, REVIEW AND UPDATE

7.1 Plan Evaluation and Inspections

In order to evaluate the implementation status and effectiveness of the Chemical Hygiene Plan, laboratory personnel, laboratory supervisors, Chemical Hygiene Officers, or Environmental Health and Safety will conduct inspections at least every two years to review laboratory safety practices and check safety equipment.

Inspection checklists are available at ehs.harvard.edu/programs/lab-safety-assessments-inspections.

If an alternative checklist is utilized, a copy should be included in Part III of this document.

EH&S will also perform annual fume hood certifications. These certifications will assess the adequacy of air flow in the hood by determining average face velocity, air flow pattern and direction and extent of turbulence (if any). Details of the fume hood evaluation procedures and documentation are contained in Part II of this document.

7.2 Plan Review and Update

The laboratory Principal Investigator or designee shall review annually and, if necessary, update laboratory-specific safety procedures when particularly hazardous substances are introduced into or removed from the laboratory or when experimental procedures involving particularly hazardous substances change. Environmental Health and Safety will review annually and, if necessary, update this Chemical Hygiene Plan. Changes to the plan will be based on regulatory changes, changes in university-wide safety policies and practices, feedback from laboratory personnel and results of laboratory inspections.

Harvard Chemical Hygiene Plan
Part II. General Safety Practices

1.0 INTRODUCTION

Part II of this Chemical Hygiene Plan is intended to provide Harvard University laboratory personnel with information regarding generic hazards of common chemicals that may be present in the laboratory and appropriate work practices, procedures and controls to protect laboratory workers from those hazards.

Hazardous chemicals can cause harm when they enter the body in sufficient amounts via inhalation, ingestion, injection or skin absorption. Harmful effects can also occur by eye or skin contact alone. The nature of the hazardous chemical and the routes by which it enters or contacts the body determine the type of controls that are needed. The Occupational Safety and Health Administration (OSHA) and other organizations have set occupational exposure limits on airborne chemical exposure. Keeping exposures below these limits is generally believed to protect employees. Permissible Exposure Limits (PELs) can be found on the OSHA website. Threshold Limit Values (TLVs) established by the American Conference of Governmental Industrial Hygienists (ACGIH) are available on MSDSs or by contacting EH&S. Regardless of the established exposure limit for a particular chemical, all laboratory workers should take steps to minimize chemical exposure via all routes of entry.

Three methods are used to limit chemical exposure:

- Engineering controls;
- Administrative controls; and
- Personal protective equipment (PPE).

1.1 Engineering Controls

Whenever possible, substitution of less hazardous chemicals should be used as a primary method of preventing adverse effects due to chemical exposure.

Properly exhausted fume hoods, other local exhaust ventilation, glove boxes and other special purpose hoods must be used when there is a likelihood of excessive exposure to air contaminants generated by laboratory activity. Used in conjunction with good work practices, properly designed and operated exhaust ventilation is effective in minimizing air contaminant exposure.

1.2 Administrative Controls

Administrative controls are work procedures such as safety policies, rules, supervision, and training in order to reduce the duration, frequency, and severity of exposure (via inhalation and physical contact) to hazardous chemicals. Some administrative controls include, but are not limited to, using granular materials instead of powders, using low pours, avoiding working alone after hours with particularly hazardous substances or procedures, etc.

1.3 Personal Protective Equipment

The use of personal protective equipment (PPE) is necessary when feasible engineering and administrative controls are unavailable or if there is a need to supplement those controls. The following types of PPE are used to minimize inhalation and physical contact exposures:

- *Eye and face protection*: safety glasses, chemical splash goggles and face shields.
- *Protective clothing*: lab coats, aprons, arm covers, and closed-toe shoes.
- *Respiratory protection*: respirators for short-term use or during emergencies may be necessary to supplement existing engineering or administrative controls.

2.0 PRIOR APPROVALS AND PROCUREMENT

Laboratory personnel should obtain prior approval to proceed with a laboratory procedure from a senior member of the lab staff or one more experienced in similar procedures when:

- Working with particularly hazardous substances (see Appendix II-A for definitions);
- Performing particularly hazardous procedures (i.e., potential for violent reaction); and/or
- Working alone with particularly hazardous materials or hazardous procedures

The Chemical Hygiene Officer and/or Environmental Health and Safety are available to assist laboratory staff in reviewing hazards associated with any procedure, equipment or chemical to be used in the laboratory to ensure that appropriate safety procedures are established.

Part III of this Chemical Hygiene Plan is intended to provide guidance in the establishment and documentation of specific safety procedures.

3.0 GENERAL SAFETY PROCEDURES

3.1 Basic Precautions

Awareness is the most fundamental rule of chemical safety. Take time to understand the safety and health hazards of the chemicals in the workplace. Every laboratory worker should take the following precautions:

- Prior to use, review the safety and health hazard data of all chemicals used in the laboratory.
- Know the signs and symptoms of overexposure and the physical and sensory characteristics (odor, appearance) of these chemicals.
- Know appropriate procedures for emergencies, including the location and operation of all emergency equipment.
- When working with hazardous materials, have a second person nearby
- Avoid leaving experiments unattended, whenever possible.
- Never use unlabeled chemicals or chemicals.
- Always order the least amount of chemical.
- Use hazardous chemicals in a chemical fume hood
- Maintain equipment and inspect it regularly for proper function.
- Use guards and shields where possible. All mechanical equipment should have adequate guarding.
- Use safety shields when there is a possibility for explosion or implosion.
- Store and handle chemicals in accordance with the guidelines contained in this Chemical Hygiene Plan or in accordance with the chemical manufacturer's guidelines.
- Store hazardous waste in a closed, labeled container in a designated satellite accumulation area.

- Dispose of hazardous waste through the University Hazardous Waste Program . For more information on hazardous waste go to ehs.harvard.edu/programs/lab-waste-management.
- Do not eat, drink, chew gum, apply cosmetics while near or within chemical use or storage areas.
- Do not store food/drink containers in the laboratory or in a chemical refrigerator.
- Use mechanical pipettes or aspirators.
- Do not use chipped or cracked glassware.
- Report all accidents, even if they do not result in injury, to the principal investigator, chemical hygiene officer, laboratory supervisor and/or EH&S immediately.

3.2 Housekeeping/Hygiene

The following housekeeping and hygiene practices should be implemented at all times to reduce the likelihood of accident or chemical exposure:

- Work areas should be kept clean and free from obstructions.
- Hands should be washed after every experiment, before touching any non-contaminated area or object, and before leaving the laboratory area.
- Access to exits, emergency exits, aisles, hallways, stairways, stairwells and controls must never be blocked.
- Emergency exits must be kept unlocked from the inside.
- Hallways should not be used as storage areas.
- Work areas should be cleaned at the end of the experiment and at the end of the day.

3.3 Chemical Storage and Handling

Many potential hazards are associated with the storage and handling of laboratory chemicals. Understanding the properties of the chemicals and planning procedures by which they may be handled safely may minimize these hazards. Simply storing chemicals alphabetically is not prudent. Flammable, corrosive, explosive, and peroxide forming agents require special precautions. Storing incompatible chemicals together may have disastrous results.

The following guidelines are prudent for all chemical storage and handling:

Chemical handling: Use bottle carriers to transport chemicals. Close caps securely. Pour all chemicals carefully. Add acid to water, not water to acid.

Labels: Be sure all labels are securely attached and legible. Keep chemicals in their original container if possible. Label all secondary containers to avoid unknown chemicals and/or inadvertent reaction. Date all chemicals which may become unstable over time or are peroxidizable.

Shelves: Avoid storing hazardous liquid chemicals on hard-to-reach shelves. Labels on stored chemicals should be able to be read easily. Shelves should be made of a chemically resistant material.

Incompatible chemicals: Incompatible chemicals must not be stored together. For each chemical, the hazardous nature must be considered individually and in relation to other chemicals in the area. Refer to the chemical MSDSs, or see Appendix II-B for a table of common incompatible chemicals.

Excessive storage: Avoid stockpiling chemicals. Purchase only what is needed. Use older stock first. Discard chemicals, which are no longer needed or that have expired.

Hallway storage: Hallways should not be used as storage areas for chemicals.

Chemical Fume hoods: In general, fume hoods should not be used for storage of chemicals, unless they are part of the experiment being conducted in the fume hood at that time. The exception is storage in a fume hood, which is specifically designed for that storage, and where experimental procedures are not carried out.

3.4 Flammable Liquids

Glass containers: Whenever practical, glass containers should not be used for storing flammable liquids. If a glass container must be used, the maximum allowable container size is ***one gallon***.

Metal (non-DOT) or plastic containers: No more than 5 gallons of flammable liquid should be stored in regular metal or plastic containers.

Safety cans: Safety cans are the preferred containers for storage outside a flammable liquid storage cabinet. Safety cans are available in several sizes. They have spring-loaded spout covers that can open to relieve internal pressure when subjected to fire, and will prevent leakage if tipped over. Flame arresters are present in the spout to prevent flame propagation into the can. The maximum size of the container should be 5 gallons.

Flammable liquid storage cabinets: Use of flammable liquid storage cabinets is the method of choice for storage of small quantities of flammable liquids. Flammable storage cabinets are made of double-walled steel, and are equipped with flame arresters. Some models have doors that close automatically and some have sprinkler systems. The cabinet must bear a label assuring that it is approved by Factory Mutual or Underwriters Laboratories.

Refrigerators/freezers: Refrigerators and freezers used for storage of flammable materials must be rated for flammable storage.

Maximum quantities: In general, no more than 10 gallons of flammable liquids per 100 square feet of laboratory space should be stored outside a flammable liquid storage cabinet or safety can.

Handling: Transfer and storage of flammable materials should not be in an area where a spill of the liquid could block an exit from the room, hallway, or building in the event of a fire, and where there is a source of ignition.

Incompatibles: Store flammable liquids separate from oxidizers, compressed gases, highly toxic materials, corrosives, and water-reactive chemicals.

3.5 Oxidizing Agents

Storage: Oxidizers should be stored on fire-resistant shelving, in a well-ventilated area.

Incompatibles: Oxidizing agents can initiate combustion and therefore should not be stored in the same area with fuel, such as flammable, organic chemicals, dehydrating agents, or reducing agents.

3.6 Perchloric Acid

At ordinary temperatures at concentrations of 72% and weaker, perchloric acid reacts as a strong, non-oxidizing acid. But at concentrations above 72% or at elevated temperatures (usually above 160 degrees Celsius), it is an exceedingly strong and active oxidizer and dehydrating agent. Anhydrous perchloric acid is unstable at room temperature and will ultimately decompose spontaneously with violent explosion.

Handling: Perchloric acid should be handled in a fume hood designed for perchloric acid use (must have a wash down system to prevent accumulation of crystals on the ductwork and the ductwork must be specially coated).

Incompatibles: Perchloric acid must be stored away from oxidizers and organic materials, including wood, paper, and cloth.

3.7 Peroxidizable Materials

Ethers, liquid paraffins, and olefins form peroxides on exposure to air or light. Since these chemicals are packaged in an air atmosphere, peroxides can form even if the containers have not been opened (e.g., isopropyl ether, diethyl ether, dioxane, tetrahydrofuran, glyme, and diglyme). A representative list of common peroxidizable and other unstable materials is provided at ehs.harvard.edu/programs/safe-chemical-work-practices.

Storage time limit: Opened containers should be used up or discarded within 6 months after they are first opened. Unopened containers should be stored no more than one year. Containers should be dated upon receipt and upon opening the bottle.

Container inspection: Containers should be inspected for peroxide formation before opening or moving the containers. If crystals are present around the lip of the container or the liquid appears cloudy, do not move or open it. Colorimetric tests are available to test for peroxide formation. Although some ethers contain a peroxide inhibitor, they should still be inspected before opening.

Dating of containers: To ensure storage time limits are not exceeded, containers of peroxidizable materials should be dated when received, when opened and when tested for peroxide formation. A sample dating label is contained in Appendix II-C.

3.8 Corrosive Materials

Corrosive substances are some of the most hazardous substances commonly encountered in the laboratory. In general, corrosive substances cause destruction of living tissue very rapidly at the site of contact (skin, eyes, respiratory tract and gastrointestinal tract). For this reason, proper selection and use of personal protective equipment is critical, when working with corrosives. See Section 6.0 for more specific guidance regarding personal protective equipment.

Containers: Whenever practical, corrosive materials should be purchased and stored in break-proof or break-resistant containers.

Storage: Many acids and alkalis are corrosive to their containers and other materials in a storage area. In general, they should be stored in a cool, dry area, equipped with corrosion-resistant shelving and plumbing, preferably in a corrosives storage cabinet.

Acids react with many metals to form hydrogen gas, and alkalis may form hydrogen gas when in contact with aluminum. Since hydrogen forms an explosive mixture with air, accumulation of hydrogen in storage areas must be prevented.

3.9 Toxic Materials

Toxic materials include carcinogens, reproductive toxins (teratogens, mutagens, etc.) and acutely hazardous materials. Toxic materials which are simultaneously hazardous because of another attribute (i.e. flammable, corrosive) should be evaluated to determine which is the most significant hazard and stored accordingly.

Access to these materials should be restricted to the people involved in the experiment and people who have been informed of the hazardous properties of the chemical. These chemicals should not be stored in a hallway, stairway, or any other emergency egress path regardless of whether they are contained in a storage can or cabinet. Additional precautions for working with toxic materials are contained in Section 5.0 of Part II of this Chemical Hygiene Plan. Lists of carcinogens are referenced in Appendix II-A.

If the toxicity of the chemical is the primary hazard, the chemical should be stored in one of the following ways:

- In a continuously operating chemical storage fume hood;
- In a volatile storage cabinet with restricted access, such as a locked cabinet;
- In a hermetically sealed container at a temperature low enough to significantly reduce its volatility (i.e. a deep freeze).

3.10 Compressed Gas Cylinders

Compressed gas cylinders present an important hazard because they have the potential for both mechanical and chemical hazards. The danger of fire or explosion is acute with a high rate of diffusion. Additional hazards arise from the reactivity and toxicity of the gas. Asphyxiation can be caused by high concentrations of even "harmless" gases such as nitrogen. Finally, the large amount of potential energy resulting from the compression of the gas makes a compressed gas cylinder a potential rocket.

Identification: The contents of the cylinder should be clearly marked. Gas lines from the cylinder should be labeled as to the gas and the laboratory served. A tag should be attached to the cylinder to indicate whether the cylinder is full, in use, or empty.

Handling: During transport cylinders should be secured to appropriate handcarts. Highly toxic gases should not be moved through corridors in areas, where occupants not knowledgeable in the hazards of the gases may be present. Cylinder valves should be opened slowly, using a hand wheel or wrench while standing away from the valve opening. Compressed Gas Association (CGA) approved valves, fittings and other connections of the proper configuration for the gas being used, should be employed at all times.

Storage: All cylinders, regardless of whether they are full or empty, must be firmly secured at all times, using a clamp and belt or chain. They should be stored in a cool, dry, well-ventilated area free from sources of ignition. Chemical oxidizers should be stored at least 20 feet away from flammable gas cylinders. A cylinder cap or regulator valve should always be in place.

Empty cylinders: Cylinder caps should always be secured and cylinders should be clearly marked "empty". Empty cylinders should be kept secured as noted above.

4.0 SAFETY PROCEDURES FOR PARTICULARLY HAZARDOUS SUBSTANCE

Additional protection is required for work with particularly hazardous substances such as carcinogens, reproductive toxins (mutagens and teratogens), biotoxins and substances with a high degree of acute toxicity**.** Listings of some of these materials are referenced in Appendix II-A. When working with these particularly hazardous materials the following general procedures must be followed:

- Obtain approval from the principal investigator or his or her designee (i.e., senior member of the lab staff, lab supervisor, and/or chemical hygiene officer) to use these particularly hazardous chemicals.
- Order the smallest quantity of the chemical necessary to perform the procedure or experiment.
- Wear appropriate personal protective equipment, paying close attention to permeation resistance of gloves or protective clothing to be used.
- Work only in a properly functioning, uncluttered chemical fume hood or biological safety cabinet. This area should be posted or labeled as a "Designated Area" for the use of particularly hazardous materials. Permit only authorized personnel to use any Designated Area.
- Determine, in consultation with the principal investigator or his or her designee (i.e., senior member of the lab staff, lab supervisor and/or chemical hygiene officer) and EH&S whether fume hood exhaust air should be filtered prior to discharge.
- Consult the MSDS for exposure and emergency information before beginning work with these materials.
- Label ALL containers with the contents, date, manufacturer's name and hazardous properties of the material(s) in the containers.
- Transfer particularly hazardous chemicals in tightly closed containers placed within a durable outer container.
- Limit traffic through the immediate area.
- Decontaminate the work surface immediately after working with these materials. To facilitate decontamination, work surfaces may be covered with stainless steel or plastic trays, absorbent paper with moisture-proof lining or other impervious material, which may be cleaned or disposed of as hazardous waste or biological waste after completing the procedure.
- Securely store these materials immediately after use.
- Label all waste materials with the corresponding chemical classification (e.g. Toxic) or as biological waste.

Laboratories that use particularly hazardous chemicals should document specific standard operating procedures for these materials and include them in Part III of this Chemical Hygiene Plan. Additional information about carcinogens, reproductive toxins, biotoxins and acutely toxic substances is contained in Appendix II-A.

5.0 PERSONAL PROTECTIVE EQUIPMENT

The Harvard University Laboratory Personal Protective Equipment Policy requires each PI or Designee assess PPE needs annually. In addition, the PI must ensure that all required PPE is readily available to researchers and that all PPE is properly used in the laboratory. EH&S has created a PPE Assessment tool available on the EH&S web site ehs.harvard.edu/programs/lab-personal-protective-equipment-ppe to aid in the assessment process.

5.1 Body and Foot Protection

When working with chemicals, a lab coat or apron and closed-toe shoes should be worn at all times. Hair and loose clothing should be confined.

5.2 Hand Protection

Hands are the most likely part of the body to come in contact with chemicals. Skin contact with chemicals may result in irritation, burns, or absorption of the chemical into the blood stream. Glove materials must be compatible with the chemical(s) used. Consult chemical information sources on the EH&S web site, the glove manufacturer's literature or EH&S for chemical protective clothing references when choosing gloves for a specific application.

5.3 Eye Protection

Safety glasses, goggles, or face shields should always be worn when eye hazards are possible. Students and visitors should be provided with eye protection before entering a laboratory.

- **Safety glasses** must be used when working with solid materials. Safety glasses should comply with the ANSI Occupational and Educational Eye and Face Protection Standard (Z87.1). Standard eyeglasses with side shields are generally not sufficient. Safety glasses should not be used when a significant splash potential exists.
- **Chemical Splash Goggles** must be used when a splash hazard exists. These generally can be worn over regular eyeglasses. Goggles equipped with vents should be used to prevent fogging.
- **Face shields** must be worn when maximum protection from flying particles and harmful liquids is needed. These may be used in conjunction with goggles for maximum protection from corrosives and hot chemicals.

5.4 Respirators

When chemical substitution and effective engineering controls are not possible, respirators should be used. The OSHA Respiratory Protection Standard at 29 CFR 1910.134 must be complied with for all personnel who are required or volunteer to wear a respirator. This standard specifies a medical valuation, training, fit testing, selection, and guidelines for proper use. EH&S must be contacted before purchasing or using respiratory protection.

Environmental Health and Safety offers training and fit testing services for those workers who may require respirators. In addition EH&S is available to assist laboratories in establishing an OSHA-compliant Respirator y Protection Program.

6.0 OTHER SAFETY EQUIPMENT

6.1 Fume Hoods/Ventilation

The laboratory fume hood is one of the most important safety devices in the laboratory.

Use: The ventilation system in the laboratory has been carefully balanced to ensure proper airflow and comfortable working conditions. To prevent cross drafts, laboratory doors should be kept closed, whenever possible. A complete guide to proper use of a laboratory fume hood is provided at ehs.harvard.edu/node/7544. Each fume hood is registered by EH&S and a blue registration sticker is affixed to the hood.

Maintenance: Laboratory fume hoods are evaluated by EH&S or outside contractors at least annually. During these evaluations, average face velocity of the hood is measured, and the hood containment is evaluated using flow visualization.

Hoods passing evaluation are labeled at an 18" sash height with a fume hood inspection sticker indicating the date of evaluation. Hoods failing evaluation are posted with a failure notification form, and the hood operator(s) is informed of the failure. Failed hoods are reported to Building Managers for service and are reevaluated after service has been completed.

6.2 Eyewash Stations

Eyewash stations are required in any lab where there is the potential for eye injury from exposure to hazardous chemicals.

Requirements: The eyewash station must be capable of providing a continuous, soft stream of tepid water for at least 15 minutes. Drench hoses may support eyewash stations, but do not replace them unless meeting ANSI standards for a combination drench hose eyewash unit.

Location: Eyewash stations should be located no more than 10 seconds travel time from the hazard (about 55 feet). The location should be marked with a highly visible sign.

Maintenance: Eyewash stations should be flushed weekly for 1 minute to assure function and avoid build-up of bacteria. The path to the eyewash station must be free from obstructions.

Use: After any eye contact with a chemical, activate the eyewash station and flush eyes for at least 15 minutes. If the chemical is alkaline, flush for at least 30 minutes. Avoid rinsing the chemical into the uninjured eye. If contact lenses are in place, flush for one minute, remove the lenses, and continue flushing. After flushing for the appropriate amount of time, seek medical attention at the University Health Services or the nearest emergency room.

6.3 Safety Showers

Safety showers should be provided where chemicals are handled. The showers provide first aid for chemical splashes.

Requirements: Safety showers should provide at least 30 gallons of water per minute. The valve should be simple to activate and should remain activated until intentionally shut off. The valve should be within reach, not more than 69 inches above the floor.

Location: Safety showers should be in an accessible location no more than 10 seconds travel time or 50 feet from the hazard. The location should be marked with a clearly visible sign and, if possible, a large yellow circle should be painted on the floor under the shower.

Maintenance: Safety showers should be flushed at least annually, preferably every six months. The path to the safety shower must be kept free from obstructions.

Use: In case of skin contact with a hazardous chemical, immediately activate the shower and flush the affected area for at least 15 minutes. For contact with dry solids, brush the contaminant gently off the skin before using the shower. While under the shower, remove clothing and jewelry from the affected area. After flushing, seek medical attention immediately at the University Health Services or the nearest emergency room.

6.4 Fire Extinguishers

Portable fire extinguishers are necessary to rapidly suppress small fires. Only people trained to use a fire extinguisher should operate one. Never try to fight a fire that is larger than you are.

Types of fires: There are four types of fires, depending on the material that is burning:

- *Class A Fires*: Fires in ordinary combustible materials, such as wood, cloth, paper, and many plastics.
- *Class B Fires*: Fires involving flammable liquids, gases, and greases.
- *Class C Fires*: Fires in energized electrical equipment. When the electrical equipment is de-energized, the fire may continue to burn as a Class A or B fire.
- *Class D Fires*: Fires in combustible metals, such as magnesium, titanium, sodium, zirconium, and potassium.

Types of extinguishers: There are several types of fire extinguishers. An extinguisher is rated as to the type of fire it can put out. The type of fire the extinguisher is designed to extinguish is printed on the cylinder. A triangle with an "A" denotes Class A, a square with a "B" denotes Class B, a circle with a "C" denotes Class C, and a star with a "D" denotes Class D.

Location: Fire extinguishers are generally mounted either near an exit or at the back of the laboratory. There should be at least one extinguisher in each laboratory.

Maintenance: All extinguishers must be inspected annually. An inspection tag must be attached to each extinguisher and must indicate the date of the last inspection.

Use: Before using a fire extinguisher, SOUND THE ALARM or call 5-5560 (Cambridge/Allston) or 2-1720 (Longwood) to report the fire. If the fire is small and you are trained to use a fire extinguisher, choose the correct fire extinguisher by checking the label. Point the nozzle at the base of the flame with a side-to-side motion. If the fire becomes larger than you, or the contents of the extinguisher have been discharged and the fire is still burning, evacuate the building closing doors behind you (but do not lock them).

7.0 CHEMICAL WASTE MANAGEMENT

This section outlines the key elements of the Harvard University Laboratory Hazardous Waste Program. Additional information is available by contacting your campus EH&S office or the EH&S web site at: ehs.harvard.edu/programs/lab-waste-management.

Waste Identification

Hazardous waste regulations require that hazardous waste be accurately identified. Common laboratory wastes include:

- **Spent solvents, acids, bases and oxidizers** used in extractions, cleaning or other processes;
- **Unused reagents and other chemicals** that are no longer needed, do not meet specifications, are contaminated, have exceeded their storage life or are otherwise unusable in the lab;
- **Waste oils**; and
- **Other miscellaneous materials**, including broken thermometers, heavy metal salts, poisons, etc.

These wastes may be identified as either "listed wastes" (appear on lists of specific chemicals defined as hazardous waste issued by the Massachusetts Department of Environmental Protection (DEP)) or "characteristic wastes" (exhibit certain characteristics defined by the DEP including ignitability, corrosivity, reactivity and toxicity). Environmental, Health and Safety is available to assist with waste identification.

7.1 Storage and Disposal

Regulations require that hazardous wastes be accumulated and stored in properly managed containers on sufficiently impervious surfaces (free of cracks, gaps, etc.).

Storage: Hazardous waste in laboratories is stored in satellite accumulation areas.

Disposal: Once a satellite accumulation area container is filled, it must be dated and transferred to a main accumulation area or shipped off-site within 3 days. Environmental, Health and Safety is available to provide waste pick up services. ***Disposal of hazardous wastes and chemicals in laboratory sinks is prohibited by regulation.***

Labeling: Containers that accumulate and store hazardous waste must be labeled with the following information:

- The words "Hazardous Waste";
- The waste type in words (Spent non-halogenated Solvents, Waste Oil etc.);
- The associated hazard in words (i.e. ignitable, toxic, etc.); and
- The date upon which the container became filled.

Containers must be labeled and situated so that labels are clearly visible.

Closure: Containers must be closed at all times, unless waste is being added or removed. Open-top funnels may not be left in open containers.

Condition: Containers must be in good condition. There may not be severe rusting, dents or other conditions that could cause leaks, etc.

Compatibility: Containers must be compatible with hazardous waste stored within them. When in doubt, use the original shipping container.

Inspections: Containers must be inspected weekly by laboratory personnel to ensure that they are properly labeled, in good condition and meet the criteria described above.

7.2 Training

Laboratory personnel whose duties or activities involve the management of hazardous waste are required to receive hazardous waste training within 6 months of the start of such activities and annually thereafter. Initial and refresher training is offered by Environmental, Health and Safety. Classroom training schedules and online refresher training is available at the EH&S web site at: ehs.harvard.edu/training.

7.3 Waste Minimization

Laboratory waste minimization techniques include:

- Process/equipment adjustment or modification;
- Toxic material substitution;
- Waste segregation and separation; and
- Recycling

The exercise of prudence in ordering new chemicals will also ensure that excess chemical does not become subject to disposal has hazardous waste. Contact Environmental Health and Safety for more information regarding waste minimization.

8.0 EMERGENCY PROCEDURES

Campus-specific Emergency Response (ER) Guides are available on flip charts posted around campus buildings and at the EH&S website at: ehs.harvard.edu/programs/emergency-guidance.

These ER Guides include emergency contact numbers and procedures to implement during situations that include medical emergencies, fires, and hazardous material spills.

9.0 APPENDICES

9.1 APPENDIX II-A: PARTICULARLY HAZARDOUS CHEMICAL INFORMATION

A partial list of Particularly Hazardous Chemicals is available at ehs.harvard.edu/programs/safe-chemical-work-practices.

SELECT CARCINOGENS

Select carcinogens are substances that meet any of the following criteria:

1. Regulated by OSHA as a carcinogen. Guidance on these regulated carcinogens can be found at the OSHA website.

2. Listed under the category 1. "known to be carcinogens" in the Annual Report on Carcinogens published by the National Toxicological Program (NTP):

   ntp.niehs.nih.gov/ntp/roc/twelfth/ListedSubstancesKnown.pdf

3. Listed under Group 1 ("Carcinogenic to humans") by the International Agency for Research on Cancer (IARC) Monographs.

   IARC Monographs can be found at:

   monographs.iarc.fr/ENG/Monographs/PDFs/index.php

   The current IARC carcinogen listing by group can be found at:

   monographs.iarc.fr/ENG/Classification/ClassificationsGroupOrder.pdf

4. Listed in either Group 2A or 2B by IARC or under the category "reasonably anticipated to be carcinogens" by the NTP, and cause statistically significant tumor incidence in experimental animals in accordance with any of the following criteria:

   - Inhalation exposure of 6-7 hr/day, 5 days/wk, for significant portion of a lifetime to airborne concentrations of less than 10 milligrams per cubic meter of air (mg/m^3); or
   - Repeated skin application of less than 300 mg/kg body weight per week; or
   - Oral doses less than 50 mg/kg body weight per day.

   The current IARC carcinogen listing of chemicals by group can be found at: monographs.iarc.fr/ENG/Classification/ClassificationsGroupOrder.pdf

   The current NTP listing of reasonably anticipated human carcinogens can be found at: ntp.niehs.nih.gov/ntp/roc/twelfth/ListedSubstancesReasonablyAnticipated.pdf

REPRODUCTIVE TOXINS

Reproductive toxins are chemicals that adversely affect the reproductive process. These toxins include mutagens that can cause chromosomal damage and teratogens, the effects of which include retarded fetal growth, birth defects, fetal malformations, and fetal death.

Knowledge of how chemicals affect reproductive health is in its preliminary stage. It has been only since 1973 that manufacturers were required by the Toxic Substances Control Act (TSCA) to test chemicals other than drugs for their effects on reproductive health.

Although a few well-controlled studies have been conducted, the evidence for most chemicals is limited to case reports or to studies done on a small group of exposed people after a problem emerged. Of approximately 55,000 chemical substances and mixtures in commercial production (not including drugs, pesticides, and food additives), only a limited number have been tested thoroughly on animals for reproductive effects.

Sources of information about chemicals that pose a risk to human reproduction include:

- The chemical list generated pursuant to the State of California's Safe Drinking Water and Toxic Enforcement Act of 1986 (Proposition 65). This list, which includes chemicals known to the State of California to cause reproductive/developmental toxicity (and cancer), can be found at: oehha.ca.gov/prop65/prop65_list/Newlist.html.
- Material Safety Data Sheets (MSDSs) for those chemicals.
- The Environmental Health and Safety Department.

ACUTELY TOXIC SUBSTANCES

Acutely toxic substances are defined in Appendix A of the OSHA Hazard Communication Standartd, Any substance or mixture classified as an acutely toxic by ingestion, skin absorption, or inhalation, Category 1 or two must be treated as a particularly hazardous substance.

- Substances with a median oral lethal dose (LD_{50}) in rats of 50 mg/kg or less of body weight;
- Substances with a median skin contact lethal dose (LD_{50}) in rabbits of 200 mg/kg or less of body weight; or
- Substances with a median inhalation lethal concentration (LC_{50}) of 500 parts per million (ppm) or less by volume of gas, vapor or 2 mg/l or less of vapor and 0.5 mg/l dust or mist.

Information concerning lethal doses and other measures of acute toxicity for particular substances is available on the MSDS for a particular substance, from the manufacturer or the Environmental Health and Safety Department.

Excluded Select Agents Toxins

The Department of Health and Human Services (DHHS) has identified a group of biotoxins, as select agents, which are considered particularly hazardous and acutely toxic to humans and/or animals. These toxins are exempted from most of the Select Agent regulations if the toxin amount does not exceed a designated threshold quantity. If the threshold quantity is exceeded, all Select Agent regulations must be followed. Additionally, transfers of these toxins, even in exempted amounts, require special safety and security procedures. Please contact EH&S for information regarding safe and secure use, information pertaining to threshold quantities exempted from the regulations, and transfer procedures, when applicable.

9.2 APPENDIX II-B: CHEMICAL COMPATABILITY INFORMATION

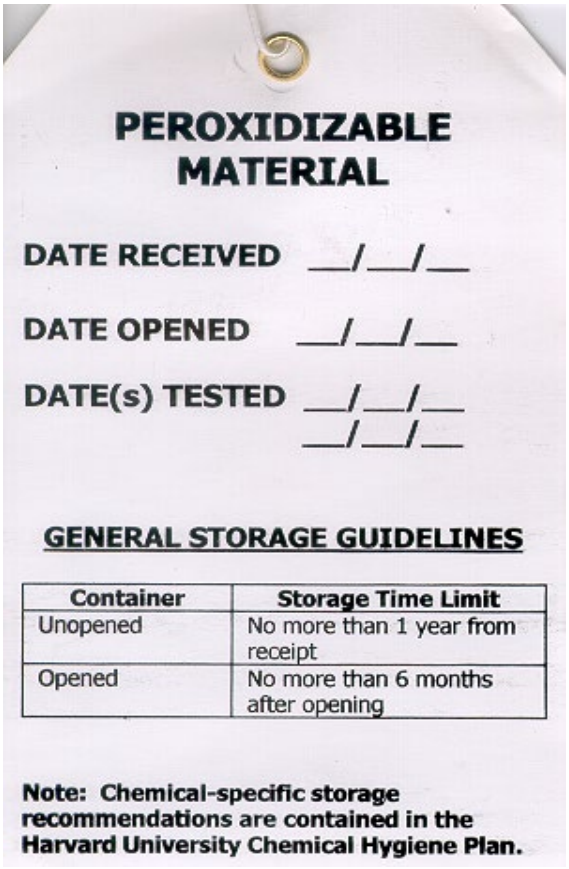
Examples of incompatible chemicals are listed below. The material on the left should be stored and handled so that it does not contact the incompatible chemical(s) on the right. Contact with incompatible chemicals would result in a potential violent reaction or toxic reaction products.

Examples of Incompatible Chemicals

CHEMICAL	IS INCOMPATIBLE AND SHOULD NOT BE MIXED OR STORED WITH	CHEMICAL	IS INCOMPATIBLE AND SHOULD NOT BE MIXED OR STORED WITH
Acetic acid	Chromic acid, nitric acid, hydroxyl compounds, ethylene glycol, perchloric acid, peroxides, permanganates	**Hydrogen peroxide**	Copper, chromium, iron, most metals or their salts, alcohols, acetone, organic materials, aniline, nitromethane, combustible materials
Acetylene	Chlorine, bromine, copper, fluorine, silver, mercury	**Hydrogen sulfide**	Fuming nitric acid, oxidizing gases
Acetone	Concentrated nitric and sulfuric acid mixtures	**Hypochlorites**	Acids, activated carbon
Alkali and alkaline earth metals (such as powdered aluminum or magnesium, calcium, lithium, sodium, potassium)	Water, carbon tetrachloride or other chlorinated hydrocarbons, carbon dioxide, halogens	**Iodine**	Acetylene, ammonia (aqueous or anhydrous), hydrogen
Ammonia (anhydrous)	Mercury, chlorine, calcium hypochlorite, iodine, bromine, hydrofluoric acid (anhydrous)	**Mercury**	Acetylene, fulminic acid, ammonia
Ammonium nitrate	Acids, powdered metals, flammable liquids, chlorates, nitrates, sulfur, finely divided organic or combustible materials	**Nitrates**	Sulfuric acid
Aniline	Nitric acid, hydrogen peroxide	**Nitric Acid (concentrated)**	Acetic acid, aniline, chromic acid, hydrogen sulfide, flammable liquids, flammable gases, copper, brass, any heavy metals
Arsenical materials	Any reducing agent	**Nitrites**	Acids
Azides	Acids	**Nitroparaffins**	Inorganic bases, amines
Bromine	See Chlorine	**Oxalic acid**	Silver, mercury
Calcium Oxide	Water	**Oxygen**	Oils, grease, gydrogen, flammable liquids, solids, or gases
Carbon (activated)	Calcium hypochlorite, all oxidizing agents	**Perchloric acid**	Acetic anhydride, bismuth and its alloys, alcohol, paper, wood, grease, oils
Carbon tetrachloride	Sodium	**Peroxide, organic**	Acids (organic or mineral), avoid friction, store cold
Chlorates	Ammonium salts, acids, powdered metals, sulfur, finely divided organic or combustible materials	**Phosphorus (white)**	Air, oxygen, alkalis, reducing agents
Chromic acid and chromium trioxide	Acetic acid, naphthalene, camphor, glycerol, alcohol, flammable liquids in general	**Potassium**	Carbon tetrachloride, carbon dioxide, water
Chlorine	Ammonia, acetylene, butadiene, butane, methane, propane (or other petroleum gases), hydrogen, sodium carbide, benzene, finely divided metals, turpentine	**Potassium chlorate**	Sulfuric and other acids
Chlorine dioxide	Ammonia, methane, phosphine, hydrogen sulfide	**Potassium perchlorate (see also chlorates)**	Sulfuric and other acids
Copper	Acetylene, hydrogen peroxide	**Potassium permanganate**	Glycerol, ethylene glycol, benzaldehyde, sulfuric acid
Cumene hydroperoxide	Acids (organic or inorganic)	**Selenides**	Reducing agents

CHEMICAL	IS INCOMPATIBLE AND SHOULD NOT BE MIXED OR STORED WITH	CHEMICAL	IS INCOMPATIBLE AND SHOULD NOT BE MIXED OR STORED WITH
Cyanides	Acids	**Silver**	Acetylene, oxalic acid, tartartic acid, ammonium compounds, fulminic acid
Flammable liquids	Ammonium nitrate, chromic acid, hydrogen peroxide, nitric acid, sodium peroxide, halogens	**Sodium**	Carbon tetrachloride, carbon dioxide, water
Fluorine	Everything	**Sodium nitrate**	Ammonium nitrate and other ammonium salts
Hydrocarbons (such as butane, propane, benzene)	Fluorine, chlorine, bromine, chromic acid, sodium peroxide	**Sodium peroxide**	Ethyl or methyl alcohol, glacial acetic acid, acetic anhydrite, benzaldehyde, carbon disulfide, glycerin, ethylene glycol, ethyl acetate, methyl acetate, furfural
Hydrocyanic acid	Nitric acid, alkali	**Sulfides**	Acids
Hydrofluoric acid (anhydrous)	Ammonia (aqueous or anhydrous)	**Sulfuric acid**	Potassium chlorate, potassium perchlorate, potassium permanaganate (similar compounds of light metals, such as sodium, lithium)
		Telurides	Reducing agents

9.3 APPENDIX II-C: PEROXIDIZABLE MATERIALS LABEL



PEROXIDIZABLE MATERIAL

DATE RECEIVED __/__/__

DATE OPENED __/__/__

DATE(s) TESTED __/__/__
__/__/__

GENERAL STORAGE GUIDELINES

Container	Storage Time Limit
Unopened	No more than 1 year from receipt
Opened	No more than 6 months after opening

Note: Chemical-specific storage recommendations are contained in the Harvard University Chemical Hygiene Plan.

Harvard University Chemical Hygiene Plan
Part III. Laboratory-Specific Standard Operating Procedures

1.0 INTRODUCTION

Part III of the Harvard University Chemical Hygiene Plan (CHP) is intended to address hazards that are specific to a department, laboratory, research group, procedure or hazardous substance. Part III is designed to contain Lab-Specific Standard Operating Procedures (SOPs) developed by laboratory personnel, with the assistance of EH&S as needed. A lab SOP must be developed for any operation or hazardous material for which the general safety procedures contained in Part II of the CHP are inadequate to address hazards. These procedures must be written to clearly identify additional or special precautions, controls, personal protective equipment and emergency procedures that are required, as well as the nature of the hazards the procedure is intended to minimize. Each lab SOP must be reviewed by the Principal Investigator or Chemical Hygiene Officer (CHO) for the area where the procedure will be implemented. The PI or designee shall review lab SOPs each year and update them if necessary.

A lab SOP that addresses the requirements noted above must be documented and maintained in Part III of the CHP. In addition, personnel authorized to perform operations for which a lab SOP has been established must be trained in the specific procedure. The PI, during the annual review of lab SOPs, will determine if refresher training is warranted at that time.

Use one of the following approaches in documenting lab-specific safety procedures:

(1) Use the questions/categories in the **lab SOP template** provided at www.ehs.harvard.edu/node/8620 to ensure that the safe work practices **are incorporated into your standard lab protocols**, including work practices to minimize exposure to specific hazards (e.g., working in chemical fume hoods) and specific personal protective equipment (PPE) to use (during normal operations and emergency procedures). *For instance, PVA (polyvinyl alcohol) gloves should be used in the case of immersion into phenol chloroform (since chloroform would easily degrade standard latex or nitrile gloves). Such information can be obtained from reference materials such as www.cdc.gov/niosh/ncpc/ (which applies to protective coveralls and gloves). MSDSs are helpful but as standalone documents sometimes do not provide enough specifics or are not as frequently reviewed as the lab protocols. Some MSDSs merely provide a general statement like "Use appropriate gloves."*

(2) **Create separate chemical-specific procedures** using the lab SOP template format.

(3) **Group similar chemicals** (e.g., aldehydes, halogenated hydrocarbons, biotoxins) into one safety procedure using the lab SOP template.

Instructions regarding use of the lab SOP template are contained in the following Section 2.0. Examples of lab SOPs for commonly used particularly hazardous substances are available at ehs.harvard.edu/programs/safe-chemical-work-practices. EH&S is available to assist laboratory personnel in the development of lab SOPs.

2.0 LAB STANDARD OPERATING PROCEDURE TEMPLATE INSTRUCTIONS

2.1 Title of Procedure

Should indicate the specific chemical, task or experiment for which it was written.

2.2 Description

Include a general description of what activities are covered under this procedure. List any specific examples of when the procedure must be implemented or any exemptions when the procedure is not required. If authorization for this procedure is limited to designated staff, that fact should be noted in this section.

2.3 Procedure

Enumerate or list the safety steps to be followed in performing the procedure. The steps should be sufficiently detailed, and should include any prohibited activities or any potentially dangerous conditions.

2.4 Potential Hazards

Complete the hazard description table for each of the principal materials utilized in this procedure. Material Safety Data Sheets, when available, should be obtained and attached to the procedures template. Many operations can result in secondary materials or hazardous by-products. A discussion of these materials should be included in this section if they represent a significant, but different hazard than the other materials.

2.5 Engineering/Ventilation Controls

Identify the engineering controls, such as lab chemical fume hoods, implemented to minimize exposures to hazardous materials and processes.

2.6 Required Personal Protective Equipment

Conduct a comprehensive Personal Protective Equipment (PPE) evaluation for the referenced materials or operation. The determination should include both the type of equipment, as well as the clothing materials. Refer to your Lab's PPE Assessment Report. Questions regarding the selection or procurement process should be directed to the lab safety representative/officer.

2.7 Additional Precautions

Indicate and describe any management approvals, medical surveillance, training or specific permits that must be obtained in order to conduct this procedure. Questions regarding applicability of these categories should be directed to the lab safety representative/officer or EH&S.

2.8 Safety References

Additional chemical safety information, including MSDSs and other information, is available electronically as tools at ehs.harvard.edu/programs/safe-chemical-work-practices. Add any lab-specific information as appropriate.

2.9 Waste Disposal

Refer to the *Laboratory Waste Guide* posted at ehs.harvard.edu/node/7699. As appropriate, list any additional equipment, supplies or procedures that are unique to the referenced materials or operations.

2.10 Emergency Procedures

Generic information related to emergency response activities is already addressed in Part II of the Chemical Hygiene Plan. Refer also to the Emergency Response Guide posted in your lab. List any additional emergency equipment, supplies or procedures that are unique to the referenced materials or operations. For example, an antidote such as calcium gluconate should be present whenever work is conducted with hydrofluoric acid.