MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Chemical Hygiene Plan

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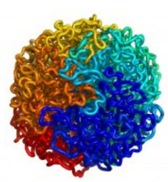
Physics of Living Systems – Junior Teaching Labs

Department of Physics



MIT EHS

ENVIRONMENT · HEALTH · SAFETY

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PART I. Getting Started

1. INTRODUCTION

1.1. Purpose, Policy, and Scope

Purpose

This document constitutes the Chemical Hygiene Plan (CHP) required by the U.S. Occupational Safety and Health Act (OSHA) of 1970 and regulations of the U.S. Department of Labor including 29 CFR 1910.1450 "Occupational Exposure to Hazardous Chemicals in Laboratories" (the "Laboratory Standard"). The purpose of the Plan is to describe the proper use and handling practices and procedures to be followed by employees, students, visitors, and other personnel working in each laboratory of the Physics Department, including PLS (Physics of the Living Systems) and the Junior Teaching lab to protect them from potential health and physical hazards presented by chemicals used in the workplace, and to keep chemical exposures below specified limits. While the Plan establishes work practices to promote safety in the laboratory, each individual has the first responsibility for ensuring that good health and safety practices are implemented in the laboratory. Not only does this individual responsibility promote personal well-being and the well-being of others, it also advances MI T's commitment to excellence in research.

Policy and Scope

It is the policy of the Massachusetts Institute of Technology (as represented by the MIT Corporation and the Office of the President) to provide a safe and healthy workplace in compliance with OSHA regulations including the "Laboratory Standard" referenced above. A link to the full OSHA Laboratory Standard is included in Part I. Section 4.1. of this Chemical Hygiene Plan. This Plan applies to all laboratories in the Physics Department Teaching Laboratories and those in the Physics of the Living Systems (PLS) Labs and all the personnel who supervise or work in these areas. For the Physics Department Teaching Laboratories and the PLS Labs, this Plan also applies to non-laboratory areas, and the additional special provisions to ensure these non-laboratory areas are in compliance with OSHA regulations pertaining to the Hazard Communication Standard are included in Part IV, Section 7 of this Plan.

In PLS Labs the Plan is located in the Laboratory Manual and can be accessed by contacting the lab EHS representative or the Department EHS coordinator, Rosa G Liberman at liberman@mit.edu (for PLS) or Sean Robinson at spatrick@mit.edu. The latest version of the PLS CHP can also be found at https://building46.mit.edu/building-46-specific-info/documents-building-46-community (Physics-PLS Chemical Hygiene Plan)

1.2. Plan Organization

Part I. Getting Started contains the basic, minimal information laboratory personnel need to know before using hazardous chemicals. It is designed to get laboratory personnel directly to the relevant information they need before beginning their laboratory work. This Part contains the purpose, policy, and scope of the Plan, and defines the roles and responsibilities for developing and implementing the Plan. Requirements for training and chemical information available to personnel are also detailed here.

Part II. General Chemical Hygiene Practices contains the minimum required precautions and standard operating procedures for working with laboratory chemicals in MIT laboratories. These precautions address broad classes of chemicals. This Part contains chemical hazard and risk assessment information, and general procedures for safe chemical management addressing the purchase, use, labeling, storage, disposal and shipping of chemicals. This Part also discusses common controls for safe use of chemicals including administrative and engineering controls.

Part III. Department, Lab, or Center-Specific Chemical Hygiene Practices or Lab Specific Standard Operating Procedures contains standard operating procedures generated by the Department, Laboratory, or Center or by a specific laboratory for specialized materials, procedures, or practices related to chemical use that are not adequately addressed in Part II. of this Plan. This Part is provided to enable individual Department, Laboratories, or Centers or individual laboratories to customize this Chemical

Hygiene Plan for their specific operations and hazards. A Lab Specific SOP Template is contained in this Part to provide assistance to laboratory personnel generating specific safety procedures.

Part IV. Additional Administrative Provisions contains information and procedures essential to a successful chemical hygiene program that address activities other than the direct handling and use of hazardous chemicals. These additional administrative provisions include information on MIT's Environment, Health and Safety Management System; prior approval and procurement requirements; medical evaluations and assessments; record keeping; laboratory inspections and audits; compliance and enforcement; and other related federal regulations that impact chemical use at MIT.

2. ROLES AND RESPONSIBILITIES

An essential component of any chemical hygiene program is to clearly articulate and clarify the different roles and responsibilities of all the stakeholders who work or visit in areas where chemicals are present. Clarifying roles and responsibilities for implementing the Chemical Hygiene Plan (CHP) will establish accountability, streamline processes, enhance safety, and avoid confusion and questions in meeting the Plan's objectives.

2.1. The DEPARTMENT, LAB, or CENTER CHAIR

The DEPARTMENT, LAB, or CENTER CHAIR shall:

A. Ensure the Chemical Hygiene Plan is written and updated.

B. Appoint the Chemical Hygiene Officer (CHO). The individual selected must be qualified by training or experience to provide technical guidance in the development and implementation of this written Chemical Hygiene Plan. This individual must have appropriate authority to assist with implementation and administration of the Chemical Hygiene Plan.

C. Provide or obtain administrative and financial support, as needed, for implementing and maintaining the Chemical Hygiene Plan and the requirements of the Plan.

2.2. The CHEMICAL HYGIENE OFFICER

The CHEMICAL HYGIENE OFFICERS are:
Dr. Sean P. Robinson for the Physics Department – Teaching Labs and Dr. Rosa G. Liberman for PLS Labs

The Chemical Hygiene Officer shall:

A. Know and understand the requirements of the OSHA Laboratory Standard regulation (29CFR 1910.1450) and the DLC Chemical Hygiene Plan.

B. Oversee the implementation of the CHP in the Department, Lab, or Center and assist Principal Investigators or Supervisors (PI/Supervisors) with implementing the Chemical Hygiene Plan within their laboratory.

C. Ensure the Plan is distributed or made available to all in the DLC who are impacted by the Plan.

D. Submit one copy of the CHP electronically to the MIT Environment, Health and Safety (EHS) Office for reference use and to facilitate the annual update process.

E. Advise Principal Investigators or Supervisors concerning adequate facilities, controls, and procedures for work with unusually hazardous chemicals.

F. Seek ways to improve the Chemical Hygiene Plan.

G. Review and update the Chemical Hygiene Plan annually, when directed by the EHS Office.

H. Support the EHS Coordinator, as needed, with inspection and audit activities and other requirements of the EHS Management System, such as the Space Registration Database.

I. Participate in investigation of serious accidents involving hazardous chemicals, acting as a liaison to the EHS Office.

I. Assist PI/Supervisors, as needed, with obtaining services or supplies and equipment for correcting chemical hygiene problems or addressing chemical hygiene needs.

J. Ensure periodic exposure monitoring requirements are met and maintain monitoring records.

K. If requested, review proposed experiments or Lab Specific SOPs for significant environment, health, and safety issues, and/or contact the EHS Office to address concerns.
L. Co-Chair the DLC-EHS Committee with the EHS Coordinator.
M. Attend annual CHO meeting conducted by the EHS Office.

2.3. The EHS COORDINATOR

The ENVIRONMENT, HEALTH AND SAFETY (EHS) COORDINATOR shall:

A. Provide assistance to the CHO, if appropriate and as requested, with developing and implementing the DLC Chemical Hygiene Plan.
B. Be familiar with the DLC Chemical Hygiene Plan.
C. Compile information from the laboratory for the EHS Space Registration Database.
D. Ensure routine inspections are conducted in the laboratory areas.
E. Participate in biannual inspections of laboratory operations.
F. Ensure DLC staff receives training required by regulation for safe handling and proper disposal of chemicals and that the training is documented.
G. Serve as contact point for arranging special studies or support from the EHS Office.
H. Act as a contact for Building Services and Repair and Maintenance staff to address concerns regarding safety for work in the laboratory area.
I. Ensure appropriate local records are collected and maintained for inspections, inspection follow-up, and lab-specific training for three years.
J. Arrange for decommissioning of laboratory space.

2.4. The PRINCIPAL INVESTIGATOR or LABORATORY SUPERVISOR

The PRINCIPAL INVESTIGATOR or LABORATORY SUPERVISOR (PI/Supervisor) shall:

A. Be familiar with this Chemical Hygiene Plan and ensure that all work is conducted in accordance with requirements of this Plan. They should contact the CHO for advice and assistance regarding this Plan and implementing the provisions of this Plan when needed.
B. The PI has the authority to take whatever actions necessary to assure the laboratory operates in a safe manner. This can include temporarily restricting access to the lab until any issues are resolved.
C. Assess all chemicals in the research laboratories under their purview, and ensure measures are established for safe use, storage, and disposal of the hazardous chemicals within the laboratory. Such measures include:
    1. Preparing additional, Lab Specific SOPs for work with potentially hazardous chemicals, equipment or processes when needed. See Part II. Section 3 for more information on when additional Lab Specific SOPs are required.
    2. Providing personal protective equipment needed for safe handling of the chemicals.
    3. Providing proper containers, containment, and cabinetry for safe storage of materials.
    4. Defining the location and processes where particularly hazardous substances will be used, ensuring these areas are labeled, and ensuring that an inventory of these substances is maintained.
    5. Pay particular attention and conduct a risk assessment for all work that researchers are conducting alone and in the case of undergraduates, you must provide written prior approval for working alone with hazardous substances, equipment, or operations
D. Ensure new processes or experiments involving hazardous materials are planned carefully and appropriate hazard information, safety equipment, and general or Lab Specific SOPs are available prior to commencing work. Always seek to minimize the amount of hazardous chemicals purchased and used for experiments or processes.

E. Ensure the information regarding the laboratory activities recorded in the Space Registration Database is accurate. This should include emergency contact information to be used in the generation of emergency “green card” laboratory door signs.

F. Plan for accidents and ensure that appropriate supplies are in place and procedures are established for responding to an accident, including cleaning up chemical spills.

G. Ensure all employees working in the laboratory receive required training for work with potentially hazardous chemical, including lab-specific training on the hazardous materials that they use. See Part I. Section 3. Follow procedures for documenting the lab-specific training.

H. Ensure that all personnel obtain medical examinations and participate in the MIT medical surveillance program when required due to the materials they are working with.

I. Monitor the safety performance of the staff to ensure that the required safety equipment, practices and techniques are understood and are being employed and ensure that action is taken to correct work practices that may lead to chemical exposures or releases.

J. When needed, contact the Environment, Health and Safety (EHS) Office to arrange for workplace air samples, swipes or other tests to determine the amount and nature of airborne and/or surface contamination, inform employees and students of the results, and use data to aid in the evaluation and maintenance of appropriate laboratory conditions.

K. Ensure laboratory inspections are conducted routinely, and address all areas prescribed in the Level I. and II. Inspections as outlined in Part IV. Section 6. Take action to correct conditions that may lead to accidents or exposure to hazardous chemicals, and to correct problems identified during inspections. See Part IV. Section 6. for more information.

L. Ensure employees who suspect they may have been exposed to a hazardous chemical, dial 100 from an MIT phone or 617-253-1212 from a cellular phone and ask for medical assistance. Such exposures may occur through accidental skin exposures, ingestion, or inhalation of the chemical.

M. Report all accidents involving an employee’s chemical exposure or involving a chemical spill that may constitute a danger of environmental contamination to the EHS Office, the CHO or EHS Coordinator.

N. Investigate all chemical accidents and near misses to determine the cause and take appropriate corrective action to prevent similar accidents. Contact the CHO or the EHS Office, when needed, for assistance with investigations, assessment, and recommendations for corrective action.

O. Ensure unwanted or excess hazardous chemicals and materials are properly disposed according to all MIT, state, and federal procedures.

P. Assist the EHS Office, EHS Coordinator, and CHO as requested.

Q. Ensure shipping of all hazardous material is done following all state and federal regulations refer to Part II Section 9 Shipping Dangerous and Hazardous Materials on page 37 of this plan. Following the prudent laboratory practices and risk communication methods outlined in this Chemical Hygiene Plan are key elements in ensuring the Institute's compliance with TSCA requirements. Refer to Part 1, Section 2 of the Plan for these general responsibilities. With respect to materials regulated under TSCA, PIs shall ensure that any research agreements, experimental efforts and transfer of materials from the lab are consistent with the definition of "research and development activity" outlined in the EHS SOP "Toxic Substances Control Act (TSCA): Procedures for Core Program Compliance". The EHS Office shall work with Departments to ensure that any required TSCA forms (Import/Export, Allegations of Adverse Reactions, Notification of Substantial Risk and the TSCA New Chemical Transfer Form) are completed; maintain TSCA records; ensure that TSCA compliance updates are communicated; and, support Chemical Hygiene Officers/EHS Coordinators in conducting incident/illness/injury investigations involving new chemicals for which little environmental and health effects information is available (or for existing chemicals, when new symptoms are exhibited). Laboratory personnel shall contact the EHS Office when a chemical sample will be shipped; when a chemical will be imported into or exported from the U.S.; and, when adverse environmental or human health effects for a new or existing chemical are observed.

R. Undergraduates shall not work alone with hazardous materials, equipment or operations that can result in immediate injury or death without prior written approval from the immediate PI or supervisor. Written approval should only be granted after the risk assessment is performed and reviewed by the PI or supervisor with the individual

2.5. The EHS REPRESENTATIVE

The ENVIRONMENT, HEALTH AND SAFETY (EHS) REPRESENTATIVE shall:

A. Be familiar with the content and requirements of this Chemical Hygiene Plan and assist the Principal Investigator or Supervisor, as directed, with implementing and complying with requirements of this Plan.

B. Assist with contacting the DLC EHS Coordinator or the CHO, when needed, for assistance with addressing requirements for safe handling of chemicals.

C. Assist with or provide lab-specific chemical hygiene training for laboratory personnel, as directed by the PI/Supervisor.

D. Assist with dissemination of EHS information to laboratory personnel.

E. Assist with required routine inspections of the laboratory, correcting problems that can be readily corrected.

F. Assist with ensuring essential supplies and equipment are in place for safe work in the laboratory.

G. Assist with monitoring staff work practices for safety.

H. Report safety problems or concerns to the PI/Supervisor and/or the EHS Coordinator.

I. Address, as directed, safety problems or concerns in the laboratory.

J. Review and be familiar with DLC Emergency Preparedness Plan.

2.6. The ENVIRONMENT, HEALTH and SAFETY (EHS) OFFICE

The ENVIRONMENT, HEALTH, and SAFETY (EHS) OFFICE shall:

A. Oversee process for annual update of the CHP, reminding CHOs and EHS Coordinators when annual CHP updates are due and reviewing updated plans. See the *CHP Preparer's Guide* on the CHP website https://ehs.mit.edu/chemical-safety-program/chemical-hygiene/ for more information on the annual update process.

B. Provide a standard CHP template for use in developing and updating Chemical Hygiene Plans.

C. Provide "General Chemical Hygiene" training by classroom, web, or when requested by a DLC.

D. Provide "Managing Hazardous Waste" training by classroom, web, or when requested by a DLC.

E. Provide materials and guidance to assist with Lab-Specific Chemical Hygiene Training.

F. Establish and maintain a system for maintaining training records.

G. Conduct an annual meeting for CHOs and EHS Coordinators to update them regarding changes in the Template, the EHS Management System, and to review significant chemical safety concerns from the year.

H. Conduct special investigations and exposure monitoring, as requested or as required by regulations, making recommendations for control when needed.

I. Participate in inspections of laboratory operations at least once a year.

J. Oversee the fume hood survey program.

K. Provide guidance regarding selection and use of personal protective equipment. When respirators are required, provide services to ensure personnel are provided the proper equipment, to ensure the equipment fits properly, and to ensure users receive the required training.

L. Provide guidance and review Lab Specific SOPs for new experiments or operations, as requested.

M. Provide, as requested, chemical safety information and guidance for appropriate controls of hazards such as proper personal protective equipment and local exhaust ventilation.
N. Assist with investigations of serious accidents or chemical exposure incidents.
O. Report all DLC-specific accidents and incidents, as appropriate, to the DLC EHS Coordinator.

2.7. EMPLOYEES, STAFF, STUDENTS

It is the responsibility of employees, staff and students to follow the procedures outlined in this Chemical Hygiene Plan and all standard operating procedures developed under the plan. Failure to comply with safety procedures could result in researchers being denied access to department laboratories where hazardous chemicals are in use. The responsibilities of employees, staff and students working with or around hazardous chemicals in a laboratory include:

A. Read and understand the OSHA Chemical *Laboratory Standard* and this Chemical Hygiene Plan.
B. Understand the hazards of chemicals they handle and the signs and symptoms of excessive exposure.
C. Understand and follow all standard operating procedures.
D. Understand and apply all training received.
E. Understand the function and proper use of all personal protective equipment and wear personal protective equipment when mandated or necessary.
F. Report to the Principal Investigator or Laboratory Supervisor any significant problems arising from the implementation of the standard operating procedures.
G. Report to the PI/Supervisor all facts pertaining to every accident that results in exposure to toxic chemicals.
H. Report to the PI/Supervisor or EHS Representative actions or conditions that may exist that could result in an accident.
I. Contact the PI/Supervisor, the Chemical Hygiene Officer, the EHS Coordinator, or the EHS Office if any of the above procedures are not clearly understood.
J. If an emergency occurs related to an experiment, provide emergency response personnel with information about the conditions that caused the emergency and the existing situation in the laboratory.

2.8. VISITORS, TOURS and PETS

To ensure the health and safety of visitors and tours to laboratories where potential hazards may exist, guidelines should be followed, which can be found in an EHS SOPs entitled "Visitors and Tours Guideline," # EHS-0036, located at https://ehs.mit.edu/sops (certificate login is required).

The Institute promotes a healthy learning and research environment by controlling potential health hazards and nuisances including **prohibiting pets** from laboratories and other registered spaces with hazards. **This is for the safety and protection of the researchers, their work and the pet itself.** The definition of a pet is a domestic animal kept for personal enjoyment or companionship and is not trained to perform any disability-related tasks or work. The exception is for police dogs and animals used in research and teaching. For questions or further guidance related to pets, contact the EHS Office at environment@mit.edu.

2.9. DEPARTMENT, LABORATORY, OR CENTER (DLC) EHS COMMITTEE

With respect to the Chemical Hygiene Plan, the DLC EHS Committee shall:

A. Participate in periodic inspections and/or review inspection reports of DLC's laboratories and facilities, providing guidance or directives, as needed, for correcting problems found.
B. Review chemical handling incidents or exposure issues that occur in the DLC and recommend appropriate corrective action.

3. TRAINING

MIT has established systems to ensure you are provided with OSHA-required training to inform you of the hazards and precautions for work with chemicals, including chemicals present in your work area. The process begins when you complete a web-based *Training Needs Assessment*. You answer questions specific to your research situation and job duties, and the system will provide you information on your training needs and requirements. You should then proceed to take the required web courses or sign up for classroom training. As a researcher or employee working in a laboratory at MIT, you must complete the *Training Needs Assessment*, and can do so by going to https://ehs.mit.edu/training/. This will take you to a page that will direct you further. If you have problems or questions regarding completing the *Training Needs Assessment*, you should contact your EHS Coordinator or your EHS Representative.

3.1. Training Requirements

Chemical hygiene training requirements are detailed in the EHS-MS training system, which can be accessed at https://ehs.mit.edu/training/. The following four components are required if you indicate in the *Training Needs Assessment* within the training system that you use potentially hazardous chemicals in a laboratory, or you are a Principal Investigator or Supervisor for those who use potentially hazardous chemicals in a laboratory.

A. General Chemical Hygiene Training – can be taken as a web-based course or taken by attending a class offered by the Environment, Health and Safety (EHS) Office. This course is required only once before beginning work with potentially hazardous chemicals in a laboratory.

B. Read the Chemical Hygiene Plan – Signing a confirmation of having read and understood the Plan is required one time before beginning work with potentially hazardous chemicals in a laboratory.

C. Lab-Specific Chemical Hygiene Training – provided by the Principal Investigator or his or her designee on lab-specific chemical hazards. This training is required before beginning work with potentially hazardous chemicals in a laboratory including chemicals developed in the lab for use exclusively in the lab. These chemicals require a hazard determination and training if the chemical is considered hazardous. Training is also done annually thereafter (usually within a lab group meeting) or whenever a new hazard is introduced. The topics covered will depend, in part, on the nature of the lab and research being done. Discuss Lab-Specific Chemical Hygiene Training questions and requirements with your PI/Supervisor, EHS Representative, Chemical Hygiene Officer or your EHS Coordinator.

D. Managing Hazardous Waste – can be taken as a web-based course or taken by attending a class offered by the EHS Office. Required before beginning work with potentially hazardous chemicals and annually thereafter.

3.2. Training Records

The PI/Supervisor or designee will keep a copy of the outline of the topics covered in Lab-Specific Chemical Hygiene Training. The roster or lists of researchers, who have completed the lab-specific training and read the Chemical Hygiene Plan, will be submitted to the EHS Coordinator. These training records are then entered into the EHS-MS Central Training Records Database. Training records are kept for at least 3 years after an employee or student leaves the Institute.

4. INFORMATION REQUIREMENTS

4.1 Basic Requirements

Information that must be available to laboratory personnel includes:

A. A copy of the OSHA *Laboratory Standard* and its Appendices. The *Laboratory Standard* can be accessed on the OSHA website via http://www.osha.gov and searching under the regulation number “1910.1450” and Appendix 10.1.

B. The Permissible Exposure Limits (PELs) for OSHA-regulated substances and the American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Values (TLVs) for hazardous substances not given OSHA PELs. These lists are provided via a web link in Appendix II-A and II-B of this document.

C. Signs and symptoms associated with exposure to hazardous substances used in the laboratory. General information is integrated into Part II. Sections 2. and 3. of this document.

D. The location and availability of known reference materials on hazards, safe handling, storage and disposal of hazardous chemicals found in the laboratory. This information is provided in the next section of this document.

E. In addition, your supervisor, Chemical Hygiene Officer, EHS Coordinator and EHS Office staff are available to provide safety information. Core safety information sources are discussed below.

4.2 Chemical Safety Information Sources

Safety Data Sheets (SDSs)

Safety Data Sheets (SDSs) are documents, prepared by chemical manufacturers that provide information about the chemical's physical and chemical hazards and recommended exposure limits, and list the means for controlling those hazards. SDSs also provide information about first aid, emergency procedures, and waste disposal.

An SDS should be reviewed before beginning work with a chemical to determine proper use and safety precautions. Once a chemical is present in the lab, the SDS should be either book marked electronically or a hard copy kept on hand for reference, or in case of emergencies. Specific information required by OSHA to be on an SDS includes:

Product Identity	Reactivity Hazards
Hazardous Ingredients	Spill Clean-Up
Physical/Chemical Properties	Protective Equipment
Fire and Explosion Hazards	Special Precautions
Health Hazards and Exposure Limits	

SDSs and additional chemical hazard information can be obtained from a variety of sources as outlined below:

A. **The Internet**. The EHS Office has compiled a list of links to sites that contain SDSs. This list can be accessed at https://ehs.mit.edu/workplace-safety-program/hazard-communication/

B. **Chemical Manufacturer**. A request may be made directly to the chemical manufacturer or supplier. This is often the best source for "products" or "mixtures" to determine what hazardous ingredients are contained in the formulation.

C. **EHS Office**. A file of SDSs for common chemicals that are in use at MIT or have been used at MIT is available through the EHS Office on the fourth floor of Building N52. They can be reached at 617-452-3477 (2-EHSS or 2-3477 from an MIT telephone).

Please contact the EHS Office if you need assistance in interpreting SDS information.

Safety Data Sheets

In spring of 2012, the Occupational Safety and Health Administration finalized an update of the OSHA Hazard Communication Standard to adopt international Global Harmonization System criteria for:

- Classifying the hazards of chemicals and chemical products and mixtures.
- Labeling of hazardous materials with standardized pictograms and standardized language to indicate hazards and precautions
- Conveying the hazard information on a standardized 16 section Safety Data Sheet.

By June 1, 2015, manufacturers will be required to generate Safety Data Sheets in place of Material safety Data Sheets. Safety Data Sheets will have a standardized 16 section format with standardized information in each section. **Appendix 10.3** contains a summary of information about the new "Safety Data Sheet" sections and section content. To search SDSs go the EHS Office web page: https://ehs.mit.edu/workplace-safety-program/hazard-communication/

Some of the suppliers of laboratory chemicals are already generating data sheets in this new format. Until June 1, 2016, you can have either an SDS or an MSDS available for the chemicals you work with. After June 1, 2016, you will need to have replaced all MSDSs with paper copies or links to SDSs for the chemicals you work with in the laboratory.

Newly Synthesized Chemicals and SDS or MSDS Requirements
New chemical substances synthesized or produced in your laboratory and used or shared *outside* of your laboratory suite are subject to OSHA Hazard Communication Standard (29 CFR 1910.1200) requirements. These rules mandate the preparation of an SDS or MSDS for each synthesized substance and labeling of containers containing the chemical substance.

Laboratory Chemical Safety Summaries (LCSS)
The LCSSs listed in Prudent Practices in the Laboratory provide concise, critical discussions of the toxicity, flammability, reactivity, and explosibility of 88 chemicals commonly used in scientific research laboratories. These are particularly useful as they address laboratory use of chemicals. PubChem has a listing of many more LCSSs https://pubchem.ncbi.nlm.nih.gov/lcss/

Chemical Container Labels
Chemical container labels are a good resource for information on chemical hazards. All containers of hazardous chemicals must have labels attached. Labels on purchased chemicals must include:

- The common name of the chemical;
- The name, address and telephone number of the company responsible for the product; and
- Appropriate hazard warning(s). The warning may be a single word (e.g. Danger, Caution, Warning) or may identify the primary hazard both physical (e.g. water reactive, flammable, or explosive) and health (e.g. carcinogen, corrosive or irritant).

Most labels provide additional safety information to help workers protect themselves from the substance. This information may include protective measures and/or protective clothing to be used, first aid instructions, storage information and emergency procedures.
Laboratory personnel are responsible for:

- Inspecting incoming containers to be sure that labels are attached and are in good condition and contain the information outlined above.
- Reading the container label each time a newly purchased chemical is used. It is possible that the manufacturer may have added new hazard information or reformulated the product since the last purchase.
- Ensuring that chemical container labels are not removed or defaced, except when containers are empty.
- Labeling any secondary containers used in the laboratory, to prevent unknown chemicals or inadvertent reaction.
- Verifying that chemical waste containers have completed and accurate chemical waste labels.

Additional guidance on labeling chemical containers can be found in Part II. Section 6.

Global Harmonization Pictograms and Labels. Under the 2012 changes to the OSHA Hazard Communication Standard, requirements for language on chemical labels is standardized using the Global Harmonization System criteria, and standardized pictograms are to be used to convey the hazards. Some suppliers of laboratory chemicals have already begun to implement changes on their labels, making use of the new pictograms and language. **Appendix 10.4** contains information about the new pictograms and their meaning. It is recommended the lab post the chart of pictograms so personnel can become familiar with them and their meaning. Additional information can be found at: https://ehs.mit.edu/workplace-safety-program/hazard-communication/ along with a link to pictogram information for printing and posting. A color printer should be used because the red borders on the pictograms are a key component.

By June 1, 2015, all suppliers will need to label their containers using the standard labeling criteria but until then you may see different types of labels.

Environment, Health and Safety Reference Literature
The EHS Office maintains a library of reference materials addressing environment, health and safety issues. These references include applicable exposure standards and recommended exposure levels, as well as copies of the OSHA Lab Standard and its Appendices. These materials, as well as additional health and safety references, may be reviewed by visiting the EHS Office located on the fourth floor of Building N52.

PART II. General Chemical Hygiene Practices

1. INTRODUCTION

Part II of this Chemical Hygiene Plan contains the minimum required precautions and standard operating procedures for working with laboratory chemicals in MIT laboratories. These precautions address broad classes of chemicals. This Part contains chemical hazard and risk assessment information, and general procedures for safe chemical management addressing the purchase, use, labeling, storage, disposal and shipping of chemicals. This Part also discusses common controls for safe use of chemicals including administrative and engineering controls, such as fume hoods, personal protective equipment, and designated areas.

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 and students. Permissible Exposure Limits (PELs) set by OSHA are contained in Appendix II-A. Threshold Limit Values (TLVs) established by the American Conference of Governmental Industrial Hygienists (ACGIH) are contained in Appendix II-B. For many laboratory chemicals, exposure limits have not been established. In addition, little is known about the effects of combined exposures. Therefore, all laboratory workers should take steps to minimize chemical exposure via all routes of entry.

OSHA recognizes that some classes of chemical substances pose a greater health and safety risk than others. To differentiate this different risk characteristic, OSHA identifies two categories of hazardous chemicals: **hazardous chemicals** and **particularly hazardous substances**. *Particularly hazardous substances* (PHSs) are a subset of hazardous chemicals that is regulated more stringently because they have been deemed to pose a substantially greater risk. Because of this, OSHA requires additional precautions and procedures be undertaken when *particularly hazardous substances* are used in the laboratory.

Introduction to Standard Operating Procedures
A standard operating procedure (SOP) is a written set of instructions or guidelines that detail the uniform procedures to be followed routinely, and safety precautions to take when carrying out a particular experiment or procedure. The development and implementation of SOPs for critical activities is a core component of promoting excellence in a laboratory and for ensuring a safe, healthy, and environmentally sound workplace. For these reasons, the use of general SOPs and the development and use of Lab Specific SOPs is an essential administrative tool to be used in the laboratory and is a tool that is required by the OSHA Laboratory Standard. The equivalent of Lab Specific SOPs should also be developed for research conducted in the field where hazardous materials or processes are used ensuring proper safety, storage and controls in the field. For more information on Field Safety visit https://ehs.mit.edu/lab-research-program/field-research-safety/

Literally thousands of different compounds are involved in the research being conducted in campus laboratories. The specific health hazards associated with many of these compounds are unknown, and many substances are new compounds which have not been reported previously in the chemical literature. Consequently, it is impossible in this Chemical Hygiene Plan to provide standard operating procedures for each specific hazardous substance. Instead, this Part outlines general procedures that should be employed in the use of all hazardous substances. Individual research groups may be required to supplement these general procedures with additional Lab Specific SOPs for handling specific hazardous substances that are used in their laboratories.

This Chemical Hygiene Plan contains core standard operating procedures for the safe use of two categories of chemicals: *hazardous chemicals*, and *particularly hazardous substances* (PHS). These standard operating procedures are contained in Part II. Section 3. These general safety procedures are designed to ensure basic levels of staff health and safety in the laboratory, for routine and common practices, uses, and chemicals.

You are required to develop additional Lab Specific SOPs if the general SOPs provided in Part II of this Plan DO NOT adequately ensure the protection of personal health and safety, and the environment for a particular activity, operation, or experiment conducted in your laboratory. This requirement is particularly applicable if a procedure requires detailed and specific guidance to avoid dangerous exposures or consequences such as an explosion. Lab Specific SOPs must be developed prior to initiating any significantly hazardous procedures.

Guidelines and a template for preparing Lab Specific SOPs when required as noted above, are contained in Part III. of this Plan. A copy of all Lab Specific SOPs developed must be located in the laboratory spaces and be available to all people in the laboratory. It is recommended, but not required, that all additional Lab Specific SOPs be included in Part III. of this Chemical Hygiene Plan.

Prior to working with chemicals following the SOPs in Part II. Section 3, there are certain steps you must take to understand the hazards of the work you are doing with chemicals. A process for assessing the hazards of chemical use is outlined below.

2. IDENTIFICATION AND CLASSIFICATION OF HAZARDOUS CHEMICALS

Determine the specific chemicals you are working with and the type of hazard they present. Many of the substances encountered in the laboratory are known to be toxic or corrosive, or both. Compounds that are explosive and/or are highly flammable pose another significant type of hazard. New and untested substances that may be hazardous are also frequently encountered. Thus, it is essential that all laboratory workers understand the types of toxicity, recognize the routes of exposure, and are familiar with the major hazard classes of chemicals. The most important single generalization regarding toxicity in chemical research is to treat all compounds as potentially harmful, especially new and unfamiliar materials, and work with them under conditions to minimize exposure by skin contact and inhalation.

When considering possible toxicity hazards while planning an experiment, it is important to recognize that the combination of the toxic effects of two substances may be significantly greater than the toxic effect of either substance alone. Because most chemical reactions are likely to contain mixtures of substances whose combined toxicities have never been evaluated, it is prudent to assume that mixtures of different substances (e.g., chemical reaction mixtures) will be more toxic than the most toxic ingredient contained in the mixture. Furthermore, chemical reactions involving two or more substances may form reaction products that are significantly more toxic than the starting reactants.

The OSHA Laboratory Standard defines a hazardous chemical as *"a chemical for which there is statistically significant evidence based on at least one study conducted in accordance with established scientific principles that acute or chronic health effects may occur in exposed employees. 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".* Highly flammable and explosive substances comprise a category of hazardous chemicals.

The major classes of *hazardous* and *particularly hazardous chemicals* and their related health and safety risks are discussed in further detail below.

2.1. Possible Animal Carcinogens

Carcinogens are chemical or physical agents that cause cancer. Generally they are chronically toxic substances; that is, they cause damage after repeated or long-duration exposure, and their effects may only become evident after a long latency period. Chronic toxins are particularly insidious because they may have no immediate apparent harmful effects. For a large number of compounds there is limited evidence of carcinogenicity to animals from studies involving experimental animals. These compounds should be handled using the general procedures for work with hazardous substances outlined in Part II. Section 3.1 and 3.2 below.

Certain *select carcinogens* are classified as "particularly hazardous substances" and must be handled using the additional special precautions described in Part II. Section 3.3. Select carcinogens (defined in detail below) consist of compounds for which there is evidence from human studies that exposure can cause cancer. It is important to recognize that some substances involved in research laboratories are new compounds and have not been subjected to testing for carcinogenicity.

2.2. Corrosive Substances

As a health hazard, corrosive substances cause destruction of, or alterations in, living tissue by chemical action at the site of contact. Major classes of corrosive substances include strong acids (e.g., sulfuric, nitric, hydrochloric, and hydrofluoric acids), strong bases (sodium hydroxide, potassium hydroxide, and ammonium hydroxide), dehydrating agents (sulfuric acid, sodium hydroxide, phosphorus pentoxide, and calcium oxide), and oxidizing agents (hydrogen peroxide, chlorine, and bromine). Symptoms of exposure for inhalation include a burning sensation, coughing, wheezing, laryngitis, shortness of breath, nausea, and vomiting. For eyes, symptoms include pain, blood shot eyes, tearing, and blurring of vision. For skin, symptoms may include reddening, pain, inflammation, bleeding, blistering and burns. As a physical hazard, corrosive substances may corrode materials they come in contact with and may be highly reactive with other substances. It is important to review information regarding materials they corrode, and their reactivity with other substances, as well as information on health effects.

2.3. Irritants

Irritants are defined as non-corrosive chemicals that cause reversible inflammatory effects on living tissue by chemical action at the site of contact. A wide variety of organic and inorganic compounds, including many chemicals that are in a powder or crystalline form, are irritants and consequently, skin contact with all laboratory chemicals should always be avoided.

2.4. Sensitizers

A sensitizer (allergen) is a substance that causes exposed people to develop an allergic reaction in normal tissue after repeated exposure to the substance. Examples of allergens include diazomethane, chromium, nickel, formaldehyde, isocyanates, arylhydrazines, benzylic and allylic halides, and many phenol derivatives.

2.5. Flammable, Highly Reactive and Explosive Substances

A number of highly flammable substances are in common use in campus laboratories. Highly Reactive substances are materials that decompose under conditions of mechanical shock, elevated temperature, or chemical action, with the release of large volumes of gases and heat. Some materials, such as peroxide formers, may not be explosive, but may form into substances that will deflagrate or explode.

Explosives are any chemical compound, mixture or device, the primary or common purpose of which is to function as by explosion; i.e., with substantially instantaneous release of gas or heat. The term includes, but is not limited to, dynamite and other high explosives, black powder, pellet powder, initiating explosives, detonators, safety fuses, squibs, detonating cord, igniter cord, and igniters. The possession or use of explosive materials are highly regulated by federal and state agencies, contact the EHS office 617-452-3477 for assistance before contemplating use. For the list of Alcohol, Tobacco and Firearms (ATF) explosive materials see http://cryptome.org/2013/10/atf-13-1028.htm

2.6. Hazardous Substances with Toxic Effects on Specific Organs

Substances included in this category include (a) hepatotoxins (substances that produce liver damage such as nitrosamines and carbon tetrachloride); (b) nephrotoxins (agents causing damage to the kidneys such as certain halogenated hydrocarbons); (c) neurotoxins (substances which produce their primary toxic effects on the nervous system such as mercury, acrylamide, and carbon disulfide); (d) agents which act on the hematopoietic system (such as carbon monoxide and cyanides which decrease hemoglobin function and deprive the body tissues of oxygen); and (e) agents which damage lung tissue such as asbestos and silica.

2.7. Particularly Hazardous Substances/Select Carcinogens

As discussed in earlier sections of this Chemical Hygiene Plan, hazardous chemicals are chemicals for which there is scientific evidence that adverse acute or chronic health effects may occur in exposed workers. An agent is an acute toxin if its toxic effects are manifested after a single or short-duration exposure. Chronically toxic agents show their effects after repeated or long-duration exposure and the effects usually become evident only after a long latency period. Many of the substances in frequent use in laboratories are classified as hazardous substances, and the procedures for working with these chemicals are detailed in Part II Section 3.1. and 3.2. There are some substances, however, that pose such significant threats to human health that they are classified as "particularly hazardous substances" (PHSs). The OSHA Laboratory Standard requires that special provisions be established to prevent the harmful exposure of researchers to PHSs. General procedures for working with such materials are presented in detail in Section 3.3.

For information and a list of PHSs, see https://ehs.mit.edu/chemical-safety-program/dangerous-highly-toxic-chemicals/

Chemicals are classified as *particularly hazardous substances* if they belong to one or more of the following three categories. Compounds classified as *particularly hazardous substances* generally must then be handled using the procedures outlined in Part II. Section 3.3 **in addition to** the procedures outlined for hazardous chemicals in Part II. Section 3.1 and 3.2. Appendix II. C. provides procedures to assist you in how to determine if a chemical is a particularly hazardous substance, as well as additional information on PHSs.

2.7.1 Select Carcinogens

Certain potent carcinogens are classified as "select carcinogens" and treated as PHSs. A select carcinogen is defined in the OSHA *Laboratory Standard* as a substance that meets one of the following criteria:

a) It is regulated by OSHA as a carcinogen,

b) It is listed as "known to be a carcinogen" in the latest Annual Report on Carcinogens published by the National Toxicology Program (NTP),

c) It is listed under Group 1 ("carcinogenic to humans") by the International Agency for Research on Cancer (IARC), or

d) It is listed under IARC Group 2A or 2B, ("probably carcinogenic to humans") or under the category "reasonably anticipated to be a carcinogen" by the NTP, and causes statistically significant tumor incidence in experimental animals in accordance with any of the following criteria: (i) after inhalation exposure of 6-7 hours per day, 5 days per week, for a significant portion of a lifetime to dosages of less than 10 mg/m3; (ii) after repeated skin application of less than 300 mg/kg of body weight per week; or (iii) after oral dosages of less than 50 mg/kg of body weight per day.

The following Table on the next page lists the substances meeting criteria (a), (b), or (c). For information on compounds meeting criteria (d), examine IARC Group 2A and 2B lists and the NTP lists that are available on the Internet. See Appendix II-C for more information on PHSs.

Partial List of Select Carcinogens (Includes OSHA Carcinogens)

- 2acetylaminofluorene
- acrylamide
- acrylonitrile
- 4-aminodiphenyl
- arsenic and certain arsenic compounds
- asbestos
- azathioprine
- benzene
- benzidine
- bis(chloromethyl) ether
- 1,3 butadiene
- 1,4-butanediol dimethylsulfonate (myleran)
- cadmium
- chlorambucil
- chloromethyl methyl ether
- chromium and certain chromium compounds
- coal-tar pitches
- coal tars
- coke oven emissions
- conjugated estrogens
- cyclophosphamide
- 1,2-dibromo-3-chloropropane
- 3,3'-dichlorobenzidine (and its salts)
- diethylstilbestrol
- dimethylaminoazobenzene
- dimethyl sulfate
- ethylene dibromide
- ethylene oxide
- ethylenimine
- formaldehyde
- hexamtehylphosphoramide
- hydrazine
- melphalan
- 4,4'-methylene-bis(2-chloroaniline)
- methylene chloride
- methylene dianiline
- mustard gas
- N,N'-bis(2-chloroethyl)-2-naphthylamine (chlornaphazine)
- alpha-naphthylamine
- beta-naphthylamine
- nickel carbonyl
- 4-nitrobiphenyl
- N-nitrosodimethylamine
- beta-propiolactone
- thorium dioxide
- treosulphan
- vinyl chloride

Note: the above list is not intended to be complete, and it is the responsibility of the researcher (in consultation with their laboratory supervisor) to evaluate each compound involved in their work and to determine whether it should be handled as a select carcinogen.

2.7.2 Reproductive and Developmental Toxins

Reproductive toxins can affect the reproductive health of both male and female employees and students if proper procedures and controls are not used. For women, exposure to reproductive toxins during pregnancy can cause adverse effects on the fetus; these effects include embryolethality (death of the fertilized egg, embryo or fetus), malformations (teratogenic effects), and postnatal functional defects. Examples of embryotoxins include thalidomide and certain antibiotics such as tetracycline. Women of childbearing potential should note that embryotoxins have the greatest impact during the first trimester of pregnancy. Because a woman often does not know that she is pregnant during this period of high susceptibility, special caution is advised when working with all chemicals, especially those rapidly absorbed through the skin (e.g., formamide). Researchers who are pregnant or intending to become pregnant should arrange for a confidential consultation with MIT Medical. They should also consult with their laboratory supervisor and the Environment, Health and Safety (EHS) Office before working with substances that are suspected to be reproductive toxins. As minimal precautions, the general procedures outlined in Part II. Section 3.3 below should then be followed for work with such compounds. For men, the effects of certain reproductive toxins may include decline in fertility, malformations in off-spring, and certain types of cancer. Therefore, adequate protection from exposure must be employed.

Information on reproductive toxins can be obtained from Safety Data Sheets, by contacting the EHS Office Industrial Hygiene Program (617-452-3477).

The following Table lists some common materials that are suspected to be reproductive toxins; in most laboratories it will be appropriate to handle these compounds as *particularly hazardous substances*.

Partial List of Reproductive Toxins

arsenic and certain arsenic compounds	lead compounds
benzene	mercury compounds
cadmium and certain cadmium compounds	toluene
carbon disulfide	vinyl chloride
ethylene glycol monomethyl and ethyl ethers	xylene
ethylene oxide	

Note: The above list is not intended to be complete, and it is the responsibility of the researcher (in consultation with their laboratory supervisor) to evaluate each compound involved in their work and to determine whether it should be handled as a reproductive toxin.

2.7.3 Compounds with a High Degree of Acute Toxicity

Compounds that have a high degree of acute toxicity comprise a third category of *particularly hazardous substances* as defined by the OSHA *Laboratory Standard*. Acutely toxic agents include certain corrosive compounds, irritants, sensitizers (allergens), hepatotoxins, nephrotoxins, neurotoxins, agents that act on the hematopoietic systems, and agents which damage the lungs, skins, eyes, or mucous membranes. Substances that have a high degree of acute toxicity are interpreted by OSHA as being substances that "may be fatal or cause damage to target organs as the result of a single exposure or exposures of short duration".

Toxic and Highly Toxic Agents

OSHA regulations (29 CFR 1910.1200 Appendix A) define toxic and highly toxic agents as substances with median lethal dose (LD_{50}) values in the following ranges:

Test	Toxic	Highly Toxic
Oral LD_{50} (albino rats)	50-500 mg/kg	<50 mg/kg
Skin Contact LD_{50} (albino rabbits)	200-1000 mg/kg	<200 mg/kg
Inhalation LC_{50} (albino rats)	200-2000 ppm/air	<200 ppm/air

It is important to note that the above classification does not take into consideration *chronic toxicity* (e.g. carcinogenicity and reproductive toxicity). Also, note that LD_{50} values vary significantly between different species, and the human toxicity for a substance may be greater or less than that measured in test animals. OSHA considers substances that are either toxic or highly toxic, as defined above, to be *particularly hazardous substances*.

In evaluating the acute toxicity of chemical substances, the HMIS (Hazardous Materials Identification System) rating criteria developed by the National Paint and Coatings Association may be helpful. HMIS numbers can often be found in SDSs. LD_{50} values can be found in SDSs and in references such as the *Sigma-Aldrich Library of Chemical Safety Data* and Patnaik's *A Comprehensive Guide to the Hazardous Properties of Chemical Substances.*

The following Table lists some of the compounds that may be in current use in campus laboratories and that have a high degree of acute toxicity:

Partial List of Compounds with a High Degree of Acute Toxicity

abrin
acrolein
arsine
chlorine
diazomethane
diborane (gas)
hydrogen cyanide
hydrogen fluoride
methyl fluorosulfonate
nickel carbonyl
nitrogen dioxide
osmium tetroxide
ozone
phosgene
ricin
sodium azide
sodium cyanide (and other cyanide salts)
strychnine

Note: the above list is not intended to be complete, and it is the responsibility of the researcher (in consultation with their laboratory supervisor) to evaluate each compound involved in their work and to determine whether it is a substance with a high degree of acute toxicity.

Compounds classified as having a high degree of acute toxicity must generally be handled using the procedures outlined in Part II. Section 3.3 below in addition to the procedures outlined for hazardous chemicals in Part II. Section 3.1 and 3.2. Finally, several of the compounds listed may require prior approval from the DLC EHS Committee before work with them can be carried out. See Part IV. Section 2. for a discussion of prior approval requirements.

In evaluating the hazards associated with work with toxic substances, it is important to note that a number of factors influence the response of individuals to exposure to toxic compounds. For example, people are rarely exposed to a single biologically active substance. With this point in mind, it is noteworthy that one toxin can influence the effect of a second. This underscores the importance of maintaining good laboratory practices at all times, and with all chemicals.

2.8 Green Chemistry

Green Chemistry is the utilization of a set of principles that reduces or eliminates the use or generation of hazardous substances in the design, manufacture, and application of chemical products. Use the 12 Principles of Green Chemistry to design or modify experiment to make it more environmentally friendly and sustainable. Consider waste and hazard prevention during design, rather than disposing, treating and handling waste after a processor material has been developed. For more information on Green Chemistry and the 12 Principles, visit the EHS Office website at https://ehs.mit.edu/green-chemistry/.

12 Principles of Green Chemistry:

1. **Prevent waste**: Design chemical syntheses to prevent waste. Leave no hazardous or toxic waste.
2. **Maximize atom economy**: Design syntheses so that the final product contains the maximum proportion of the starting materials. Waste few or no atoms.
3. **Design less hazardous chemical syntheses**: Design syntheses to use and generate substances with little or no toxicity to either humans or the environment.
4. **Design safer chemicals and products**: Design chemical products that are fully effective yet have little or no toxicity.
5. **Use safer solvents and reaction conditions**: Avoid using solvents, separation agents, or other auxiliary chemicals. If you must use these chemicals, use safer ones.
6. **Increase energy efficiency**: Run chemical reactions at room temperature and pressure whenever possible.
7. **Use renewable feedstocks**: Use starting materials (also known as feedstocks) that are renewable rather than depletable. The source of renewable feedstocks is often agricultural products or the wastes of other processes; the source of depletable feedstocks is often fossil fuels (petroleum, natural gas, or coal) or mining operations.

8. **Avoid chemical derivatives**: Avoid using blocking or protecting groups or any temporary modifications if possible. Derivatives use additional reagents and generate waste.
9. **Use catalysts, not stoichiometric reagents**: Minimize waste by using catalytic reactions. Catalysts are effective in small amounts and can carry out a single reaction many times. They are preferable to stoichiometric reagents, which are used in excess and carry out a reaction only once.
10. **Design chemicals and products to degrade after use**: Design chemical products to break down to innocuous substances after use so that they do not accumulate in the environment.
11. **Analyze in real time to prevent pollution**: Include in-process, real-time monitoring and control during syntheses to minimize or eliminate the formation of byproducts.
12. **Minimize the potential for accidents**: Design chemicals and their physical forms (solid, liquid, or gas) to minimize the potential for chemical accidents including explosions, fires, and releases to the environment.

3. STANDARD OPERATING PROCEDURES FOR WORK WITH HAZARDOUS CHEMICALS

3.1. Preliminary Steps and Procedures

All work involving chemicals in MIT laboratories must be conducted using the "Standard Operating Procedures" outlined below. In addition, laboratory workers must determine whether any of the chemicals to be handled in the planned experiment meet the definition of a particularly hazardous substance (PHS) due to high acute toxicity, carcinogenicity, and/or reproductive toxicity (PHS definition refer to Part II 2.7 p.15) by:

1. Performing a check to see if the chemical(s)meets the definition and is on the PHS list https://ehs.mit.edu/chemical-safety-program/dangerous-highly-toxic-chemicals/. If your chemical(s) is not listed it should still be evaluated for high acute toxicity, carcinogenicity, and/or reproductive toxicity. For more guidance on how to determine if a chemical is a PHS see Part II 10.3 Appendix IIC p.40.
2. If listed or determined to be a PHS chemical, then do a risk assessment to see if there are any procedures or protective measures "beyond" those already required for hazardous chemicals outlined in this section. Consider the total amount of the substance that will be used, the expected frequency of use, the chemical's routes of exposure, and the circumstances of its use in the proposed experiment.
3. If it is determined that the PHS requires additional protective measures, they can be found in Part II section 3.3 p. 27.
4. If the chemical is not listed or determine to be a PHS or does not require additional protective measures, then follow the procedures for Hazardous Chemicals outlined in this section.

For very toxic or hazardous substances, or specialized practices, consideration must be given to whether additional consultation with safety professionals and development of Lab Specific SOPs is warranted or required. EHS or the EHS Coordinators/Chemical Hygiene Officer may decide if the lab should develop additional SOPs for PHSs. ***NOTE:*** Additional consideration should be given to laboratory operations involving hazardous substances that are sometimes carried out continuously or overnight. It is the responsibility of the researcher to design these overnight experiments with provisions to prevent the release of hazardous substances in the event of interruptions in utility services such as electricity, cooling water, and inert gas. Laboratory lights should be left on and appropriate signs should be posted on the entrance door(s) as well as near the experiment identifying the nature of the experiment and the hazardous substances in use. In some cases, arrangements should be made for periodic inspection of the operation by other workers. Information should be posted on the signs indicating how to contact you in the event of an emergency.

STEP 1: Determine the toxicity and warning properties of the chemicals to be used in your experiment.

- ❑ Identify the chemicals involved in the proposed experiment and determine the amounts that will be used.
- ❑ Use an up-to-date LCSS or SDS to determine the exposure limit, type of toxicity, warning properties (smell, irritation, etc.) and symptoms of exposure for each chemical involved in the planned experiment.
- ❑ If a new chemical substance(s) will be produced during the experiment and the toxicity is unknown, assume it is a particularly hazardous substance and follow the procedures in Part II. Section 3.3.
- ❑ Assume that any mixture of chemicals will be more toxic than its most toxic component.
- ❑ Consider substituting less toxic chemicals. Find the resources for greener chemical alternatives at the EHS Office website https://ehs.mit.edu/green-chemistry/.

STEP 2: Determine most likely routes of exposure based on how chemicals will be used and their physical/chemical properties.

- ❑ ***Inhalation*** – Inhalation risks are highest when volatile liquids, gases, dusts, or mists are used or generated. Heating will increase the volatility of liquids. Pay particular attention to chemicals with low exposure limits. Potential for inhalation is highest when chemicals are used on an open lab bench. Use in enclosed apparatus or chemical laboratory hoods decreases inhalation exposure potential.
- ❑ ***Skin Exposure*** – Chances for skin exposure exist for most laboratory chemical procedures. When the "skin" notation is listed in the exposure limit section of the SDS, the chemical can be absorbed through the intact skin.
- ❑ ***Injection or ingestion*** – Not normally a major route of exposure if proper handling procedures are used. Determine whether the experiment involves a significant risk of inadvertent ingestion or injection of chemicals.

STEP 3: Determine required control measures, personal protective equipment, and proper work practices to minimize exposure.

A. Inhalation Control Measures

Determine When to Use Laboratory Chemical Hoods (Fume Hoods)

Procedures involving volatile toxic substances and those operations involving solid or liquid toxic substances that may result in the generation of vapors or aerosols should be conducted in a laboratory hood or other type of local exhaust ventilation. See Part II. Section 5. for a more detailed discussion of laboratory hoods. Other types of control devices include glove boxes, custom designed hoods, shut-off valves, and monitoring equipment linked to alarms and shut-off valves.

Determine Whether Respirators Might Be Required

Generally, hazards should be controlled by use of ventilation and it should not be necessary to use respirators. Contact the Industrial Hygiene Program for help in evaluating the need for a respirator. If one is needed and you are medically qualified to wear a respirator, obtain one of the correct types and size from the Industrial Hygiene Program. A respirator will be provided at no charge to employees and researchers if one is needed to keep their exposure below applicable PELs". Do not use a lab mate's respirator. The MIT Respirator Protection Program is described in full at https://ehs.mit.edu/workplace-safety-program/personal-protective-equipment/

B. Personal Protective Equipment For Eyes and Skin

Note: More details regarding PLS and the Junior Physics Lab policy for use of eye protection in the laboratory is found in section 4.2 below.

Select and wear appropriate eye and face protection. Wearing eye protection is required by OSHA regulation whenever and wherever potential eye hazards exist. Hazards requiring eye and/or face protection include flying particles; molten metal; liquids including acids and caustic materials, biological or radioactive materials; chemical gases or vapors; and potentially injurious light radiation. Many Departments, Labs and Centers require eye protection at all times in labs and shops, and post "eye protection required" signs on the doors or in the hazardous areas. Use safety glasses with side shields as basic eye protection for handling chemicals where there is a low risk of splash or splatter. When pouring large amounts of chemicals, observing processes that are under heat or pressure, making adjustments to chemical containing apparatus, or performing other operations or tasks with a moderate to high potential splash risk or severe consequences in the event of a splash, chemical goggles should be used. A face shield can be used with the goggles to protect the face under these circumstances.

Wear appropriate clothing when in the laboratory. The minimum requirements that apply to any spaces that fall under this DLC CHP are outlined in the table below. Note that specific labs or DLCs may have stricter requirements. In some cases, through a hazard assessment, laboratory supervisors may identify situations (a task, experiment, or area) where alternative or more protective apparel must be worn. Refer to section 4 and to https://ehs.mit.edu/workplace-safety-program/personal-protective-equipment/ for more detailed information on PPE assessments, selection and use.

	Activity			
Minimum Requirements	**Brief lab visit or walk-through***	**Not Working With or Nearby to Chemicals, BL2 Materials, or Radioactive Materials ****	**Working With or Nearby to Chemicals, BL2 Materials, or Radioactive Materials*****	**Details**
Shoes that fully cover the feet.	Required for PLS space; Not required for Physics Teaching Labs, however bare feet are still forbidden.	Required for PLS space; Not required for Physics Teaching Labs, however bare feet are still forbidden.	Required	• Never wear open toe or open heel shoes such as flip-flops or sandals in PLS space. • High heeled shoes or flats that leave the top of the foot exposed should not be worn in PLS space. • Shoes made of porous materials such as mesh or fabric provide only limited protection in a spill and should be avoided when working with materials that can become a spill hazard.
Clothing that covers the legs	Recommended for PLS space; Not required for Physics Teaching Labs.	Required for PLS space; Not required for Physics Teaching Labs.	Required	• When required, the combination of shoes and clothing must provide full coverage of feet and legs. • Thin or tight leg coverings, such as tights, should be avoided when working with materials that can become a spill hazard. • Synthetic materials such as spandex, nylon, and polyester can melt to the skin when heated and should not be worn when there is a significant fire hazard.

Lab coat	Recommended for PLS space; According to PPE Hazard Assessment performed by each lab	Recommended for PLS space; According to PPE Hazard Assessment performed by each lab	Required	• Lab coat material should be chosen based on a hazard assessment. • Flame resistant lab coats are required when handling pyrophoric materials. • Comparable protective measures may be used in place of a lab coat depending on special research needs. These alternatives must be reviewed with the DLC EHS Coordinator.
Gloves			According to PPE Hazard Assessment performed by each lab	• Appropriate gloves chosen based on hazards and compatibility.
Eye protection and other PPE	According to PPE Hazard Assessment performed by each lab	According to PPE Hazard Assessment performed by each lab	According to PPE Hazard Assessment performed by each lab	• Eyewear requirements based on DLC/lab policies and hazard assessments. • Other PPE may be required depending on PPE hazard assessment for the lab or DLC.

* This category includes people that will only be in a lab space briefly, including but not limited to delivery personnel, MIT students and employees going through a space but not stopping to work, and tour participants. Visitors will not spend time observing or standing near areas where active work with chemicals, biologicals, radioactive materials, lasers, or other potential hazards are being used.

** This category includes but is not limited to those at desks or office areas within labs that are away from active work areas and those that are using equipment where there are no chemicals or other hazards.

*** This category includes those working with hazardous materials as well as those working nearby to those materials where there is an expected risk of exposure. People working at desks may fall under this category depending on the activities happening around the desk. Ultimately it is the responsibility of the PI to assess the hazards around desk areas and determine if lab coats or other PPE are required due to the proximity of hazardous materials or processes.

A combination of clothing and shoes that fully cover the legs and feet is required when working in spaces that have hazardous chemicals, which includes almost all lab spaces. Similarly, there are requirements to have the legs covered in spaces with other hazards that could pose a risk to individuals, such as physical hazards or biological and radioactive materials that pose an exposure risk. Individuals briefly visiting a space are exempt from this requirement if they are not near hazardous materials.

At the time of preparing this CHP, PLS labs comprised spaces under two PIs and were located in NE46 with plans to move to Building 4 in early 2023. Given the configuration of the space, both in NE46 and Bldg. 4, it is not possible to grant any exception to required clothing and PPE. Even if there was any room that could qualify for such exemption, these rooms exit to the main lab and there is no way to enforce that researchers would don the appropriate clothing and PPE should they go from an area without hazards to the main lab. Offices, rooms with computers for exclusively computer work and dry labs (not included in the EHS PI Space registration) are not considered among “spaces with hazards”, therefore the requirement does not apply to them and people are not required to abide by the rules above.

The Physics Teaching Labs will follow PPE clothing hazard assessment as per the task-specific listing in following document, as prepared by Physics Teaching Labs EHS Coordinator (Sean P. Robinson): https://github.mit.edu/juniorlab/SOPs/blob/master/task-locationSpecificPPE_4-361.md
Other than the listed locations and activities, the Physics Teaching Labs are considered a low-risk space with no special clothing or PPE requirements other than the requirement of no bare feet (including animals).

Avoid skin contact and ingestion of hazardous substances by using appropriate hand protection, protective clothing, and proper work practices.
Contact with the skin is a frequent mode of chemical injury. A common result of skin contact is localized irritation, but an appreciable number of hazardous substances are absorbed through the skin with sufficient rapidity to produce systemic poisoning. Ingestion of substances is rarely deliberate, but may occur because of contamination of hands handling food, contamination of common work surfaces in the lab, and incidental contamination of food or materials that come in contact with the mouth, and through poor work practices. Avoid contact with, and ingestion of, hazardous substances by taking the following precautions:

- Select and wear appropriate hand protection, generally gloves, to prevent injury to hands or exposure by absorption of chemicals through the skin of the hands. See details on glove selection in Section 4.

- Never use mouth suction to pipette chemicals or to start a siphon; a pipette bulb or aspirator should instead be used to provide vacuum.

- Never taste laboratory chemicals.

- Wash your hands with soap and water immediately after working with hazardous chemicals.

- Eating, drinking, smoking, gum-chewing, and applying cosmetics in laboratories where hazardous substances are in use is prohibited. Do not store food, beverages, cups, or other drinking and eating utensils in areas where hazardous chemicals are used or stored.

- Immediately clean up small spills on work benches or in laboratory hoods.

Properly use and maintain personal protective equipment (PPE).
Personal protective equipment should be kept clean and stored in an area where it will not become contaminated. Personal protective equipment should be inspected prior to use to be sure it is in good condition. It should fit properly and be worn properly. If it becomes contaminated or damaged, it should be cleaned or fixed or, in the case of disposable equipment, discarded and replaced.

For additional requirements and information on selection of PPE, see Part II. Section 4. and visit the EHS Office website at https://ehs.mit.edu/workplace-safety-program/personal-protective-equipment/

STEP 4: Be Prepared for Emergencies

Before beginning an experiment, know what specific action you will take in the event of the accidental release of any hazardous substances involved. Know the location and how to operate all safety equipment eye washes, safety showers, spill carts and spill control materials. Be familiar with the location of the nearest fire alarm and telephone, and know what telephone numbers to call in the event of an emergency. Know the location of the circuit breakers for your laboratory. For information on fire blankets see https://ehs.mit.edu/workplace-safety-program/fire-safety/

For all emergencies, contact Campus Police at 617-253-1212 or 100 from an MIT telephone.
An *MIT Emergency Response Guide* should be posted in every laboratory in an area accessible to all. This guide outlines the procedures to follow for most types of emergency situations. The MIT Emergency

Response Guide is available electronically at https://ehs.mit.edu/about/emergency-management/ Carefully review the guidelines for handling medical emergencies, personal injury, chemical spills and fire in the laboratory. This information could save your or your lab mate's life. Only a subset of that information is repeated here.

Fire
If the fire alarms are ringing in your building, stop what you are doing, leave all belongings and immediately proceed to the nearest, safe building exit. Many buildings have evacuation diagrams in strategic building locations. You can always follow the illuminated exit signs when evacuating a building unfamiliar to you. As you leave the building, close doors behind you and use the stairs - do not take elevators.
Once outside proceed directly to your designated assembly area watching out for emergency vehicles that may be responding. Your supervisor will inform you where your assembly area is located and your primary and secondary evacuation route. You must remain in the assembly area until the "All Clear" has been communicated. DO NOT re-enter your work area until given the "All Clear."

In addition, *Emergency Action Plans* are required for each Department, Laboratory, or Center (DLC) under the Occupational Health and Safety Administration (OSHA) regulations. All staff and students should be familiar with their laboratory's Emergency Action Plan, as it specifies the appropriate response and building exit plans for a variety of life-safety emergency situations.

A. Chemical Contamination

Chemical Exposure: Chemical exposures may occur through accidental skin exposure, ingestion, or inhalation of the chemical. Follow appropriate first aid procedures as described in the safety data sheet of that specific chemical.
Chemical Contamination: If the victim or their clothes are chemically contaminated, put on appropriate personal protective equipment and remove victim's contaminated clothing. Using a chemical shower, eyewash, or sink in a safe area*, flood* contaminated body part(s) with *large amounts* of water for 15 *minutes and seek medical assistance*.
For hazardous chemical exposures and personal contamination incidents, call 100 from a MIT phone or 617-253-1212 from a cell phone. An alternative response for exposure to a particular hazard may be indicated in its written SOP only after consultation with EHS and MIT Medical.

B. Safety Data Sheets (SDS)

As time permits, and if you will not be placed at risk, attempt to identify the chemicals involved and obtain SDS, or other relevant information. Provide the SDS to the ambulance crew.

C. Chemical Spills – Minor vs. Major

Be prepared in advance. Have spill supplies available for the types of spills that might occur. Know under what circumstances you should clean up the spill, or when you should evacuate and seek help.

Minor hazardous materials or waste spills that present no immediate threat to personnel safety, health, or to the environment can be cleaned up by laboratory personnel that use the materials or generate the waste. A minor hazardous material spill is generally defined as a spill of material that is not highly toxic, is not spilled in large quantity, does not present a significant fire hazard, can be recovered before it is released to the environment, and is not in a public area such as a common hallway. Such a spill can usually be controlled and cleaned up by one or two personnel. ***For assistance for the cleanup of minor spills call the EHS Office 617-452-3477 or nights and weekends the Facilities Operations Center 617-253-4948 or internally 3-4948 (fixit).***

Major hazardous material and waste spills should be reported to the MIT emergency number (617-253-1212, or 100 from an MIT telephone) to receive immediate professional assistance and support in the control and cleanup of the spilled material. Major hazardous materials or waste spills are generally defined as having a significant threat to safety, health, or the environment. These spills generally are a highly toxic material or a less toxic or flammable material spilled in a large enough quantity that may present a significant fire hazard, cannot be recovered before it is released to the environment, or is spilled in a public area such as a common hallway. Upon reporting such a spill personnel should stand-by at a safe distance to guide responders and spill cleanup experts to the spill area. Reporting personnel should also keep other personnel from entering into the spill area.

In the case of a spill that presents a situation immediately dangerous to life or health, or a situation with significant risk of a fire, personnel should evacuate the area and summon emergency assistance by dialing the MIT emergency number (617-253-1212, or 100 from an MIT telephone), activating a fire alarm station, or both.

3.2. Essential Laboratory Work Practices

3.2.1. Properly use, maintain, and dispose of laboratory glassware and other sharps.

Improper use of glassware is a frequent cause of injuries and accidents in the laboratory.

- Careful handling and storage procedures should be used to avoid damaging glassware. Always carefully inspect glassware for flaws and cracks before use. Damaged items should be discarded or repaired.
- Adequate hand protection should be used when inserting glass tubing into rubber stoppers or corks or when placing rubber tubing on glass hose connections. Tubing should be fire polished or rounded and lubricated, and hands should be held close together to limit movement of glass should fracture occur. The use of plastic or metal connectors should be considered.
- Glass-blowing operations should not be attempted unless proper annealing facilities are available.
- Vacuum-jacketed glass apparatus should be handled with extreme care to prevent implosions. Equipment such as Dewar flasks should be taped or shielded. Only glassware designed for vacuum work should be used for that purpose.
- Hand protection should be used when picking up broken glass. (Small pieces should be swept up with a brush into a dustpan).
- Broken glassware, syringes, and other "sharp objects" must be disposed of properly. Such waste should be separated from other trash and stored for pickup in clearly marked containers labeled "sharps". See Part II. Section 8. for more details on handling “sharps”.

3.2.2. Attend to housekeeping by establishing and following routine cleaning procedures as part of the work you do.

There is a definite relationship between safety and orderliness in the laboratory. The following housekeeping rules should be adhered to in all laboratories:

- Clean bench tops and other work areas and equipment regularly. Do not allow dirty glassware, expired or unneeded samples or chemicals, and trash or boxes to accumulate. When floors require cleaning, notify building services.
- Maintain ready access to exits, safety equipment such as fire extinguishers, eyewashes, and safety showers and electrical panels. Do not store materials in a way that will block access to exits, safety equipment or electrical panels. Maintain a minimum clearance of 36 inches in aisles between work benches and 44 inches in the main cross aisle of the lab that leads to the lab exit door. The main cross aisle is the aisle that all of the bench aisles intersect with to allow the occupants to follow the egress path to the exit door.
- Ensure all compressed gas tanks are properly secured to walls or benches.
- Chemical storage refrigerators should be defrosted periodically and should not be overcrowded.

- Utilize proper cord management techniques so that cords do not get damaged or become tripping hazards.

3.2.3. Working Alone

As a practice, working alone with hazardous materials, equipment or otherwise working under conditions that may create the risk of serious injury (hereafter referred to as hazardous conditions) should be avoided.

Anyone at MIT (faculty, staff, students, and visitors) who works with (or intends to work with) potentially hazardous conditions (in any location, i.e. laboratories, shops, field work) that may result in immediate injury or serious harm must discuss this activity with their Principal Investigator (PI) or supervisor prior to conducting the work alone and determine that the risk of working alone is controllable under the specific conditions established by the PI or supervisor for the work. If the PI or supervisor determines that the risk cannot be minimized to a controllable level, then the individual should perform the work only when others are present or a suitable alarm device that is available that will summon help immediately.

Furthermore, **undergraduates** shall not work alone with hazardous materials, equipment or operations that can result in immediate injury or death without prior written approval from the immediate PI or supervisor. Written approval should only be granted after the risk assessment is performed and reviewed by the PI or supervisor with the individual. This policy states the minimum requirements for working alone across the Institute and supersedes any less restrictive policy or procedure.

Specific Working Alone policies from Institute Committees or individual DLCs or individual PIs or supervisors that are more restrictive shall take precedence.

Guiding Principles In Support of MIT's Working Alone Policy can be found on the EHS web site https://ehs.mit.edu/about/policies/working-alone-policy/

3.2.4. Discourage children and pets in laboratories.

Prudent safety practices discourage allowing children in laboratories where hazardous substances are stored or are in use. It is therefore urged that children not be permitted in laboratories. However, if children are allowed, they must be under the direct supervision of their parent or other qualified adult, and should be allowed to visit only for a brief period of time.

3.2.5. Establish and follow safe chemical storage procedures for your laboratory.

Researchers should consult the Environment, Health and Safety (EHS) Office website for chemical storage information at: https://ehs.mit.edu/chemical-safety-program/chemicals/ and the standard operating procedure (SOP) on Chemical Storage at https://ehs.mit.edu/sops/ (certificate login is required) for a discussion of procedures for storing chemicals in laboratories. All procedures employed must comply with OSHA, flammable material, and building code regulations. The following minimum guidelines must be adhered to:

- Access to all hazardous chemicals, including toxic and corrosive substances, should be restricted at all times. Specifically, good practice would dictate that these materials be stored in laboratories or storerooms that are kept locked at all times when laboratory personnel are not present. In the case of unusually toxic or hazardous materials, additional precautions are advisable and likely required, such as keeping the materials in locked storage cabinets. Contact the EHS Office to determine the appropriate controls.

- To avoid the accumulation of excess chemicals, it is recommended that you review the lab's chemical inventory prior to purchasing new chemicals. When purchasing new chemicals, purchase the minimum quantities of commercial chemicals necessary for your research.

- ❑ Make sure all containers of chemicals are in good condition.

- ❑ Make sure all containers of chemicals, (including research samples), are properly labeled. When appropriate, special hazards should be indicated on the label. For certain classes of compounds, (e.g. ethers), the date the container was opened should be written on the label. More guidance on labeling is provided in Part II. 6.

- ❑ Store incompatible materials in separate cabinets. If they must be stored together due to space limitations, provide secondary containment to separate incompatible materials.

- ❑ Do not store hazardous liquids above eye-level. Particularly, large containers (more than 1 liter) should be stored below eye-level on low shelves. Avoid storage of hazardous chemicals on the floor. If such storage is required, provide secondary containment for liquids stored on the floor.

- ❑ For refrigerated storage of chemicals, ensure refrigeration equipment is selected properly for the types of materials to be stored. Temperature-sensitive, flammable chemicals with a flashpoint of 140 °F or less (GHS flame pictogram) must be stored in a refrigerator/freezer that has a spark free interior and that is UL, FM or other NRTL approved for flammable storage. The sparks from the components in a household-type refrigerator/freezer could ignite flammable vapors and cause a fire or explosion. For more details, refer to https://ehs.mit.edu/chemical-safety-program/chemicals/. Food should never be kept in refrigerators used for chemical storage.

- ❑ Do not store flammable, volatile toxic, or corrosive chemicals in cold rooms.

- ❑ Do not store items in the working space of fume hoods.

3.2.6. Take precautions when transporting hazardous substances between laboratories.

Chemicals must be transported between stockrooms and laboratories in break-resistant or approved secondary containers. Approved secondary containers are defined as commercially available bottle carriers made of rubber, metal, or plastic, with carrying handle(s), and which are large enough to hold the contents of the chemical container in the event of breakage. When transporting cylinders of compressed gases, always strap the cylinder in a suitable hand truck and protect the valve with a cover cap. For shipping hazardous materials off-site, please refer to Part II. Section 9.

3.2.7. Follow established procedures for handling excess and waste chemicals to ensure compliance with regulatory requirements.

Consideration of the means of disposal of chemical wastes should be part of the planning of all experiments before they are carried out. The cost of disposing of excess and waste chemicals has become extremely expensive, and frequently exceeds the original cost of purchasing the chemical. Whenever practical, order the minimum amount of material possible in order to avoid the accumulation of large stocks of "excess chemicals" which will not be needed in future research. Such collections of "excess chemicals" frequently constitute safety hazards, since many substances decompose upon long storage and occasionally their containers become damaged or degrade. In addition, the disposal of significant quantities of excess chemicals ultimately presents a very significant financial burden to faculty research accounts.

The procedures for handling excess and waste chemicals are outlined in Part II. Section 8.

3.2.8. Take additional precautions for work with flammable substances.

Flammable substances are among the most common of the hazardous materials found in campus laboratories. Flammable substances are materials that readily catch fire and burn in air. A flammable liquid does not itself burn; it is the vapors from the liquid that burn. The rate at which different liquids produce flammable vapors depends on their vapor pressure, which increases with temperature. The degree of fire hazard depends also on the ability to form combustible or explosive mixtures with air, the ease of ignition of these mixtures, and the relative densities of the liquid with respect to water and of the gas with respect to air.

An open beaker of diethyl ether set on the laboratory bench next to a Bunsen burner will ignite, whereas a similar beaker of diethyl phthalate will not. The difference in behavior is due to the fact that the ether has a much lower flash point. The flash point is the lowest temperature, as determined by standard tests, at which a liquid gives off vapor in sufficient concentration to form an ignitable mixture with air near the surface of the liquid within the test vessel. As indicated in the following table, many common laboratory solvents and chemicals have flash points that are lower than room temperature and are potentially very dangerous.

	Flash Point (°C)		Flash Point (°C)
Acetone	-17.8	Ethanol	12.8
Benzene	-11.1	Hexane	-21.7
Carbon disulfide	-30.0	Methanol	11.1
Cyclohexane	-20.0	Pentane	-40.0
Diethyl ether	-45.0	Toluene	4.4

Precautions for handling flammable substances include:

- Flammable substances should be handled only in areas free of ignition sources. Besides open flames, ignition sources include electrical equipment (especially motors), static electricity, and for some materials, (e.g. carbon disulfide), even hot surfaces.

- Never heat a flammable substance with an open flame.

- When transferring flammable liquids in metal equipment, static-generated sparks should be avoided by bonding and the use of ground straps.

- Ventilation is one of the most effective ways to prevent the formation of flammable mixtures. A laboratory hood should be used whenever appreciable quantities of flammable substances are transferred from one container to another, allowed to stand or be heated in open containers, or handled in any other way. Be sure that the hood is free of all ignition sources including, in particular, variable transformers (variacs).

- Generally, only small quantities of flammable liquids should be kept at work benches. Larger quantities should be stored away from ignition sources in flammable storage cabinets. It is advisable to purchase highly flammable solvents (e.g., acetone, hexane, diethyl ether, ethyl acetate, tetrahydrofuran) only in metal or break-resistant (e.g., plastic or plastic-coated), containers.

- Refrigerators used for storage of chemicals must be explosion-proof or flame proof. Storage trays or secondary containers should be used to minimize the distribution of material in the event a container should leak or break.

3.2.9. Take additional precautions for handling highly reactive or peroxide forming substances.
Highly reactive substances are materials that decompose under conditions of mechanical shock, elevated temperature, or chemical action, with the release of large volumes of gases and heat. Special precautions are required for the safe use of highly reactive materials. It is the responsibility of the researcher to evaluate the reactive hazards involved in their work and to consult with their supervisor to develop detailed standard operating procedures for any work involving highly reactive substances. Work with highly reactive materials will generally require the use of special protective apparel (face shields, gloves, lab coats) and protective devices such as explosion shields and barriers.

Organic peroxides are among the most hazardous substances handled in campus laboratories. As a class, they are low-power explosives, hazardous because of their sensitivity to shock, sparks, and even friction (as in a cap being twisted open). Many peroxides that are routinely handled in laboratories are far more sensitive to shock and heat than high explosives such as Dynamite or trinitrotoluene (TNT), and may detonate rather than burn. All organic peroxides are highly flammable, and most are sensitive to heat, friction, impact, light, as well as strong oxidizing and reducing agents.

Some peroxides in use at MIT are commercial compounds such as m-chloroperoxybenzoic acid, benzoyl peroxide, hydrogen peroxide, and t-butyl hydroperoxide. However, many common solvents and reagents are known to form peroxides on exposure to air, and these chemicals often become contaminated with sufficient peroxides to pose a serious hazard. Classes of compounds that form peroxides by autoxidation include:

- Aldehydes including acetaldehyde and benzaldehyde,
- Ethers with primary and/or secondary alkyl groups, including acyclic and cyclic ethers, acetals, and ketals. Examples include diethyl ether, diisopropyl ether (especially dangerous!), dioxane, dimethoxyethane, tetrahydrofuran, ethyl vinyl ether and alcohols protected as tetrahydropyranyl ethers. Isopropyl alcohol also frequently forms peroxides upon storage.
- Hydrocarbons with allylic, benzylic, or propargylic hydrogens. Examples of this class of peroxide-formers include cyclohexene, cyclooctene, methyl acetylene, isopropylbenzene (cumene), and tetralin (tetrahydronaphthalene).
- Conjugated dienes, enynes, and diynes, among which divinylacetylene is particularly hazardous.
- Saturated hydrocarbons with exposed tertiary hydrogens; common peroxide-formers include decalin (decahydronaphthalene) and 2,5-dimethylhexane.

Precautions for work with peroxide forming materials:

- Store peroxide forming materials away from heat and light.
- Protect peroxidizable compounds from physical damage, heat, and light.

Date peroxide formers containers with date of receipt and date of opening. Affixing a label stating "Warning, Peroxide Former" can also be helpful to alert others regarding these materials. Assign an expiration date if one has not been provided by the manufacturer. Recommended safe storage – time periods for peroxide forming chemicals are provided in the EHS SOP #0042 peroxide forming chemicals found on the EHS web site https://ehs.mit.edu/sops/ (certificate login is required).

- Peroxide forming chemicals without received, open or manufacturer's expiration date will need to be tested by the lab prior to disposal as well as those containers with expiration dates that have been reached and assigned an expiration date. Any chemical waste streams with >25% peroxide forming chemicals by volume must be tested by the lab and peroxide levels indicated on the red hazardous waste label. If there is greater than 20ppm, a stabilization permit is required prior to shipment and final disposal. (see below)
- Test for peroxidizables before distilling or evaporating peroxidizable solvents for research purposes. Do not distill for research purposes without treating to remove peroxides. It is illegal to evaporate or treat a regulated waste to avoid disposal of that material. All waste material should be disposed of properly as outlined in Part II. Section 8.
- If crystals are visibly present on the container or lid, or if the container is open but has not been tested, DO NOT OPEN, DO NOT TOUCH. Contact the EHS Office to arrange for disposal.

In the event your lab has any peroxidizable chemicals in inventory please refer to the EHS SOP (#0042) for proper management, storage and testing requirements for use and prior to disposal. If

peroxides have formed over 20ppm a stabilization permit is required prior to shipment and final disposal, which the lab will be asked to pay for by EHS. Contact EHS with questions and concerns. The SOP can be found on the EHS web site https://ehs.mit.edu/sops/ (certificate login is required).
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- Immediately rinse empty containers that once held peroxidizables. Do not let residues evaporate.

For assistance in disposing of larger quantities of peroxides or other explosive materials, contact the EHS Office at 617-452-3477.

3.2.10. Take additional precautions for handling explosives.

Follow manufacturer's instructions for handling and use of explosives. Contact EHS office at 617-452-3477 for assistance

3.2.11. Take additional precautions for work with corrosive substances.

Corrosivity is a complex hazard. Corrosives can be solids, liquids, and gases and includes acids, bases, oxidizers, as well as other chemical classes. Corrosives may belong to more than one chemical class. What is at risk varies, as well. Elemental mercury is considered a toxic substance, but it is shipped as a corrosive substance because it can deteriorate some metals. For purposes of these standard operating procedures, a corrosive is any chemical that can rapidly damage human tissue, metals, and other compounds, such as wood or concrete by chemical action. Store by compatibility. Segregate acids from bases. Segregate oxidizing acids, such as nitric acid from organic acids, such as acetic acid.

- Store corrosives on a lower shelf or in ventilated corrosive storage cabinets.
- Make sure containers and equipment, such as tubing, etc. used with corrosive materials is compatible with those materials.
- Personal protective equipment is important for work with corrosives. Neoprene or rubber gloves, goggles and face shield, rubber apron, and rubber boots should be considered.
- Always add acid to water, never water to acid.
- Wherever corrosives are used or stored, be sure there is a working, readily accessible eyewash and safety shower, and
- For hazardous chemical exposures and personal contamination incidents, call 100 from a MIT phone or 617-253-1212 from a cell phone. An alternative response for exposure to a particular hazard may be indicated in its written SOP only after consultation with EHS and MIT Medical.

3.2.12. Take additional precautions for using appliances in laboratories.

Non-lab grade or household equipment such as vacuum cleaners, microwaves and fans may not be compatible with chemicals and processes in laboratories. Consult EHS or the EHS Coordinators prior to using those equipment with chemicals.

3.3. Additional Procedures for Work with Particularly Hazardous Substances

3.3.1. Compile Information.

Before beginning a laboratory operation, each researcher should consult the appropriate literature for information about the toxic properties of the substances that will be used. The precautions and procedures described below should be followed if any of the substances to be used in significant quantities is known to have high acute or moderate chronic toxicity. If any of the substances being used is known to be highly toxic, it is desirable that there be at least two people present in the area at all times. These procedures should also be followed if the toxicological properties of any of the substances being used or prepared are unknown. Part II 10.3 Appendix II-C p.40 outlines a process for determining whether a chemical is considered a *particularly hazardous substance* (PHS).

3.3.2. Establish designated areas in the laboratory for use of Particularly Hazardous Substances.

A key requirement of the OSHA Laboratory Standard is that all work with *particularly hazardous substances* be confined to designated areas. The designated area established in your laboratory depends on the circumstances of use for the PHS. A designated area may be the laboratory, a specific area of the laboratory, or a device such as a glove box or fume hood. There also may be designated equipment such as a specific balance, or centrifuge in which you work with or process PHS materials. It is most common for laboratory hoods to serve as designated areas for most research. Laboratory supervisors are required to notify the Chemical Hygiene Officer of the specific location of any designated areas established in their research groups *that are not laboratory hoods.*

3.3.3. Make sure designated areas are posted with a yellow and black caution sign.
It is the responsibility of laboratory supervisors to define the designated areas in their laboratories and to post these areas with conspicuous signs reading "DESIGNATED AREA FOR USE OF PARTICULARLY HAZARDOUS SUBSTANCES--AUTHORIZED PERSONNEL ONLY". Printed signs can be obtained from the EHS Office. In some cases, it may be appropriate to post additional signs describing unusual hazards present and/or identifying the specific hazardous substances in use. You can also consider marking with yellow tape a section of a bench space or section of a lab hood where PHSs are used.

3.3.4. Use *particularly hazardous substances* only in the established designated areas.
Using PHSs outside of areas designated for their use, poses a significant danger to you and the others in your laboratory and surrounding areas, as well as violates MIT and OSHA rules and regulations.

3.3.5. Take action to prevent skin contact.
Contact with the skin is a frequent mode of chemical injury. *Avoid all skin contact with particularly hazardous substances* by using suitable protective apparel including the appropriate type of gloves or gauntlets (long gloves) and a suitable laboratory coat or apron that covers all exposed skin. Always wash your hands and arms with soap and water immediately after working with these materials. In the event of skin contact, the affected areas should be flushed with water and medical attention should be sought. To obtain medical attention, call 100 from a MIT phone or 617-253-1212 from a cell phone. An alternative response for an exposure may be indicated in a written SOP only after consultation with EHS and MIT Medical.

3.3.6. Avoid inhalation of PHSs.
Avoid inhalation of PHSs by ensuring that work involving potential for exposure to a gas, vapor or airborne dust is conducted in a laboratory hood, or other suitable containment device such as a glove box. Purchase material in liquid form rather that powder form when possible.

3.3.7. Thoroughly decontaminate and clean the designated area(s) at regular intervals.
Decontamination procedures should be established in writing, especially those involving chemical treatments, and consist of any necessary periodic (daily, weekly, etc.) procedures performed to control exposure of employees. Depending on the chemical material, this may consist only of wiping a counter with a wet paper towel, or periodic use of a neutralizing agent. To determine the proper decontamination procedures, one must consider the chemical (or type of chemical), the amount of chemical used, the specific use, the location of use, and other factors. Contact the EHS Office if assistance is needed to determine the most appropriate decontamination procedures at 617-452-3477.

3.3.8. Be prepared for accidents.
The laboratory worker should always be prepared for possible accidents or spills involving toxic substances. To minimize hazards from accidental breakage of apparatus or spills of toxic substances in the hood, containers of such substances should generally be stored in pans or trays made of polyethylene or other chemically resistant material and, particularly in large-scale work, apparatus should be mounted above trays of the same type of material. Alternatively, the working surface of the hood can be fitted with a removable liner of adsorbent plastic-backed paper. Such

procedures will contain spilled toxic substances in a pan, tray, or adsorbent liner and greatly simplify subsequent cleanup and disposal.

If a major release of a particularly hazardous substance occurs outside the hood, then the room or appropriate area should be evacuated, and necessary measures taken to prevent exposure of other workers. The EHS Office should be contacted immediately (617-452-3477) for assistance and equipment for spill clean-up. EHS Office personnel can be contacted for assistance after working hours by calling Campus Police (617-253-1212, or 100 from an MIT telephone). Spills should only be cleaned up by personnel wearing suitable personal protective apparel. Contaminated clothing and shoes should be thoroughly decontaminated or incinerated. See Part II. 3.1. for further discussion of the control of accidental releases of toxic substances.

3.3.9. Don't contaminate the environment.

Vapors that are discharged from experiments involving *particularly hazardous substances* should be trapped or condensed to avoid adding substantial quantities of toxic vapor to the hood exhaust air. The general waste disposal procedures outlined in Part II. Section 8. should be followed; however, certain additional precautions should be observed when waste materials are known to contain substances of high toxicity.

3.3.10. Recordkeeping.

It is ***required*** that every research group in the department maintain a list of all *particularly hazardous substances* in use in their laboratories, including an inventory of the maximum quantity present at any given time. It is recommended that EHS Representatives be assigned the responsibility for ensuring that this inventory list is kept up to date. In addition, records that include amounts of material used and names of workers involved should be kept as part of the laboratory notebook record of all experiments involving *particularly hazardous substances*.

3.3.11. When necessary, restrict access to designated areas when particularly hazardous substances are in use.

Designated areas should be posted with special warning signs indicating that particularly toxic substances may be in use. As discussed above, many laboratory hoods are designated areas for work with particularly hazardous substances.

3.4. Additional Requirements for Work with Select Toxins

Select Toxins are biologically derived toxic chemicals that are specifically regulated by the federal U.S. Department of Health and Human Services under regulation 42 CFR Part 73 when handled at levels above specified quantities. To ensure that MIT inventories of select toxins are maintained at levels below the regulatory threshold, all researchers using these toxins must order them and register their research through the Biosafety Program (BSP) of the EHS Office. For details regarding ordering these materials, contact the BSP at 617-452-3477 or visit the EHS Office website at https://ehs.mit.edu/biological-program/select-agent-toxins/ .A list of Select Toxins is provided in Appendix II-C.

These materials are highly toxic and special precautions should be taken whenever handling concentrated forms, even in small amounts. Stocks of these chemicals should be stored under lock and key. A log must be maintained that tracks the use of these materials. Researchers working with these materials should contact the EHS Office for Select Toxin information and should develop a Lab Specific SOP for work with these materials based on *Biosafety in Microbiological and Biomedical Laboratories* (BMBL) guidelines, *Appendix I* (U.S. Department of Health and Human Services, Centers for Disease Control and Prevention and National Institutes of Health, Washington, DC: 1999). This Lab Specific SOP should be maintained and accessible in the researchers' laboratory space and should be provided to the Chemical Hygiene Officer. It is suggested that Select Toxin Lab Specific SOPs be added to the Chemical Hygiene Plan in Part III. Information and a template form are available from the EHS Office for assistance with development of an SOP for work with Select Toxins. Contact the EHS Office at 617-452-3477 for information and assistance.

3.5. Special Precautions for Work with Hydrofluoric Acid

Hydrofluoric acid (HF) is a *particularly hazardous substance*, like many acids, but has added dangers that make it especially dangerous to work with. HF is less dissociated than most acids and deeply penetrates the skin. Symptoms of exposure may be delayed for up to 24 hours, even with dilute solutions. HF burns affect deep tissue layers, are extremely painful, and disfiguring. The highly reactive fluoride ion circulates throughout the body and can cause multiple organ toxicity, including heart arrhythmias and death, if not treated. *Any* suspected exposure to HF should be immediately flooded with water, decontaminated with calcium gluconate gel, and receive medical attention immediately. To do so, call 100 from a MIT phone or 617-253-1212 from a cell phone. An alternative response for an exposure may be indicated in a written SOP only after consultation with EHS and MIT Medical.

All employees are required to be trained by the EHS Office before beginning work with HF. The training covers safe use, personal protective equipment, and decontamination procedures. The training can be taken on the web or in the classroom. Please go to the EHS Training website (https://ehs.mit.edu/training/) to register for the training. Please go to the EHS Training website (https://ehs.mit.edu/training/) to update training profile, select "Use or work in the area that store or uses hydrofluoric acid" and complete for the training.

All laboratories using HF must have unexpired calcium gluconate decontamination gel on hand. The gel can be obtained at no cost from the EHS Office by submitting request in Hydrofluoric Acid section on this website https://ehs.mit.edu/chemical-safety-program/chemicals/.

Hydrofluoric acid wastes must be collected in polyethylene (plastic) containers no greater than 5 gallons/20Liters. For processes requiring containers larger than 5 gallons/20Liters, reach out to the EHS Office for guidance. Do not collect hydrofluoric acid wastes in glass or metal containers. Concentrations of the wastes must be stated on the red tag, with the 'Corrosive' and 'Toxic' hazards selected. Some hydrofluoric acid wastes may be discharged to the sink with neutralization but requires EHS process review and approval first.

3.6. Special Precautions for Work with Formaldehyde

Formaldehyde is a *particularly hazardous substance* that is widely used at MIT and is covered under a specific OSHA Standard 1910.1048. MIT must identify all laboratory activities that are above the OSHA action level or STEL through initial air monitoring and provide training, medical surveillance, and engineering and work practice controls if air levels warrant it.

Formaldehyde is an animal carcinogen and a suspect human carcinogen according to OSHA and IARC. It is also a sensitizer and can cause allergic skin reactions and asthma-like respiratory symptoms. It is an irritant to eyes, nose, and throat.

The Industrial Hygiene Program (IHP) has performed extensive air sampling for formaldehyde during a variety of lab activities such as animal perfusion, dissections, and tissue fixation and found the results to be below OSHA levels provided that suitable exhaust ventilation is used. Almost all formaldehyde procedures should be performed with ventilation such as a fume hood, slot hood, or vented downdraft table. All work should be done using gloves with adequate resistance to formaldehyde, such as the Best N-Dex brand (a disposable nitrile glove).

With proper exhaust ventilation, you should not detect any odors from formaldehyde work nor experience any symptoms of exposure such as eye tearing or throat irritation. If you do, please contact IHP immediately at 617-452-3477 for an evaluation. IHP sends a questionnaire annually to laboratory EHS representatives to survey formaldehyde use and conducts air sampling of procedures where there may be a potential for exposure. Notify IHP for an evaluation if your procedures change and you work with large quantities of formaldehyde, perform animal perfusions, or do extensive tissue dissection work.

3.7. Special Precautions for Work with Nanomaterials

Nanomaterials are defined by the ASTM as a material with two or three dimensions between 1 to 100 nm. They can be composed of many different base materials (carbon, silicon, and metals such as gold, cadmium, and selenium). They can also have different shapes: such as nanotubes, nanowires, crystalline structures such as quantum dots, and fullerenes. Nanomaterials often exhibit very different properties from their respective bulk materials: greater strength, conductivity, and fluorescence, among other properties.

The toxicity of most nanomaterials is currently unknown. Preliminary toxicity testing has indicated that some nanoparticles may be more toxic than the corresponding micron sized particle because of their greater surface area and reactivity. Nano-sized titanium dioxide produces 40 fold more lung inflammation than micron-sized particles. In preliminary tests, carbon nanotubes have produced lung inflammation and fibrosis similar to crystalline quartz and asbestos. Nanoparticles are similar in size to viruses and are easily taken up by the body's cells, translocate around the body, and can possibly pass into the brain and through the skin.

The MIT EHS Office considers nanoparticles that have the potential for release into the air to be handled as particularly hazardous substance because their toxicity is, for the most part, unknown and early studies have been suggestive of toxic effects. In the future, many types of nanoparticles may turn out to be of limited toxicity, but precaution should be used until more is known. Work with nanoparticles that may release particles should be conducted in enclosures, glove boxes, fume hoods, and other vented enclosures. All work should be done with gloves, at a minimum disposable nitrile gloves. More information on additional precautions and a review of the toxicity of some types of nanomaterials are on the EHS web site at: https://ehs.mit.edu/chemical-safety-program/chemicals/
This article also lists good reference sources for researchers to consult to keep up with toxicity information on their materials as it develops. EHS has developed a web course, Nanomaterials Safety and Health (MIT Atlas Learning Center – requires certificates), which includes information on the toxicity of different types of nanomaterials and laboratory practices to prevent exposures. Currently, nanoparticles and solutions containing them are being disposed of as hazardous waste. Please call the EHS Office at 617-452-3477 for exposure evaluation of experimental setups and additional information. *Label all containers of nanomaterials (including waste) with the designation "nano".

3.8. Special Precautions for Work with Cyanide Salts and Compounds

Cyanides have a white crystalline or granular powder appearance and the dry salts are odorless but the reaction with atmospheric moisture may produce hydrogen cyanide which has a faint odor of bitter almonds. They are slightly soluble in water and when mixed with acids will produce lethal hydrogen cyanide gas. Cyanides are used in chemical synthesis and electroplating. A hazard assessment should be done addressing safe work practices, emergency procedures, roles and responsibilities and training prior to work.
Emergency procedures for cyanide exposure (see also Part IV section 3.4): For a medical emergency and treatment for *any* cyanide exposure (confirmed or suspected) dial 100 from any MIT phone or 617-253-1212 or 617-253-1212 from a cell phone. When calling, it is critical to state that it is a potential cyanide exposure and to request an ambulance service equipped with a CYANOKIT and capable of treating cyanide poisoning (See Laboratory Use of Cyanide Salts guidance https://ehs.mit.edu/chemical-safety-program/chemicals/).

3.9. Special Precautions for Work with Pyrophoric and Water-Reactive Materials

Special precautions are required when working with pyrophoric materials as well as certain water-reactive chemicals

- Pyrophoric materials are solids, liquids and gases that may ignite spontaneously in air.
- Water-reactive substances exposed to water or moisture will release a gas that is either flammable or a health hazard. The information in this section refers to water-reactive substances that have a risk of igniting on contact with moisture.

While these materials may be common reagents in chemistry laboratories, researchers should be aware that these materials have uses in many other types of research including material science and semiconductor research.

Due to the uniquely hazardous properties of these two classes of materials it is required that a hazard assessment be done and laboratory SOP must be completed if the general SOP provided in Part II 3.3 for work with Particularly Hazardous Substances of this Plan DOES NOT adequately ensure the protection of personal health and safety, and the environment for its use. The SOP should include information on storage, usage, disposal, appropriate PPE and emergency procedures for the material in the lab. See part III for a template that may be used for developing lab specific SOPs.

Guidance on pyrophoric and water-reactive materials and a list of materials that are pyrophoric or water reactive can be found at https://ehs.mit.edu/chemical-safety-program/chemicals/

Details on specific requirements for labs with pyrophoric materials can be found in the MIT EHS Pyrophorics SOP at https://ehs.mit.edu/site/system/files/secure/sop_004 3.pdf

Refer to both resources before handling pyrophoric or water-reactive materials.

3.10. Special Precautions for Work with Cytotoxic Drugs

Cytotoxic drugs (sometimes known as antineoplastics) describe a group of chemicals which are toxic to cells, preventing their replication or growth. They are frequently used to treat cancer. It is recommended that any work with cytotoxic powders be carried out in an exhausted biological safety cabinet (either a Class II A2 with a thimble connection or Class II B2). For any work with cytotoxics that are volatile it is recommended that any work be carried out in a Class II B2 biological safety cabinet.

4. PERSONAL PROTECTIVE EQUIPMENT

Personal protective equipment (PPE), to include eye and face protection, gloves, protective clothing, head protection, hearing protection, protective footwear, and respiratory protection may be needed to ensure an employee is adequately protected from hazards associated with the work they are doing. Refer to the table in Section 3.1 for an overview of PPE and clothing requirements in labs.

4.1. PPE Hazard Assessment

When personal protective equipment is needed, it is required by regulation that a hazard assessment be made to identify the specific hazards of concern and the PPE required for protection from those hazards. This hazard assessment may be done for a work area, or for a specific experiment, job, or task. The protective equipment is selected based on the hazard assessment. This assessment needs to be documented in writing. This hazard assessment and documentation requirement would be satisfied through the application of the standard operating procedures outlined in this Chemical Hygiene Plan, namely Part II. Section 3. or through the development of additional Lab Specific SOPs in Part III., except for the use of respiratory protective equipment. If you believe respiratory protection is warranted, you must first contact the Environment, Health and Safety (EHS) Office for a consultation. For more information on PPE, visit the EHS Office website at https://ehs.mit.edu/workplace-safety-program/personal-protective-equipment/

4.2. Laboratory coats

The MIT Committee on Toxic Chemicals and the Institute EHS Council has established the following policy with respect to laboratory coats. A laboratory coat or equivalent protection is required when working with or when working nearby to hazardous chemicals, unsealed radioactive materials, and biological agents at BL2 or greater. A flame resistant lab coat is required when handling pyrophoric substances outside of a glove box. It is recommended that a flame resistant lab coat be worn when working with all flammable chemicals. Laboratory supervisors shall carry out a hazard assessment to identify situations (a task, experiment, or area) where alternative or more protective apparel must be worn.

EHS website https://ehs.mit.edu/workplace-safety-program/personal-protective-equipment/ provides additional details to aid in the process of performing a hazard assessment to select an appropriate lab coat based on the hazards in the lab area, and provides information on the use and care of lab coats, including laundry service options.

4.3. Gloves

Gloves for work with chemicals must be selected based on the potential contact hazard, and the permeability of the glove material. For incidental skin contact with small amounts of chemicals on a surface, or work with most powders, disposable nitrile gloves are usually adequate. For work involving materials that are readily absorbed through the skin, the glove must be carefully selected using glove impermeability charts. Silver Shield brand gloves work well for many common laboratory chemicals that can be absorbed through the skin, but you should verify their effectiveness for your application. You should also evaluate need for hand protection from physical hazards such as extreme heat or cold, and make sure you use appropriate gloves.

4.4. Eye Protection

The Committee on Toxic Chemicals established a policy in 2009 to assure special emphasis is placed on the use of appropriate eye protection for work with hazardous chemicals in laboratories. The policy states:

> "For every laboratory room where hazardous chemicals are stored or are in use a determination must be made as to the level of eye protection that shall be required. The level of eye protection required shall be identified in writing. Where no determination has been made regarding the level of eye protection required in an area, the default shall be that eye protection is required."

Eye protection is also required when there is the potential for eye injury due to other hazards besides hazardous chemicals. Examples of this include working with tools, power tools, and/or shop equipment when the work emits debris or flying particles, or when working with molten metal. Work with unsealed radioactive sources, lasers and certain biological agents also require eye protection by regulation.

Eye protection provided shall meet the requirements of ANSI/ISEA Z87.1-2015, or equivalent.

The specific policy for eye protection in this Department is as follows

Hazard assessments are performed to identify eye protection requirements. The EHS Coordinator has developed a PPE hazard assessment form, available from the EHS Coordinator, to be used for assessing a lab area for eye protection and other PPE requirements. The EHS rep completes the assessment and reviews it with the lab PI, who signs the assessment. The EHS Coordinator is available to assist upon request. A signed copy of the assessment is turned in to the EHS Coordinator. The assessment form developed is based on the EHS Office Guidance Document "Eye Protection in Laboratories Assessment, Selection, Use and Maintenance" available at: https://ehs.mit.edu/workplace-safety-program/personal-protective-equipment/.

Yellow and black caution signs are posted at locations where eye protection is required stating "Eye Protection Required", and specifying type of protection, e.g. safety glasses, goggles, face shield.
Work involving potential exposure to eye hazards can only be done in posted locations. Personnel working in the lab are provided appropriate eye protection and are informed of all locations where it is required during lab specific training.
The procedure for obtaining prescription glasses is described at: https://ehs.mit.edu/workplace-safety-program/personal-protective-equipment/

Eye protection is available for visitors who may need to go to locations where there are eye hazards.

When changes are made in a lab that may introduce eye hazards to a location where they are not currently present, an assessment must be performed to determine if it will be an eye hazard area where eye protection is required. The process described above is used for that assessment, and if required, the area must be labeled with appropriate signage. All lab personnel must be informed of any changes made.

5. OTHER SAFETY AND STORAGE EQUIPMENT

5.1. Laboratory Fume Hoods/Ventilation

Laboratory Fume Hoods

Local exhaust ventilation is the primary method used to control inhalation exposures to hazardous substances. The laboratory hood is the most common local exhaust method used on campus; other methods include vented enclosures for large pieces of equipment or chemical storage, and snorkel types of exhaust for capturing contaminants near the point of release. Some systems are equipped with air cleaning devices (HEPA filters or carbon absorbers).

It is advisable to use a laboratory hood when working with all hazardous substances. In addition, a laboratory hood or other suitable containment device must be used for all work with "particularly hazardous substances". For more information see Part II. Section 3.3. A properly operating and correctly used laboratory hood can control the vapors released from volatile liquids as well as dust and mists.

General Rules

The following general rules should be followed when using laboratory hoods:

A. No hoods should be used for work involving hazardous substances unless it has a certification label less than one year old.

B. Always keep hazardous chemicals at least six inches behind the plane of the sash.

C. Never put your head inside an operating laboratory hood to check an experiment. The plane of the sash is the barrier between contaminated and uncontaminated air.

D. Work with the hood sash in the **lowest possible position.** The sash will then act as a physical barrier in the event of an accident in the hood. Keep the sash closed when not conducting work in the hood.

E. Do not clutter your hood with bottles or equipment. Keep it clean and clear. Only materials actively in use should be in the hood. This will provide optimal containment and reduce the risk of extraneous chemicals being involved in any fire or explosion that may occur in the hood.

F. Clean the grill along the bottom slot of the hood regularly so it does not become clogged with papers and dirt.

G. Promptly report any suspected hood malfunctions to the Industrial Hygiene Program (617-452-3477).

   Do not make any modifications to hoods or duct work without first contacting the DLC EHS Coordinator and the Industrial Hygiene Program (617-452-3477). Any changes made to the local exhaust system must be approved by the Industrial Hygiene Program. Do not use a laboratory hood for large pieces of equipment unless the hood is dedicated to this use (large obstructions can change the airflow patterns and render the hood unsafe for other uses). It is generally more effective to install a specifically designed enclosure for large equipment so that the laboratory hood can be used for its intended purpose.

   The Industrial Hygiene Program annually inspects all laboratory hoods on campus. This inspection consists of measuring the face velocity of the hood and using a smoke stick to check its containment effectiveness visually. If the laboratory hood passes both the face velocity and smoke containment tests, then it is posted with an updated certification label. If the hood does not pass and the problem is so severe that the hood is unsafe for use, then it is labeled with a "DO NOT USE" sign. For more information on fume hoods, please visit https://ehs.mit.edu/lab-research-program/fume-hoods-laboratory-ventilation/

5.2. Fire Extinguishers, Safety Showers, and Eyewash Stations

5.2.1. Fire Extinguishers

Laboratory supervisors are required to instruct new personnel in the location of fire extinguishers, safety showers, and eyewashes *before* they begin research in the laboratory. Laboratories where a potential fire hazard exists (use and/or storage of flammable and combustible liquids, solids, or gases; any spark producing work, welding, use of open flames, etc.) should be outfitted with fire extinguishers. All fire extinguishers should be mounted on a wall in an area free of clutter or stored in a fire extinguisher cabinet. Research personnel should be familiar with the location, use, and classification of the extinguishers in their laboratory.

It is MIT policy that laboratory personnel are not required to extinguish fires that occur in their work areas and are not permitted to use fire extinguishers unless properly trained. To be trained, researchers may attend the Fire Extinguisher Familiarization Course offered by EHS. Always activate the nearest fire alarm pull station before attempting to use a portable fire extinguisher. Refer to MIT's standard operating procedure on Portable Fire Extinguishers available at https://ehs.mit.edu/sops (certificate login is required)/ for additional information. Any time a fire extinguisher is used, it should be reported to the MIT Operations Center (x3-1500) or EHS (2-3477)

5.2.2. Safety Showers and Eyewash Stations

Every laboratory where the use of materials that are either corrosive or that otherwise present a significant skin/eye contact or absorption hazard must have access to an unobstructed safety shower and eyewash facility that meets the requirements of OSHA regulations (29 CFR 1910.151(c)). For the weekly inspection of the eyewash it is recommended that in each lab a person, such as the EHS Representative or EHS Coordinator, be assigned the inspection task that includes checking access and flushing the eyewash by running the water for one minute. This will flush out any bacteria that grow in the stagnant water. If an eyewash or safety shower needs to be repaired create and submit a service request to the Dept. of Facilities in Atlas https://atlas.mit.edu/. All showers are tested twice a year by Facilities if one or more shower inspections are out of date use the above link submit a service request include the bldg.-room number(s).

5.3. Safe Use of Warm and Cold Environmental Rooms

Both warm and cold rooms at MIT use a refrigerant gas (Freon-22, R-12, or MP39) to control temperatures. In order to keep temperatures stable, there is minimal ventilation to the rooms. These rooms are NOT designed for chemical use because of the minimal ventilation. Do not store flammable, volatile toxic or corrosive chemicals in cold or environmental rooms unless they have been specifically designed for such purposes. Storage or use of dry ice should not be done in cold rooms because large quantities of carbon dioxide are released when dry ice sublimes, displacing oxygen in the room.

Each room is alarmed if the temperature changes by more than one degree, which may indicate that a door has been left open or in rare instances, that refrigerant gas is leaking. If an alarm sounds, please leave the room and the alarm should reset. If it does not, please call the Department of Facilities (617-253-4948, or FIXIT from an MIT telephone) and report the alarm condition. Do not enter the room until it has been checked. Minimize time spent in environmental rooms. Notify a coworker if you are using the room alone.

If you have any questions about work or general air quality in environmental rooms, please contact the Industrial Hygiene Program (617-452-3477) for an evaluation. For more information on safe use of warm and cold rooms, go to https://ehs.mit.edu/lab-research-program/warm-and-cold-rooms/

5.4. Electrical Safety and Lockout/tagout Considerations

Electricity can be an invisible hazard if not handled appropriately. The hazard level increases as failures to follow electrical safety practices increase. Below are some considerations that will help protect yourself and others when working with electricity.

- Monitor equipment loads so that electrical circuits do not trip.
  - Do not daisy chain extension cords and power strips
  - High amperage or heat producing equipment (ovens, refrigerators, hot plates, heaters, etc.) should be plugged directly into a wall outlet and not into a power strip or extension cord.

- Purchase equipment that is listed or labelled by a Nationally Recognized Testing Lab (NRTL). Visit this site for a list of all the current NRTLs.

- Contact EHS if you need assistance reviewing any modified or researcher build lab equipment. More complicated equipment may require an external consultant to assist with this review.

- When working on equipment maintenance or removing guards, control of any hazardous energies is essential for personnel safety. Follow OSHA 1910.147 requirements for locking and tagging of these energy sources. There are three main components to a successful program;
  - Training for authorized and affected personnel
  - Written Energy Control Procedures (ECPs)
  - Periodic Program Inspection

  For more information go the EHS LOTO Webpage https://ehs.mit.edu/workplace-safety-program/loto/

- When all energy sources cannot be isolated from equipment by unplugging during maintenance or other activities, lab personnel shall contact DOF to have the electrical or other source of energy/pressure be mitigated and locked out by DOF.

The hazard analysis for new research should include electrical safety when appropriate. Contact EHS to review any procedure or equipment setup that exposes lab personnel to unguarded hazardous voltages of >50 Volts.

6. CHEMICAL CONTAINER LABELING GUIDELINES

Labeling is important for safe management of chemicals, preventing accidental misuse, inadvertent mixing of incompatible chemicals, and facilitating proper chemical storage. Proper labeling helps assure quick response in the event of an accident, such as a chemical spill or chemical exposure incident. Finally, proper labeling prevents the high costs associated with disposal of “unknown” chemicals.

Labeling requirements. With the exception for transient containers that will contain chemicals for brief periods, one day or less, all containers of chemicals being used or generated in MIT research laboratories must be labeled sufficiently to indicate contents of the container. On original containers, the label should not be removed or defaced in any way until the container is emptied of its original contents. Incoming containers should be inspected to make sure the label is in good condition. It is also advisable to put a date on new chemicals when they are received in the lab, and to put a date on containers of chemicals generated in the lab and the initials of the responsible person. For chemical management expiration dates should also be placed on the label see Part II section 3.2.9 Precautions for Work with Peroxide Forming Chemicals page 25 of this document.

Abbreviations, or other acronyms may be used to label containers of chemicals generated in the lab, as long as all personnel working in the lab understand the meaning of the label or know the location of information, such as a lab notebook, or log sheet that contains the code associated with content information. In addition, small containers, such as vials and test tubes, can be labeled as a group by labeling the outer container (e.g., rack or box). Alternatively, a placard can be used to label the storage location for small containers (e.g., shelf, refrigerator, etc.).

Containers of practically non-toxic and relatively harmless chemicals must also be labeled with content information, including containers such as squirt bottles containing water.

7. COMPRESSED GAS CYLINDERS

Compressed gas cylinders are used in many workplaces to store gases that vary from flammable (acetylene) to inert (helium). Many of these cylinders store gases at high pressures that can turn a damaged cylinder into a torpedo, capable of going through multiple concrete block walls. Other cylinders store the contents as a liquid (acetylene) and have special orientation requirements. If handled properly, compressed gas cylinders are safe. Regardless of the properties of the gas, any gas under pressure that is improperly stored can result in a hazardous release of energy.

Any person who handles compressed gas cylinders should be informed of their potential health and safety hazards and trained to handle them properly. The EHS Office has developed a standard operating procedure, “Compressed Gases”, located at https://ehs.mit.edu/chemical-safety-program/compressed-gas-cylinder-safety/ for ordering or removal of gas cylinders.

For additional advice, and/or assistance in training, contact the EHS Office.

8. CHEMICAL WASTE MANAGEMENT

8.1. Waste Management Responsibility

Hazardous waste may be generated from laboratory operations, construction and renovation activities, photo processing, and a variety of other activities at the Institute. The proper disposal of waste chemicals at the Institute is of serious concern, and every effort must be made to do it safely and efficiently. The responsibility for the identification and proper management of waste chemicals within the Institute prior to pick-up by the Environment, Health and Safety Office or their designated contractor, rests with the individuals who have generated the waste.

8.2. Training

All personnel using hazardous chemicals must complete the training requirements on managing hazardous waste as outlined in Part I. Section 3. of this Plan.

8.3. Procedures for Hazardous Waste Generators

The following summary provides a general overview of regulatory requirements applicable to hazardous waste generators.

8.3.1. Waste Identification

A. Waste Identification:

Hazardous waste (HW) includes materials that possess hazardous characteristics (e.g. toxic, ignitable, corrosive or reactive), or substances that are listed as hazardous waste by the regulatory agencies.

B. Containers and Labeling:

Separate containers must be used for different categories of chemical wastes and the container must be compatible with the waste contained. Compatible wastes can be consolidated. Empty containers in the lab can be reused for collecting hazardous waste provided the old label is removed or completely defaced. Only compatible chemicals shall be combined in a container. Any chemicals spilled on the outside of the container must be immediately cleaned off. Containers that store hazardous waste must be properly and clearly labeled. Labels must include: 1) the words "Hazardous Waste"; 2) the chemical names of constituents written-out with no abbreviations (e.g. "ethanol"); and 3) the hazards associated with the waste in words (e.g. "TOXIC"). The hazardous waste labels are available from the EHS Office Environmental Management Program (617-452-3477 or https://ehs.mit.edu/regulated-waste-program/chemical-waste/).

8.3.2. Accumulation and Storage

A. Accumulation & Storage:

Federal Environmental Protection Agency (U.S. EPA) and Massachusetts state regulations allow for two types of hazardous waste management areas: less than 90-day storage areas (90-day areas) and satellite accumulation areas (SAAs).

Satellite Accumulation Areas: SAAs must be established at or near the point of generation and remain under the control of the person generating the waste. SAAs must be clearly delineated and are to be posted with the sign "Hazardous Waste Satellite Accumulation Only." The Environmental Management Program has green "Hazardous Waste Satellite Accumulation Only" stickers available upon request.

A maximum of 55 gallons of hazardous waste or 1 quart of acutely hazardous waste may be accumulated at each SAA. Only one in-use container is allowed per waste stream. Hazardous waste containers must be closed unless waste is being added to the container.

Hazardous wastes with free liquids must be kept within secondary containment. EMP will provide secondary containers upon request. In addition, containers of incompatible wastes must be kept segregated and stored in separate secondary containers.

Hazardous waste containers in SAAs must be marked or labeled with the following:

- ❑ The words "Hazardous Waste"
- ❑ The hazardous waste(s) identified in words (e.g., acetone, toluene)
- ❑ The type of hazard(s) associated with the waste(s) indicated in words (e.g., ignitable, toxic, etc.)

Once a hazardous waste container is filled, the label must be dated and the container removed from the satellite accumulation area within three business days. The Environmental Management Program provides a hazardous waste pick-up service for the waste ready for disposal, or you can move those containers to a 90-day area if one is available. Hazardous waste pick-up can be requested online at https://ehs.mit.edu/regulated-waste-program/chemical-waste/ or by calling the Environmental Management Program (617-452-3477).

Less than 90 Day Storage Area: The Environmental Management Program must set up and manage your less than 90-day storage area. EMP will delineate the 90-day area with appropriate markings. All wastes in the 90-day area must be labeled as per SAA requirements with the additional requirement that the date must be marked on the waste tag. Hazardous waste containers must be closed unless waste is being added to the container.

B. Inspections

Hazardous waste areas (satellite accumulation areas and 90-day storage areas) must be inspected on a weekly basis. Personnel managing satellite accumulation areas are responsible for conducting their area's inspections. Environmental Management Program personnel conduct the weekly inspection of all 90-day areas.

8.3.3. Waste Minimization

Guidelines for Waste Reduction

Plan a procedure for waste disposal before you start on a project. Protection of the environment makes the disposal of large quantities of chemical and solid wastes a difficult problem. It is in everyone's best interest to keep quantities of waste to a minimum.

The following suggestions may help:

A. Order only the amount of material you need for your project or experiment even if you can get more quantity for the same money.

B. Use only the amount of material that is needed for conclusive results.

C. Avoid storing excess material, particularly if it is an extremely toxic or flammable material as this often only adds to the waste stream.

D. Before disposing of unwanted, unopened, uncontaminated chemicals check with others in your department who may be able to use them.

E. On termination of a research project or completion of a thesis, all unused chemicals to be kept by the laboratory shall be labeled.

F. Make sure all samples and products to be disposed of are properly identified, labeled with its chemical name, and containerized. Do not leave them for others to clean up after you.

8.3.4. SPECIAL PROCEDURES REQUIRED for Lab Waste Stream

Unknown waste chemicals cannot be accepted for disposal. It is the responsibility of the Department, Laboratory, or Center involved to identify all chemicals and this may require polling laboratory personnel, students and faculty members to ascertain the owner of such unknown waste and its identity. If identification is not possible, the Environmental Management Program can arrange for analysis of unknown materials and the Principal Investigator/Lab Group will be responsible for the cost of analysis.

Gas cylinders are to be returned to the supplier. Some small lecture bottles are non-returnable, which become a disposal problem when empty or near empty with a residual amount of gas. The Environmental Management Program will arrange for disposal of lecture bottles. However, the Principal Investigator/Lab Group is responsible for the cost of disposal. As outlined in Part IV. Section 2.4, small non-returnable gas cylinders originally purchased from MIT's preferred vendor Airgas, can be returned to the vendor.

Controlled drugs to be discarded *cannot be disposed of as hazardous waste*. The handling, records, and disposal of controlled drugs are the responsibility of the Department, Laboratory, or Center involved operating within the Drug Enforcement Agency (DEA) regulations. However, the Environmental Management Program can provide assistance during the process.

Laboratories often generate wastes that may consist of a combination of radioactive, biohazard, or hazardous chemical contaminants. In addition, any waste material contaminated with radioactive, biohazard or hazardous chemical waste and is also considered a "sharp" requires segregation from other regulated wastes. Consult the EHS Lab Waste Streams Chart for guidance on the proper segregation and labeling of the wastes. The chart may be downloaded from MIT's secure web site : https://ehs.mit.edu/sops/ (certificate login is required).

8.4 Sink Discharges/Wastewater

The EHS Office has developed a list of chemicals and materials that may be discharged into the sinks or floor drains. The list is based on regulatory requirements, MIT EHS policy, specific buildings, operations and activities knowledge, best practices and professional judgment regarding the potential impact of a chemical if discharged down the drain. The following materials are the only allowable discharges to laboratory sinks:

- Inorganic solutions with pH between 5.5 and 12
- Soaps/detergents
- Mercury-free Bleach/Wescodyne™/Cidex OPA™ / Quatricide® /Cetylcide II solutions

- Aqueous, soluble and dispersible radioactive isotopes into designated sinks or pipe openings within established limits (detailed lists posted at the designated sinks)
- Infectious/Biological materials that have been properly treated as described in each laboratory's registration protocols
- Non-contaminated growth media
- Purified biological materials such as amino acids and proteins in aqueous or buffer solutions
- Sugars and sugar alcohols (polyols) such as glycerol, xylitol and sorbitol
- Buffer solutions
- Spent photo developer (not fixer)
- Inorganic salts for which both the cations and anions are listed in the following table:

Cations	***Anions***
Aluminum, Al^{3+}	*Borate, BO_3^{3-}, $B_4O_7^{2-}$*
Ammonium, NH_4^+	*Bromide, Br^-*
Calcium, Ca^{2+}	*Carbonate, CO_3^{2-}*
Cesium, Cs^+	*Chloride, Cl^-*
Iron, Fe^+	*Bicarbonate, HCO_3^-*
Lithium, Li^+	*Bisulfite, HSO_3^-, Bisulfate, HSO_4^-*
Magnesium, Mg^{2+}	*Fluoride, F^-*
Manganese, Mn^{2+}, Mn^{3+}, Mn^{4+}, Mn^{7+}	*Hydroxide, OH^-*
Potassium, K^+	*Iodide, I^-*
Sodium, Na^+	*Nitrate, NO_3^-, Nitrite, NO_2^-*
Strontium, Sr^{2+}	*Oxide, O^{2-}*
Tin, Sn^{2+}	*Phosphate, PO_4^{3-}*
Titanium, Ti^{3+}, Ti^{4+}	*Sulfate, SO_4^{2-}, Sulfide, SO_3^{2-}*
Zirconium, Zr^{2+}	*Thiosulfate, $S_2O_3^{2-}$*

The list is available as a sticker that ***could*** *be placed near the sink.*

All materials that are not on the list of the allowed discharges must be accumulated and managed as hazardous waste. For a case-specific evaluation of materials that are not on the list, a request can be made to the Environmental Management Program (EMP) of the EHS Office or the DLC EHS Coordinator.

9. SHIPPING HAZARDOUS AND DANGEROUS MATERIALS

The transportation of hazardous materials and compressed gases over public roads or by air is strictly governed by federal and state regulations. Dangerous goods, as defined by governing regulations, include:

- Explosives (class 1)
- Compressed gases (class 2)
- Flammable liquids (class 3)
- Other flammables, e.g. spontaneously combustible materials (class 4)
- Oxidizers --- oxygen sources (class 5)
- Poisonous/toxic substances (class 6)
- Biohazard materials (class 6)
- Radioactive material (class 7)

- Corrosive materials (class 8)
- Miscellaneous hazards, e.g. dry ice and asbestos (class 9)

Any shipment of these items that is to travel over public roads or by air must comply with regulations regarding quantity, packaging, and labeling. The principle regulations are the U.S. Department of Transportation (DOT) (49 CFR 100-185), regulations for shipping hazardous materials. Information can be accessed at https://www.fmcsa.dot.gov/regulations/hazardous-materials Department, Laboratory, or Center (DLC) personnel who intend to ship materials by air or land, or convey these items over public roads by Institute or personal vehicles must contact the EHS Office. More details regarding shipping hazardous materials and the EHS Office service can be found on the EHS Website at: https://ehs.mit.edu/lab-research-program/hazardous-materials-shipping/

If you plan to ship materials, the EHS Office offers two awareness courses: "Shipping Hazardous Chemicals Awareness" and "Shipping Biohazardous Materials Awareness". You should select options in the EHS Training Needs Assessment to indicate you may ship hazardous chemicals or biological materials, to assure you are provided the appropriate awareness training. Individuals may register for the courses at https://ehs.mit.edu/training/

If you are shipping or receiving chemicals that are not generally found in commerce (i.e. available commercially), you may be subject to additional rules through the EPA Toxic Substances Control Act (TSCA). See Part IV. Section 8. for additional information on TSCA.

If you plan to ship materials to other countries, this will be considered an export, and there are additional requirements you need to meet to assure the materials are properly shipped. More guidance is on the EHS shipping website at: https://ehs.mit.edu/lab-research-program/hazardous-materials-shipping

10. APPENDICES

10.1. Appendix II-A OSHA Permissible Exposure Limits (PELs)

Most SDSs provide PELs for individual chemicals, if a PEL has been established. For a complete list of all PELs, consult the OSHA web site at https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=9992

10.2. Appendix II-B ACGIH Threshold Limit Values (TLVs)

Most SDSs also provide TLVs for individual chemicals. American Conference of Governmental Industrial Hygienists (ACGIH) TLVs can also be looked up on the National Library of Medicine Toxnet web site at http://toxnet.nlm.nih.gov/, (then search the Hazardous Substance Data Bank by individual chemical). A complete list of all ACGIH TLVs is available at the EHS Office (N52-496) or can be purchased at https://www.acgih.org/

10.3. Appendix II-C How to Determine if a Chemical is a Particularly Hazardous Substance

As discussed in Section 3, *particularly hazardous substances* (PHSs) are those chemicals with special acute or chronic hazards. OSHA did not provide a list of PHSs because new chemicals are continually being developed and tested in research laboratories. The OSHA Laboratory Standard provides a definition with which researchers can classify their chemicals to determine which ones have special hazards. OSHA defines PHSs as those chemicals that are select carcinogens, reproductive toxins, or have a high degree of acute toxicity. Details of the definitions and places to obtain information are provided below.

10.3.1. Particularly Hazardous Substance Evaluation of Common Laboratory Chemicals Used at MIT

The first place to look for information on PHSs is on the searchable list *Toxicity Evaluation of Common Laboratory Chemicals Used at MIT*, available from the EHS Office at the Chemical Hygiene Plan website https://ehs.mit.edu/chemical-safety-program/dangerous-highly-toxic-chemicals/.

The EHS Office has taken 160 chemicals used widely in MIT laboratories and evaluated them to determine whether they are particularly hazardous. If a chemical is not on the list, it does not mean that it is not a PHS. You then must perform your own determination using the criteria provided below.

10.3.2. Select Carcinogens

Certain potent carcinogens are classified as "select carcinogen" by OSHA and treated as PHSs.

A select carcinogen is a chemical that is:

- Regulated by OSHA as a carcinogen in a specific standard,
- Listed as "known to be a carcinogen" or "reasonably anticipated to be a carcinogen" by the National Toxicology Program (NTP), or
- Listed as "carcinogenic to humans" (Group 1) or "probably or possibly carcinogenic to humans" (Groups 2A and 2B) by the International Agency for Research on Cancer (IARC).

OSHA Carcinogens: A list of all OSHA carcinogens is provided in Part II. Section 3. under Partial List of Select Carcinogens. For more information on any of these chemicals, consult the OSHA web site athttp://www.osha.gov/SLTC/carcinogens/index.html .

NTP and IARC Carcinogens: The SDS for an individual chemical frequently lists whether the chemical is an NTP or IARC carcinogen. If not provided on the SDS, go to the National Library of Medicine Toxnet web site at http://toxnet.nlm.nih.gov/ and search the Hazardous Substance Data Bank by individual chemical. The data bank will indicate if the chemical is an NTP or IARC carcinogen. If you want additional information on why these chemicals were classified as confirmed or possible human carcinogens or complete lists of all chemicals evaluated, consult the NTP or IARC web sites. The NTP Annual Report on human carcinogens can be found at: https://ntp.niehs.nih.gov/pubhealth/roc/index-1.html The IARC Monographs on human carcinogens can be found at: http://monographs.iarc.fr/

10.3.3. 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. They also include chemicals that may injure male and female reproductive health.

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. Only a limited number have been tested thoroughly on animals for reproductive effects.

SDSs will often indicate if the chemical has been found to have reproductive health effects. If there is no information on the SDS, the most comprehensive list of reproductive toxins is the chemical list of the State of California's Safe Drinking Water and Toxic Enforcement Act of 1986 (Proposition 65). This list includes chemicals known to the State of California to cause reproductive toxicity and indicates whether it causes female, male, or developmental health effects. The list is available on the web at: https://oehha.ca.gov/

You may also consult general references such as the Catalog of Teratogenic Agents, Seventh Edition, T.H. Shepard, ed., 1992, and other references available in the EHS Office library in N52-496. Please call the Industrial Hygiene Program (617-452-3477) for additional information.

10.3.4. Substances with a High Degree of Acute Toxicity

Acutely toxic substances produce adverse effects when exposed individuals receive only small doses of that substance for a short period of time (hydrogen fluoride, for example). OSHA defines substances that have a high degree of acute toxicity as those "which may be fatal or cause damage to target organs as the results of a single exposure or exposures of short duration."

For many chemicals, the health effects in humans may not have been tested. Frequently, only basic animal testing has been done, such as the LD_{50} or the LC_{50}. The LD_{50} is the Lethal Dose that kills 50 percent of the animals when the chemical is given orally or applied to the skin. The LC_{50} is the Lethal Concentration in air that kills 50 percent of the animals.

OSHA has given dose criteria for substances of high acute toxicity based on LD_{50} and LC_{50} animal tests as follows:

Compounds with High Degree of Acute Toxicity:

TEST	TOXIC	HIGHLY TOXIC
Oral LD_{50} (albino rats)	50-500 mg/kg	<50 mg/kg
Skin Contact LD_{50} (albino rabbits)	200-1000 mg/kg	<200 mg/kg
Inhalation LC_{50} (albino rats)	200-2000 ppm in air	<200 ppm in air
Probable Equivalent Lethal Oral Dose for Humans (for 70 kg or 150 lb person)	<35 g (about 1 oz or 2 tablespoons)	<3.5 g (about 1/10 oz or 1/2 teaspoon)

Note: both “toxic” and “highly toxic” chemicals in the table above are considered by OSHA to have a high degree of acute toxicity, and therefore are *particularly hazardous substances*.

Animal toxicity test results are often presented in SDSs. If not provided on the SDS, go to the National Library of Medicine Toxnet web set at http://toxnet.nlm.nih.gov/ and search the Hazardous Substance Data Bank by individual chemical. Under your chemical, select “Animal Toxicity Studies” and then ”Non-Human Toxicity Values” from the table of contents to obtain LD_{50} and LC_{50} test results.

Select Toxins

As a result of requirements of the U.S. Patriot Act, the U.S. Department of Health and Human Services (DHHS) and the U.S. Department of Agriculture (USDA) have identified a select group of biologically-derived toxins, which are considered particularly hazardous because of their acute toxicity. They have enacted regulations pertaining to these agents when they are present in amounts above regulatory threshold quantities. These agents and the threshold quantities are provided in the tables below.

DHHS Toxins

Toxin	Regulatory Threshold Quantity Requiring CDC Certificate of Registration
Abrin	100 mg
Contoxins	100 mg
Diacetoxyscirpenol	1000 mg
Ricin	100 mg
Saxitoxin	100 mg
Tetrodotoxin	100 mg
Shiga-like ribosome inactivating proteins	100 mg

Overlap Toxins (DHHS and USDA)

Toxin	Regulatory Threshold Quantity Requiring CDC or USDA Certificate of Registration
Botulinum neurotoxins	0.5 mg

Clostridium perfringens epsilon toxin	100 mg
Shigatoxin	100 mg
Staphylococcal enterotoxins	5 mg
T-2 toxin	1000 mg

Please see Part II. Section 3.4 for MIT requirements for ordering, use and storage of these biotoxins to ensure that the Institute as a whole does not exceed threshold quantities, and to ensure that the Institute manages these biotoxins safely.

Please note also that there are other biotoxins such as aflatoxins and picotoxin that are not regulated under DHHS and USDA, but that would be considered PHSs because they meet the definition of acute toxicity. Appropriate precautions should be taken when handling these biotoxins, as well as other biotoxins not mentioned because, as a class of chemical, they are usually highly toxic.

10.3.5. Substances with Unknown Toxicity

New substances used in laboratories frequently have not been tested for their acute, carcinogenic, or reproductive toxicity. These compounds should be used with the utmost caution and generally handled as if they are particularly hazardous substances. For example, a laboratory working with chemicals it knows to be potent mutagens, but which have not yet been screened for carcinogenic or reproductive effects, may choose to consider these chemicals PHSs and handle them accordingly.

PART III. DLC or Laboratory Specific Chemical Hygiene Practice or Lab Specific Standard Operating Procedures

1. INTRODUCTION

This Part contains policies, procedures or precautions that are required by a specific Department, Laboratory, or Center (DLC). This Part is provided to enable Departments, Centers, or individual laboratories to customize this Chemical Hygiene Plan for their operations. A template for developing Lab Specific SOPs is included in this Part to provide assistance to laboratory personnel generating specific safety procedures.

Additional Lab Specific SOPs must be developed for any operation or hazardous material for which the general safety procedures contained in Part II. of this Chemical Hygiene Plan 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 Specific SOP must be reviewed by the PI and the DLC Chemical Hygiene Officer (CHO). EHS is available to assist with development or review of Lab Specific SOPs as well.

A Lab Specific SOP that addresses the requirements noted above must be documented and maintained in the laboratory and it is suggested the SOP be included in Part III. of this Chemical Hygiene Plan. A Lab Specific SOP template is provided in Appendix III-A, paragraph 4 below, to facilitate Lab Specific SOP development. Instructions regarding use of the SOP template are contained in the following section.

2. LAB SPECIFIC SOP TEMPLATE INSTRUCTIONS

2.1. Title, Authors, Reviewers, Date and Hazard Type

Complete the blanks shown in this section. The revision date should indicate when the most recent modifications were made to this procedure. The title of the procedure should indicate the specific chemical, task or experiment for which it was written. Note that each procedure, and its subsequent revisions, should be reviewed by the PI, and the Chemical Hygiene Officer. The EHS Office can review the SOP as well. The most appropriate box to indicate hazard type covered by the Laboratory Specific SOP should be checked.

2.2. Scope and Applicability

Complete boxes. 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. The brief description of the operation or experiment should be used to summarize the basic safety concerns or hazards and critical controls.

2.3. Chemical Hazards

Complete the hazard description table for each of the principal materials utilized in this procedure. 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, or if the hazard is unknown. Information about the SDS location for chemicals should be noted, or the SDS (s) could be attached to the SOP.

2.4. Step by Step Hazard Summary

In most cases, the hazard is not just about the chemical(s) being used, but how they are being used. In some cases, the hazards may be related to the equipment being used for a step, or to the nature of the process involving materials used. This section is appropriate for a procedure involving several steps or tasks, as do most experiments, highlighting concerns at critical points in the process. List the step, hazards associated with the step, and the controls to contain the hazard.

2.5. Personal Protective Equipment (PPE)

Conduct a comprehensive Personal Protective Equipment (PPE) evaluation for the referenced materials or operation. The determination should include both the type of protective equipment or clothing materials. The results from this evaluation should be identified by completing the PPE and Clothing tables, but could also be included in the step by step process in section 2.4 above.
This section can be used to provide more details regarding PPE to be used, such as gloves, clothing, eye protection, etc. For guidance on PPE assessment, go to: https://ehs.mit.edu/workplace-safety-program/personal-protective-equipment/

2.6. Special Precautions

Provide general information on specific training requirements for the procedure, any medical surveillance requirements, or other precautions that might be warranted.

2.7. Special Emergency Procedures

Generic information related to emergency response activities is already addressed in Part II. Section 3. of the Chemical Hygiene Plan. List any additional or specific equipment, supplies or procedures that are unique to the process or operation in this SOP.

3. STANDARD OPERATING PROCEDURES

This section contains the Lab Specific SOPs developed for specific laboratories, experiments or operations.

4. **APPENDICES**

4.1. Appendix III-A -Lab Specific SOP Template

This template form is available at: https://ehs.mit.edu/chemical-safety-program/chemical-hygiene/

STANDARD OPERATING PROCEDURE (SOP) TEMPLATE
For Hazardous Materials and Operations

Overview	
Title	
Author(s)	
DLC/Research Group	
Lab (Room Number)	
Experimental Objective	
Type of Hazard(s)	☐ Chemical ☐ Biological ☐ Radiation ☐ Process/Equipment ☐ Other *(explain):*

Preparation	
Training required for researchers *Please check the EHS Training Requirements for researchers performing the procedure described in this document*	
Core EHS Training Requirements	
☐ General Chemical Hygiene (100)	☐ Bloodborne Pathogen Training (200)
☐ Lab Specific Chemical Hygiene (110)	☐ General Biosafety for Researchers (260)
☐ Signature of Chemical Hygiene Plan (111)	☐ Managing Hazardous Waste (501)
DLC or Process Specific	
☐ Laser Safety (371, 376)	☐ Lab Laser Specific (375)
☐ Radiation Safety (300, 302)	☐ Other *(please specify)*

Material List *(please remove the rows that do not apply to this procedure)*
(*) Chemical hazards include but not limited to: Peroxide former, flammable, corrosive, sensitizer, carcinogen, teratogen/mutagen, biological toxin, pyrophoric, water-reactive, shock-sensitive, unstable, penetrates the skin. Check the SDS, section 2.

Type of Material	Name	Hazards
Chemicals (*)		
Biological Materials		
Radioactive Materials		

Steps to prepare the work space and equipment: *Please describe step by step what is necessary to prepare the space and the equipment. includes key steps such as making sure there is sufficient space to do the work, removing incompatibles from the area, and making sure fume hoods and other equipment is functional.*	
Specific Needs *(please remove the rows that do not apply to this procedure)*	
Glassware/Plastic Ware	
Equipment *(include special hazards for each piece of equipment)*	
Spill Kit Material *(must have appropriate spill cleaning material before starting to work)*	
Working alone *(does it need PI approval?)*	

Procedure

Enumerate and outline the steps to be followed in performing the procedure and the required precautions to avoid harm. The steps should be detailed and should include prohibited activities and cautionary statements where applicable (add/delete rows if necessary).

Steps	Hazards	Precautions

Personal Protective Equipment (PPE)

Note: Standard PPE as listed in Part II of the Department Chemical Hygiene Plan should always be worn in the lab (or as required in the CHP). (*) FR-CR: flame resistant-chemical resistant

Eye & Face Protection			
☐ Goggles	☐ Safety Glasses	☐ Face Shield	☐ Other *(list)*
Protective Clothing			
Always wear clothing that fully covered your skin and sturdy, closed-toe shoes			
☐ Poly-cotton lab coat	☐ Flame resistant coat	☐ FR-CR coat (*)	☐ Other *(list)*
Gloves			
☐ Butyl	☐ Neoprene	☐ Latex	☐ Silver shield of 4H
☐ PVC	☐ Kevlar	☐ Nitrile – double glove	☐ Hybrid Gloves
☐ Other *(list)*			

Special Equipment
☐ **Respirator** *(if checked, contact EHS Office for additional assistance, unless already in the program)*

Special Precautions

☐ **Medical Surveillance** *(list)*	
☐ **Temperature/Pressure Sensitive** *(explain)*	
☐ **Primary Containment** *(ex., BSC, fume hood, glove box)*	
☐ **Placarding and Signage** *(ex., PHS signage, hazard labels)*	
☐ **Storage** *(list the chemical storage conditions)*	
☐ **Other** *(list)*	

Clean Up

List steps needed to do as part of the cleanup procedure.

- *Clean work area – what needs to be done to clean the workspace and equipment in preparation for the next person*
- *If any materials will be stored following the procedure, document the appropriate storage locations and methods (ex. Type of storage cabinet, requirement for vented caps, etc.)*
- *Potential waste produced during the experiment and procedures for proper disposal.*

Emergency Response

Outline emergency procedures based on the types of incidents that may occur. Examples include the following. Contact the EHS Coordinator if guidance is needed on the appropriate types of responses.
Major and/or minor spill, Skin/eye/respiratory exposure, Sharps injury, Fire/explosion, Gas or cryogen release, Non-ionizing, radiation exposures (lasers, UV light, etc.), Loss of utilities (including proper shutdown procedures)

Supporting Documents

Use this section to provide links to useful documents, such as previous publications related to the experiments, SDSs, equipment manuals, or safety information related to the work.

Revisions		
This document has been reviewed by (check all applicable)		
☐ **PI**	☐ **CHO/EHS Coordinator**	☐ **EHS**
Name and Signature:		
Date:		

PART IV. Additional Administrative Provisions

1. INTEGRATION WITH MIT EHS MANAGEMENT SYSTEM

MIT has designed and implemented a comprehensive and integrated *Environment, Health and Safety Management System* (EHS-MS). This management system provides better institutional accountability for achieving and maintaining compliance with federal, state, and local environment, health and safety regulations in MIT's departments, laboratories, and centers, while simultaneously retaining the independence of research and teaching. The EHS-MS also seeks to create a more sustainable campus by encouraging the incorporation of positive initiatives into activities, such as reducing wastes and toxics, preventing pollution, and conserving and reusing resources. One of the defining features of MIT's EHS-MS is the integration of regulatory compliance with positive initiatives and educational programs in a decentralized academic research setting.

This Chemical Hygiene Plan is an integral component of the EHS-MS. It is an administrative tool that provides for the establishment of safe and sound workplace practices in the laboratory, and ensures the Institute's regulatory compliance with the OSHA *Laboratory Standard*. The Chemical Hygiene Plan incorporates and advances core components of the EHS-MS, such as clarifying roles and responsibilities, outlining training requirements, identifying chemical risks, and documenting safe operating procedures to mitigate those risks. For more information on the EHS Management System, please visit https://ehs.mit.edu/about/ehs-management-system/

2. SECURITY, PRIOR APPROVALS, INVENTORIES AND PROCUREMENT

2.1. Chemical Inventory and Security

To minimize the theft and improper use of hazardous chemicals including toxic and corrosive substances the following actions should be taken:

1. The MIT Committee on Toxic Chemicals has instituted a requirement to maintain an inventory of hazardous chemicals. Hazardous chemicals include chemicals for which there is statistically significant evidence of health effects following exposure as well as flammable and explosive substances. Although inventories can be kept using any type of electronic or non-electronic method, the use of MIT's centrally provided chemical inventory platform which is supported by EHS is strongly recommended. For more information please visit https://ehs.mit.edu/chemical-safety-program/chemical-inventory/ or by calling 2-3477. Your lab's inventory should be used to:

- ❑ Manage the chemical purchases to reduce or completely eliminate unnecessary purchases. Prior to purchasing new chemicals, review your lab's current chemical inventory/search the shared inventory in the centralized system. When purchasing new chemicals, purchase minimum quantities necessary for your work. Less over-purchasing will lead to less chemical waste.
- ❑ Provide a list of applicable chemicals to EHS when requested to meet regulatory reporting requirements, such as MIT's annual SARA Inventory Reporting requirement see Part IV section 9.

2. Access to all hazardous chemicals, including toxic and corrosive substances, should be restricted at all times. Specifically, good practice would dictate that these materials be stored in laboratories or storerooms that are kept locked at all times when laboratory personnel are not present. Also there are a few select highly toxic chemicals, requiring prior approval for purchase see #4, which additional precautions are required such as keeping the materials under a second layer of security e.g. locked storage or gas cabinet, drawer, storeroom or other security measures. These chemicals are hydrogen cyanide, arsenic trioxide, chlorine, nitrous oxide, phosgene, potassium cyanide (analytical reagent and purified), sodium arsenate (analytical reagent), sodium cyanide (analytical reagent) see http://vpf.mit.edu/instructions-for-purchasing-hazardous-and-dangerous-items Contact the EHS Office to determine the appropriate controls. Contact Campus Safety Working Group (CSWG) to request security cameras to be installed in your DLC.

3. Needles and syringes that could be used to administer drugs should be kept secure at all times either in a locked laboratory cabinet or locked laboratory space. They should only be utilized in a laboratory space that provides a barrier to access.
4. In the case of highly toxic chemicals (hydrogen cyanide, arsenic trioxide, chlorine, nitrous oxide, phosgene, potassium cyanide (analytical reagent and purified), sodium arsenate (analytical reagent), sodium cyanide (analytical reagent) Requisition must be signed by a member of the Institute community with the title Department Head, Laboratory Director, Professor, M.D., or Pharmacist see https://vpf.mit.edu/instructions-for-purchasing-hazardous-and-dangerous-items

Other unusually toxic or hazardous materials to consider for this level of security include substances with a high degree of acute and/or chronic toxicity and also may include explosives, certain highly reactive and/or corrosive substances. Unusually toxic chemicals are those that meet the OSHA definition of high acute toxicity (oral LD50 <50mg/kg, skin contact Ld50 < 200 mg/kg, or inhalation LC50 <200 ppm in air).
5. Areas where biological agents and radioactive material are stored should be kept secure when not in use.
6. Restrict access to the laboratory to authorized personnel only and become familiar with these people
7. Ship chemicals by following requirements in Part II section 9 to ensure safety and security.

2.2. Department, Laboratory, or Center-Based Prior Approvals

Researchers must obtain prior approval from the DLC EHS Coordinator and or the DLC EHS Committee before purchasing any of the 41 chemicals (see Part IV Appendix 10.2) with low threshold reporting quantities from the Department of Homeland Security (DHS) larger list of chemicals of interest (COI). EHS Coordinators will inform the EHS Office when a chemical from the list is purchased (though no prior approval from the central EHS office is required).

It is recommended that Departments, Laboratories, or Centers (DLCs) institute a program for requiring prior approvals before work with certain hazardous materials can commence. A suggested framework is provided in the *CHP Preparer's Guide*, located at https://ehs.mit.edu/chemical-safety-program/chemical-hygiene/. Details of the program should be included here. If no program is implemented, this Section 2.2 should be deleted.]

2.3. MIT-Wide Signature Control Program for the Purchase of Certain Hazardous Materials

The MIT Procurement Department through its *Purchasing Policies and Procedures* has established Institute-wide restrictions on the purchase of certain hazardous materials. These materials require pre-approval by authorized MIT agents prior to purchase. These materials include:

- Radioactive Materials
- Controlled Substances, such as drugs
- Hypodermic Needles and Syringes
- Ethyl Alcohol
- Certain Highly Toxic Chemicals
- Nitrous Oxide Gas
- Explosives
- Liquid Petroleum Gases
- Certain Biological Materials
- Certain Poisons

Detailed information on the purchase of these materials can be found on the Procurement Department's website at https://vpf.mit.edu/instructions-for-purchasing-hazardous-and-dangerous-items

2.4. Purchase of Large Chemical Quantities

In most cases, MIT discourages the practice of bulk ordering of chemicals that reduces the chemical cost per unit volume. Although bulk orders may save individual Departments, Laboratories, and Centers (DLCs) money in the short-term, in the long run, the cost of disposal of unused chemicals can far outweigh any savings from the bulk order. However, if it can be demonstrated that the bulk purchase of a chemical for an on-going laboratory process can simultaneously reduce disposal costs and not increase risks to environment, health and safety, the EHS Office may support some degree of bulk purchasing. Contact the EHS Office to discuss particular situations if you are considering a bulk purchase.

The following points should be addressed to determine the proper volume of any chemical to order. Consider the following when placing an order:

- Investigate if there is a less hazardous substitute that can be used to achieve the same results. This could reduce the hazards involved in the process as well as the waste disposal costs.
- Order only the amount likely to be used for its intended purpose within the specified shelf life of the material and within the planned timeframe of the procedure. This can minimize chemical waste if processes or research changes and previously purchased chemicals are no longer needed. Although many chemicals can be safely stored over long periods of time, decomposition can result in explosions, ruptured containers and the formation of hazardous by-products.
- Evaluate the chemical properties that may preclude long-term storage before the chemical quantity to be ordered is decided.
- Order only the quantity that will fit into the appropriate storage area(s). Storing excess chemicals in a fume hood or outside adequate storage facilities will create other hazards.
- Request that the chemical vendor package the material in smaller containers on large orders and request that stock be delivered on an as needed basis. This is particularly useful when one lot or a special blend is required.
- Consult laboratory chemical inventory lists, if available, before ordering additional stock. If the decision is made to order new stock because of concerns about quality of existing stock, please properly dispose of existing stock of questionable quality as soon as possible.
- Manage the stock so that the oldest materials are used first.
- Refer to the EHS Office *Flammable Liquids SOP* when applicable. EHS Office SOPs are available at https://ehs.mit.edu/sops/ (certificate login is required).**Error! Hyperlink reference not valid.**
- Refer to the EHS Office *Hazardous Waste Management SOP* when applicable. EHS Office SOPs are available at http://web.mit.edu/environment/ehs/topic/sops.html https://ehs.mit.edu/sops (certificate login is required).**Error! Hyperlink reference not valid.**

If you need assistance in making a determination on the most appropriate quantity of chemical to purchase, please contact the EHS Office at 617-452-3477.

2.5. Purchase of Non-Returnable Gas Cylinders

The purchase of non-returnable gas cylinders should be avoided. All gas cylinders should be returned to the supplying vendor when their use is completed. All non-returnable cylinders will have to be disposed of as hazardous waste, and the cost of doing so will be charged to the Department, Laboratory, or Center.

"Lecture bottles" are often considered non-returnable by the vendor. However, MIT has an agreement with their preferred chemical vendor, Airgas, to take back non-returnable gas cylinders, including "lecture bottles" that were purchased through them. Contact Airgas Gas on-campus directly at 617-253-4761 (3-4761 from an MIT telephone) for more information.

2.6. Purchase of Select Toxins

Certain biological toxins are governed by special regulations that require strict controls if threshold amounts are exceeded. Researchers working with regulated toxins must submit paper requisitions to the EHS Office Biosafety Program. More details are provided at https://ehs.mit.edu/biological-program/select-agent-toxins/

3. MEDICAL EVALUATION, EXAMINATION, SURVEILLANCE and FIRST AID KITS

3.1. Medical Evaluation

Employees or students who work with hazardous materials are entitled to a medical evaluation by an occupational medicine physician or occupational health nurse under the following circumstances:

- A spill, leak, explosion or other incident created a likelihood of exposure.

- The individual(s) develops signs/symptoms associated with hazardous chemicals to which they were exposed. (Note that acute (same-day) onset of symptoms should seek immediate medical attention by calling 100 from a MIT phone or 617-253-1212 from a cell phone. If non-life-threatening symptoms developed slowly over more than a couple days, an appointment may be made with Occupational Health as described below).
- The individual works with reproductive toxins.

In addition, an employee or student will be offered medical evaluation if it is determined after consulting EHS that:

- environmental monitoring results are routinely above action level or PEL (permissible exposure limit) for a hazardous substance for which there are monitoring/medical surveillance requirements; or
- a hazardous substance, for which there is a standard surveillance program, is intrinsic to a research program lasting for at least a year.

Appointments are made with Occupational Health by calling 617-253-8552 or by sending a message to an Occupational Health provider through HealthELife, the secure messaging system used by MIT Medical.

Information to Provide to the Clinician
At the time of the medical evaluation, the following information shall be provided to the clinician:
- Identity of the hazardous chemicals to which the individual may have been exposed;
- A description of the conditions under which the exposure occurred;
- A description of the signs and symptoms of exposure, if any; and
- A copy of the chemical information sheet (SDS, or Safety Data Sheet) shall be provided.

Clinician's Written Opinion
The MIT Medical Department and the Industrial Hygiene Program within the Environment, Health and Safety Office have a collaborative relationship in dealing with chemical and other work-related exposures that may result in the need for medical care. This collaborative relationship includes protecting patient information while ensuring that supervisors receive the information necessary to ensure that an individual's return to work following medical treatment for a work-related exposure does not compromise the patient's health.

All patient medical information is protected by law and is considered strictly confidential. A patient, however, is entitled to view his/her medical record. When a work-related exposure has occurred that results in medical examination and/or treatment, the Medical Department will notify the supervisor of the incident, along with any recommended restrictions on work activity.

Additional Steps to be Taken
MIT requires the *Supervisor's Report of Occupational Injury and Illness* to be completed within 24 hours, when a spill or other accident triggers a medical evaluation or examination. The reporting form can be accessed at https://ehs.mit.edu/workplace-safety-program/occupational-injury-or-illness-reporting/. An MIT personal certificate is required to access this document.

The MIT EHS Office has developed a standard operating procedure (SOP), "Reporting Work-Related Injuries and Illnesses of OSHA-Covered Personnel" to assist Departments, Laboratories, or Centers (DLCs) in this type of reporting, which OSHA requires. The SOP may be found at https://ehs.mit.edu/sops/ (certificate login is required).

3.2. Medical Surveillance

Medical surveillance is the process of using medical exams and/or biological monitoring to determine potential changes in health as a result of a hazardous chemical or other exposure. Certain OSHA standards require a clinician evaluation as part of medical surveillance. Medical surveillance is required when initial monitoring reveals exposure levels that exceed levels (called "action levels") allowed under

OSHA standards. MIT Medical Department provides medical surveillance services. If you expect that your work will involve a hazardous exposure that may not be sufficiently addressed through engineering or administrative controls, a baseline exam may be advised before beginning work. The baseline exam is compared against follow up exams to determine any changes in health that may have resulted from exposure to the hazard. In addition, medical surveillance is offered to employees or students who are routinely exposed to certain hazards. Examples of hazards that are monitored through the medical surveillance program include:

- Asbestos
- Beryllium
- Noise (Hearing Loss)
- Respirator Use (See Respirator Policy)

This is not a full list of hazards for which medical surveillance is available. Individuals with questions pertaining to occupational hazards and the possible need for medical surveillance are encouraged to contact the Occupational Medicine Service within the MIT Medical Department. The Occupational Medicine Service in turn works collaboratively with the EHS Office to determine the need for and extent of medical surveillance.

Enrollment in Medical Surveillance

For those individuals whose work involves exposures with potential medical surveillance requirements, it is the responsibility of supervisors to identify new employees/students who are exposed to hazards, and to provide names, work addresses, and MIT Identification Numbers (MIT ID) to the EHS Office. Individuals not otherwise identified but who believe that they incur hazardous exposures, or believe they may have been inadvertently omitted, may self-enroll by dialing 617-452-3477. Supervisors who believe that individuals have been inadvertently omitted from medical surveillance may also contact this number. Finally, the EHS Office may identify individuals or populations of individuals at risk and invite their participation.

More information on Medical Consultation, Evaluation, and Surveillance may be obtained from the Medical Department's Occupational Medicine webpage at http://medweb.mit.edu/directory/services/occupational_medicine.html

3.3. Researchers with Medical Conditions

Individuals with medical conditions that could lead to sudden incapacity and who work with hazardous materials or processes during the course of their research may be at increased risk for injury to themselves or others. Anyone with such a medical condition who believes that they may be at increased risk is recommended to contact MIT Occupational Medicine services (E23-171, 253-8552) for consultation and advice on how they may more safely perform their work. Supervisors who have concerns about an individual's health condition and its effect on that person's ability to safely work in a laboratory should also consult with MIT Occupational Medical Services.

Postdoctoral researchers in need of special accommodation as a result of a medical condition should contact the MIT Disability Services Office (E19-215, x4-0082). Students should contact MIT Office of Student Disabilities Services (7-145, x3-1674). Supervisors who have concerns regarding an individual's accommodation requests should contact the appropriate Disabilities Services Office. It is MIT's policy to make every effort to provide reasonable accommodations necessary for researchers to carry out their work.

3.4 First Aid Kits and Specific Hazard First Aid

If your Department, Lab or Center (DLC) chooses to have first aid kits in labs, machine shops or other work spaces to treat minor traumatic injuries, then there are some additional requirements to address outlined in the First Aid Kit guidance at https://ehs.mit.edu/wp-content/uploads/EHS-0213.pdf. The guidance contains information on kit types, maintenance and training. In the event of medical emergencies and if you are not sure of severity of the injury or appropriate care call (617) 253-1212 or dial 100 from any MIT phone. An injury report must be completed when a first aid kit is used due to an injury/illness https://ehs.mit.edu/workplace-safety-program/occupational-injury-or-illness-reporting.

Work environments with specific potential health hazards such as Hydrofluoric Acid should be equipped with appropriate emergency equipment that is readily available and for which lab personnel have been trained. Contact the EHS Office 617-452-3477 for a hazard assessment and possible recommendation for such special supplies.
For a medical emergency and treatment for cyanide exposure (confirmed or suspected), dial 100 from any campus phone or 617-253-1212 from a cell phone to reach MIT Campus Police. When calling, it is critical to state that it is a potential cyanide exposure and to request an ambulance service equipped with a CYANOKIT and capable of treating cyanide poisoning (See Laboratory Use of Cyanide Salts guidance https://ehs.mit.edu/chemical-safety-program/chemicals/).

4. EXPOSURE ASSESSMENT (MONITORING & REPORTING)

4.1. Exposure Assessment

The EHS Office Industrial Hygiene Program provides exposure assessment services to the Institute community. Exposure assessments are measurements of air contaminants, noise levels, or other health hazards such as heat stress to determine if they are within limits that are considered safe for routine occupational exposure. Employees who believe they have had an exposure should report it to the PI/Supervisor or the EHS Representative. The PI should contact the Chemical Hygiene Officer or the Industrial Hygiene Program (617-452-3477) for an evaluation. The employee can also contact the CHO or the EHS Office directly, but should notify their PI/Supervisor of the situation. In addition, anyone with a reason to believe that exposure levels for a substance routinely exceed the action level, or in the absence of an action level the PEL, may request exposure monitoring. Monitoring may be requested at any time, however, the Chemical Hygiene Officer must be notified of monitoring requests. The Industrial Hygiene Program will conduct, or arrange to have conducted, exposure monitoring.

If the initial monitoring reveals an employee exposure over the action level (or the PEL) for a hazard for which OSHA has developed a specific standard (e.g. lead), the exposure monitoring provisions of that standard, including medical surveillance, shall be followed. It will be the responsibility of the Principal Investigator or Supervisor to insure that necessary periodic monitoring requirements are met.

Within 15 working days after the receipt of any monitoring results, the Industrial Hygiene Program will notify the employee or student of the results in writing, either individually or by posting results in an appropriate location that is accessible to employees. The PI/Supervisor and CHO will also be notified of monitoring results and be provided a copy of a written report. A copy will be kept in the Industrial Hygiene Program's records.
The Industrial Hygiene Program and the Chemical Hygiene Officer will establish and maintain for each employee an accurate record of any measurements taken to monitor exposures. Records, including those from monitoring provided by other qualified services, will be managed in accordance with OSHA standard 29 CFR 1910.1020, Access to Employee Exposure and Medical Records.

5. RECORDKEEPING

5.1. Exposure Assessment

The Industrial Hygiene Program and the Chemical Hygiene Officer will establish and maintain an accurate record of any measurements taken to monitor exposures. Records, including those from monitoring provided by other qualified services, will be managed in accordance with OSHA standard 29 CFR 1910.1020, Access to Employee Exposure and Medical Records.

5.2. Medical Consultation and Examination

Results of medical consultations and examinations will be kept by the MIT Medical Department for a length of time specified by the appropriate medical records standard. This time will be at least the term of employment plus 30 years as required by OSHA.

5.3. Training

The PI/Supervisor or designee must keep a copy of the outline of the topics covered in Lab-Specific Chemical Hygiene Training. The roster or lists of researchers who have completed the lab-specific training and read the Chemical Hygiene Plan must be submitted to the EHS Coordinator. These training records are then entered into the EHS-MS central training records database. Web-based training records are automatically entered into the database when a course is completed. The EHS Office is responsible for entering training records into the database for the courses they teach. When an employee or student leaves the Institute, their training records are moved into an archive training database. Training records are kept for at least 3 years after an employee or student leaves the Institute.

5.4. Fume Hood Monitoring

Data on annual fume hood monitoring will be kept by the EHS Office. Fume hood monitoring data are considered maintenance records, and as such, the full data will be kept for one year and summary data for 5 years.

5.5. Inspection Reports

A copy of the most recent Level II. *Laboratory Inspection Checklist* and *PI Inspection Report*, as outline below, should always be maintained locally within the Department, Laboratory, or Center by the EHS Coordinator. An additional copy will be maintained centrally by the EHS Office.

5.6. Lab Specific Policies and SOPs

If Lab Specific SOPs are developed in addition to the SOPs contained in Part II. of this Chemical Hygiene Plan, copies must be maintained in the laboratory accessible to laboratory personnel. In addition, copies of the additional Lab Specific SOPs may be included in Part III. of this Chemical Hygiene Plan.

6. LABORATORY INSPECTIONS AND AUDITS, COMPLIANCE AND ENFORCEMENT

6.1. Inspections and Audits

As a component of the MIT Environment, Health and Safety Management System (EHS-MS), the Institute has implemented a framework for conducting laboratory/work space inspections and audits to determine laboratory/work space-specific compliance with environment, health, and safety policies, laws, and regulations. The EHS-MS inspections examine a broad spectrum of areas including postings, documentation and training, safety equipment, laboratory/shop protocol, waste, and satellite accumulation areas (SAA).

The purpose of the inspection and audit system is to assist the Institute and laboratories in maintaining a safe work and study environment, ensuring compliance with regulations, identifying the locations where training or retraining is needed, and to fulfill MIT's commitment to environment, health and safety stewardship. This program will satisfy the Department, Laboratory, or Center (DLC) requirements for chemical hygiene inspections.

The MIT EHS-MS requires three levels of inspection and audit that must be implemented across the Institute: **Local Periodic Inspections** (Level I. Inspections), **DLC-Wide Inspections** (Level II. Inspections), **Institutional Audits** (Level III. Audit). For more information on the MIT EHS Inspection and Audit Program, visit the EHS Management System website at https://ehs.mit.edu/about/ehs-management-system/ and click on "Inspections" in the *EHS-MS Manual*.

6.2. Compliance and Enforcement

Each individual at the Institute is responsible for complying with all MIT, state, and federal rules, regulations, and required procedures; and is held accountable for their actions. If a PI/Supervisor does not take appropriate action to address problems noted during inspection or audits, he or she may be subject to compliance and enforcement action. Issues of non-compliance will be taken to the DLC EHS

Committee for recommendations regarding disciplinary action. The EHS Committee will provide recommendations to the Department Head for action. Deliberate failure to comply that results in serious jeopardy to personnel safety and health or the environment may result in loss of laboratory privileges.

A framework for establishing consequences for poor EHS performance and incentives for promoting best management practices has been adopted by the Institute. Visit the EHS Management System website for additional detail at https://ehs.mit.edu/about/ehs-management-system/ and click on "Roles and Responsibilities" in the *EHS-MS Manual*.

7. OSHA HAZARD COMMUNICATION STANDARD (HAZCOM)

This Chemical Hygiene Plan also applies to those areas within this Department, Lab, or Center where hazardous chemicals are used that are not laboratory operations. Such spaces include Physics Department Teaching Laboratory-affiliated machine shops and offices of technical staff members. It also applies to the Physics of Living Systems group. All provisions of this Plan apply to these spaces. In addition, for these work areas the PI/Supervisor must

OSHA Hazard Communication Requirements

This Chemical Hygiene Plan also applies to those areas within this Department, Lab, or Center where hazardous chemicals are used that are not laboratory operations. Such spaces include [Note: List operations here such as machine shops, the kitchens for glassware cleaning, etc.]. All provisions of this Plan apply to these spaces. In addition, for these work areas the PI/Supervisor must:

- ❑ Ensure a list of all hazardous chemicals used in the non-laboratory work area is compiled. The list shall include chemical or product name (as found on the label), manufacturer, location of use or storage, and maximum quantity likely to be present at one time during the year. This list must be updated annually, and a copy of the old list submitted to the EHS Office for archiving.
- ❑ Ensure that for each chemical on the list, there is a copy of an SDS or SDS in a notebook readily accessible to all personnel using the chemical. This notebook should be updated annually when the list is updated.
- ❑ Ensure all personnel are informed of the chemical list and the SDS notebook during work area-specific training.

With respect to training, employees and students working in these areas may choose to take *General Chemical Hygiene for Laboratories* or *General HAZCOM* training for non-laboratory areas. They will still need work area-specific training.

With respect to chemical labeling, all potentially hazardous chemicals transferred from their original container to a second container must be labeled with the chemical name and the principal hazard. For more information on labeling, see Part II. Section 6.

Note: Part I, 4 of this document, provides information on changes to the OSHA Hazard Communication Standard that took effect in Spring of 2012, adopting the International Global Harmonization System. This resulted in changes to Safety Data Sheets and chemical labels. Please review that section for more details.

The OSHA hazard communication program reflects the Global Harmonization System (GHS) for classification and labeling of chemicals. Based on OSHA requirements, chemical manufacturers must include the GHS labeling and SDS format for their products, see Appendix 10.3 These unique communication tools help lab members to understand the type of hazards quickly. The GHS labels include hazard pictograms, which are image conveying specific information about the hazards of a chemical, and a signal word, either "Danger" or "Warning." They have standardized language about hazards and precautions, emergency information, and contact information of the manufacturer or distributor.

Nine pictograms are designated for hazard categories under the OSHA. See Appendix 10.4.

8. TOXIC SUBSTANCES CONTROL ACT (TSCA)

The Toxic Substances Control Act (TSCA) is a set of EPA regulations (40 CFR 700-799) designed to assess new chemicals for environmental and health risks before they enter the market, and remove existing chemicals from the market if they pose substantial environmental, health and safety risks. Certain laboratory activities may be regulated under TSCA.

MIT developed a streamlined program for complying with the TSCA New Chemicals Program exemption for Research and Development, TSCA Import and Export requirements, and TSCA Allegations of Adverse Effects and Notification of Substantial Risk Reporting. Note: carbon nanotubes are considered “new chemicals” under TSCA.

Please contact the EHS Office at 617-452-3477 if you:

- Import a chemical substance
- Export a chemical substance
- Synthesize a new chemical substance, in which case you need to determine if that chemical substance is currently in commerce. If the chemical is not currently in commerce, it must be determined if it is regulated by an existing agency; if it is not regulated by an existing agency, the substance falls under TSCA regulation. Additional TSCA requirements may apply.
- Transfer a new chemical substance to another lab outside your own (on campus or to another facility in the US), you need to determine if the chemical substance is regulated under TSCA. If it is, and little to nothing is known about the environmental and/or health effects of that chemical substance, then TSCA requires you to warn other users of that fact. Labeling requirements for containers apply.
- Are working with a <u>known, commercially distributed chemical</u> and experience unusual health effects or observe unusual environmental effects <u>which are not already documented in the environmental, health and safety risk information currently available</u>
- Are involved in an incident or injury involving a new chemical substance for which little or no environmental, health and safety risk information is available.

In addition, the following roles and responsibilities help ensure TSCA compliance:

- Principal Investigators (PIs), as technically qualified individuals with direct supervision over their respective labs, are responsible for ensuring that prudent practices and risk communication are followed in their lab areas; that any experimental efforts and transfer of materials from the lab is consistent with the definition of “research and development activity” outlined in the EHS SOP "Toxic Substances Control Act (TSCA): Procedures for Core Program Compliance" along with the conditions outlined in any research agreements; and, that the Supervisor’s report of Illness and Injury is filed in a timely manner.
- Lab personnel (including PIs) are responsible for following the prudent practices outlined in this Chemical Hygiene Plan; contacting EHS if any of the activities listed above occur; notifying lab mates if they will be handling chemicals for which little or no EHS information is available; and following procedures for reporting incidents/illnesses/injuries.
- The laboratory EHS representative is responsible for either arranging or delivering laboratory-specific chemical hygiene training.
- The Chemical Hygiene Officer is responsible for updating the Department’s Chemical Hygiene Plan; assisting the EHS Coordinator to investigate lab-related incidents/illnesses/injuries; ensuring labs understand chemical risk communication requirements; and forward TSCA-related information to the EHS Office.
- The EHS Coordinator is responsible for reviewing Department training records, and ensuring training is completed on a timely basis.
- The EHS Office is responsible for working with Departments to ensure that any required TSCA forms (Import/Export, Allegations of Adverse Reactions, Notification of Substantial Risk and the TSCA New Chemical Transfer Form) are completed; maintaining TSCA records; ensuring that TSCA compliance requirements are communicated to the Department; and supporting Chemical Hygiene Officers and EHS Coordinators in conducting incident/illness/injury investigations.

9. ANNUAL SARA III CHEMICAL INVENTORY REPORTING

The Superfund Amendments and Reauthorization Act (SARA) Title III regulations were developed by the EPA to deal with the release of hazardous materials into the community, emergency response planning, and community right to know. A section of these regulations requires that all facilities in a community using hazardous chemicals report aggregate quantities greater than the "Threshold Planning Quantity" (TPQ) to local fire departments, the Local Emergency Planning Committee, and the Massachusetts State Department of Environmental Protection. The purpose is to give fire fighters and emergency responders information on what is inside a facility before an emergency occurs.

To comply with this regulation, MIT submits a chemical inventory each year by March 1 that covers both its facilities and laboratory operations. The Chemical Reporter in each laboratory receives a list of applicable chemicals in fall of each year. The quantity of each listed chemical on hand must be inventoried and reported back to the EHS Office. Chemical reporting MUST be done through Atlas or requesting EHS to submit the report for the lab. The EHS Office tabulates the aggregate quantities for the entire campus and reports total amounts and amounts by location to the required authorities. Note that most of the SARA Inventory chemicals are *particularly hazardous substances* (as defined by OSHA). The SARA Inventory Report includes only those chemicals that are in wide use on campus above aggregate TPQs and is most likely only a partial list of all the *particularly hazardous substances* that may be in use in a lab.

The lab is required to maintain a list of all *particularly hazardous substances* in use in their laboratories, including an inventory of the maximum quantity present at any given time. See Part II section 3.3.10 p. 33. For more information please visit https://ehs.mit.edu/chemical-safety-program/chemical-regulatory-reporting-security/

10. APPENDIX

10.1 OSHA Lab Standard 29 CFR 1910.1450

Occupational exposure to hazardous chemicals in laboratories
https://www.osha.gov/laws-regs/regulations/standardnumber/1910/1910.1450

1910.1450(a)
Scope and application.

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

Definitions -

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

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

Carcinogen (see select carcinogen).

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

Chemical Hygiene Plan means a written program developed and implemented by the employer which sets forth procedures, equipment, personal protective equipment and work practices that

(i) are capable of protecting employees from the health hazards presented by hazardous chemicals used in that particular workplace and

(ii) meets the requirements of paragraph (e) of this section.

Designated area means an area which may be used for work with "select carcinogens," reproductive toxins or substances which have a high degree of acute toxicity. A designated area may be the entire laboratory, an area of a laboratory or a device such as a laboratory hood.

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

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

Hazardous chemical means any chemical which is classified as health hazard or simple asphyxiant in accordance with the Hazard Communication Standard (§ 1910.1200).

Health hazard means a chemical that is classified as posing one of the following hazardous effects: Acute toxicity (any route of exposure); skin corrosion or irritation; serious eye damage or eye irritation; respiratory or skin sensitization; germ cell mutagenicity; carcinogenity; reproductive toxicity; specific target organ toxicity (single or repeated exposure); aspiration hazard. The criteria for determining whether a chemical is classified as a health hazard are detailed in appendix A of the Hazard Communication Standard (§ 1910.1200) and § 1910.1200(c) (definition of "simple asphyxiant").

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

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

Laboratory-type hood means a device located in a laboratory, enclosure on five sides with a moveable sash or fixed partial enclosed on the remaining side; constructed and maintained to draw air from the laboratory and to prevent or minimize the escape of air contaminants into the laboratory; and allows chemical manipulations to be conducted in the enclosure without insertion of any portion of the employee's body other than hands and arms.

Walk-in hoods with adjustable sashes meet the above definition provided that 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.

Mutagen means chemicals that cause permanent changes in the amount or structure of the genetic material in a cell. Chemicals classified as mutagens in accordance with the Hazard Communication Standard (§ 1910.1200) shall be considered mutagens for purposes of this section.

Physical hazard means a chemical that is classified as posing one of the following hazardous effects: Explosive; flammable (gases, aerosols, liquids, or solids); oxidizer (liquid, solid, or gas); self reactive; pyrophoric (gas, liquid or solid); self-heating; organic peroxide; corrosive to metal; gas under pressure; in contact with water emits flammable gas; or combustible dust. The criteria for determining whether a chemical is classified as a physical hazard are in appendix B of the Hazard Communication Standard (§ 1910.1200) and § 1910.1200(c) (definitions of "combustible dust" and "pyrophoric gas").

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 mean chemicals that affect the reproductive capabilities including adverse effects on sexual function and fertility in adult males and females, as well as adverse effects on the development of the offspring. Chemicals classified as reproductive toxins in accordance with the Hazard Communication Standard (§ 1910.1200) shall be considered reproductive toxins for purposes of this section.

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.

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

1910.1450(d)
Employee exposure determination -

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

1910.1450(d)(2)

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

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

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

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

1910.1450(e)(1)
Where hazardous chemicals as defined by this standard are used in the workplace, the employer shall develop and carry out the provisions of a written Chemical Hygiene Plan which is:
1910.1450(e)(1)(i)
Capable of protecting employees from health hazards associated with hazardous chemicals in that laboratory and
1910.1450(e)(1)(ii)
Capable of keeping exposures below the limits specified in paragraph (c) of this section.
1910.1450(e)(2)
The Chemical Hygiene Plan shall be readily available to employees, employee representatives and, upon request, to the Assistant Secretary.
1910.1450(e)(3)
The Chemical Hygiene Plan shall include each of the following elements and shall indicate specific measures that the employer will take to ensure laboratory employee protection;
1910.1450(e)(3)(i)
Standard operating procedures relevant to safety and health considerations to be followed when laboratory work involves the use of hazardous chemicals;
1910.1450(e)(3)(ii)
Criteria that the employer will use to determine and implement control measures to reduce employee exposure to hazardous chemicals including engineering controls, the use of personal protective equipment and hygiene practices; particular attention shall be given to the selection of control measures for chemicals that are known to be extremely hazardous;
1910.1450(e)(3)(iii)
A requirement that fume hoods and other protective equipment are functioning properly and specific measures that shall be taken to ensure proper and adequate performance of such equipment;
1910.1450(e)(3)(iv)
Provisions for employee information and training as prescribed in paragraph (f) of this section;
1910.1450(e)(3)(v)
The circumstances under which a particular laboratory operation, procedure or activity shall require prior approval from the employer or the employer's designee before implementation;
1910.1450(e)(3)(vi)
Provisions for medical consultation and medical examinations in accordance with paragraph (g) of this section;
1910.1450(e)(3)(vii)
Designation of personnel responsible for implementation of the Chemical Hygiene Plan including the assignment of a Chemical Hygiene Officer, and, if appropriate, establishment of a Chemical Hygiene Committee; and
1910.1450(e)(3)(viii)
Provisions for additional employee protection for work with particularly hazardous substances. These include "select carcinogens," reproductive toxins and substances which have a high degree of acute toxicity. Specific consideration shall be given to the following provisions which shall be included where appropriate:

1910.1450(e)(3)(viii)(A)
Establishment of a designated area;
1910.1450(e)(3)(viii)(B)
Use of containment devices such as fume hoods or glove boxes;
1910.1450(e)(3)(viii)(C)
Procedures for safe removal of contaminated waste; and
1910.1450(e)(3)(viii)(D)
Decontamination procedures.
1910.1450(e)(4)
The employer shall review and evaluate the effectiveness of the Chemical Hygiene Plan at least annually and update it as necessary.

1910.1450(f)
Employee information and training.

1910.1450(f)(1)
The employer shall provide employees with information and training to ensure that they are apprised of the hazards of chemicals present in their work area.
1910.1450(f)(2)
Such information shall be provided at the time of an employee's initial assignment to a work area where hazardous chemicals are present and prior to assignments involving new exposure situations. The frequency of refresher information and training shall be determined by the employer.
1910.1450(f)(3)

Information. Employees shall be informed of:

1910.1450(f)(3)(i)
The contents of this standard and its appendices which shall be made available to employees;
1910.1450(f)(3)(ii)
The location and availability of the employer's Chemical Hygiene Plan;

1910.1450(f)(3)(iii)
The permissible exposure limits for OSHA regulated substances or recommended exposure limits for other hazardous chemicals where there is no applicable OSHA standard;
1910.1450(f)(3)(iv)
Signs and symptoms associated with exposures to hazardous chemicals used in the laboratory; and
1910.1450(f)(3)(v)
The location and availability of known reference material on the hazards, safe handling, storage and disposal of hazardous chemicals found in the laboratory including, but not limited to, safety data sheets received from the chemical supplier.
1910.1450(f)(4)

Training.

1910.1450(f)(4)(i)
Employee training shall include:
1910.1450(f)(4)(i)(A)
Methods and observations that may be used to detect the presence or release of a hazardous chemical (such as monitoring conducted by the employer, continuous monitoring devices, visual appearance or odor of hazardous chemicals when being released, etc.);
1910.1450(f)(4)(i)(B)
The physical and health hazards of chemicals in the work area; and
1910.1450(f)(4)(i)(C)
The measures employees can take to protect themselves from these hazards, including specific procedures the employer has implemented to protect employees from exposure to hazardous chemicals, such as appropriate work practices, emergency procedures, and personal protective equipment to be used.

1910.1450(f)(4)(ii)
The employee shall be trained on the applicable details of the employer's written Chemical Hygiene Plan.

1910.1450(g)
Medical consultation and medical examinations.

1910.1450(g)(1)
The employer shall provide all employees who work with hazardous chemicals an opportunity to receive medical attention, including any follow-up examinations which the examining physician determines to be necessary, under the following circumstances:
1910.1450(g)(1)(i)
Whenever an employee develops signs or symptoms associated with a hazardous chemical to which the employee may have been exposed in the laboratory, the employee shall be provided an opportunity to receive an appropriate medical examination.
1910.1450(g)(1)(ii)
Where exposure monitoring reveals an exposure level routinely above the action level (or in the absence of an action level, the PEL) for an OSHA regulated substance for which there are exposure monitoring and medical surveillance requirements, medical surveillance shall be established for the affected employee as prescribed by the particular standard.
1910.1450(g)(1)(iii)
Whenever an event takes place in the work area such as a spill, leak, explosion or other occurrence resulting in the likelihood of a hazardous exposure, the affected employee shall be provided an opportunity for a medical consultation. Such consultation shall be for the purpose of determining the need for a medical examination.
1910.1450(g)(2)
All medical examinations and consultations shall be performed by or under the direct supervision of a licensed physician and shall be provided without cost to the employee, without loss of pay and at a reasonable time and place.

1910.1450(g)(3)
Information provided to the physician. The employer shall provide the following information to the physician:

1910.1450(g)(3)(i)
The identity of the hazardous chemical(s) to which the employee may have been exposed;
1910.1450(g)(3)(ii)
A description of the conditions under which the exposure occurred including quantitative exposure data, if available; and
1910.1450(g)(3)(iii)
A description of the signs and symptoms of exposure that the employee is experiencing, if any.

1910.1450(g)(4)
Physician's written opinion.

1910.1450(g)(4)(i)
For examination or consultation required under this standard, the employer shall obtain a written opinion from the examining physician which shall include the following:
1910.1450(g)(4)(i)(A)
Any recommendation for further medical follow-up;
1910.1450(g)(4)(i)(B)
The results of the medical examination and any associated tests;
1910.1450(g)(4)(i)(C)
Any medical condition which may be revealed in the course of the examination which may place the employee at increased risk as a result of exposure to a hazardous chemical found in the workplace; and

1910.1450(g)(4)(i)(D)

A statement that the employee has been informed by the physician of the results of the consultation or medical examination and any medical condition that may require further examination or treatment.
1910.1450(g)(4)(ii)
The written opinion shall not reveal specific findings of diagnoses unrelated to occupational exposure.

1910.1450(h)
Hazard identification.

1910.1450(h)(1)
With respect to labels and safety data sheets:
1910.1450(h)(1)(i)
Employers shall ensure that labels on incoming containers of hazardous chemicals are not removed or defaced.
1910.1450(h)(1)(ii)
Employers shall maintain any safety data sheets that are received with incoming shipments of hazardous chemicals, and ensure that they are readily accessible to laboratory employees.
1910.1450(h)(2)
The following provisions shall apply to chemical substances developed in the laboratory:
1910.1450(h)(2)(i)
If the composition of the chemical substance which is produced exclusively for the laboratory's use is known, the employer shall determine if it is a hazardous chemical as defined in paragraph (b) of this section. If the chemical is determined to be hazardous, the employer shall provide appropriate training as required under paragraph (f) of this section.
1910.1450(h)(2)(ii)
If the chemical produced is a byproduct whose composition is not known, the employer shall assume that the substance is hazardous and shall implement paragraph (e) of this section.
1910.1450(h)(2)(iii)
If the chemical substance is produced for another user outside of the laboratory, the employer shall comply with the Hazard Communication Standard (29 CFR 1910.1200) including the requirements for preparation of safety data sheets and labeling.
1910.1450(i)
Use of respirators. Where the use of respirators is necessary to maintain exposure below permissible exposure limits, the employer shall provide, at no cost to the employee, the proper respiratory equipment. Respirators shall be selected and used in accordance with the requirements of 29 CFR 1910.134.

1910.1450(j)
Recordkeeping.

1910.1450(j)(1)
The employer shall establish and maintain for each employee an accurate record of any measurements taken to monitor employee exposures and any medical consultation and examinations including tests or written opinions required by this standard.
1910.1450(j)(2)
The employer shall assure that such records are kept, transferred, and made available in accordance with 29 CFR 1910.20.

1910.1450(k)
[Reserved]
1910.1450(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.

10.2 DHS List 41 Chemicals With Low Threshold Reporting Quantities That Require Prior Approval From The DLC EHS Coordinator or DLC EHS Committee Before Purchasing

Chemical of Interest	Synonym	Chemical Abstract Service (CAS) Number	Screening Threshold Quantity (lbs)
1,4-bis(2-chloroethylthio)-n-butane		142868-93-7	100g
bis(2-chloroethylthio)methane		63869-13-6	100g
bis(2-chloroethylthioethyl)ether		63918-89-8	100g
1,5-bis(2-chloroethylthio)-n-pentane		142868-94-8	100g
1,3-bis(2-chloroethylthio)-n-propane		63905-10-2	100g
2-chloroethylchloromethylsulfide		2625-76-5	100g
Chlorosarin		1445-76-7	100g
Chlorosoman		7040-57-5	100g
DF	Methyl phosphonyl difluoride	676-99-3	100g
N,N-(2-diethylamino)ethanethiol		100-38-9	2.2
o,o-Diethyl S-[2-(diethylamino)ethyl] phosphorothiolate		78-53-5	2
Diethyl methylphosphonate		15715-41-0	2
N,N-Diethyl phosphoramidic dichloride		1498-54-0	2
N,N-(2-diisopropylamino)ethanethiol		5842-07-9	2
N,N-Diisopropyl phosphoramidic dichloride		23306-80-1	2
N,N-(2-dimethylamino)ethanethiol		108-02-1	2
N,N-Dimethyl phosphoramidic dichloride		677-43-0	2
N,N-(2-dipropylamino)ethanethiol		5842-06-8	2
Ethyl phosphonyl difluoride		753-98-0	100g
Ethylphosphonothioic dichloride		993-43-1	2
HN1 (nitrogen mustard-1)	Bis(2-chloroethyl)ethylamine	538-07-8	100g

HN2 (nitrogen mustard-2)	Bis(2-chloroethyl)methylamine	51-75-2	100g
HN3 (nitrogen mustard-3)	Tris(2-chloroethyl)amine	555-77-1	100g
Isopropylphosphonothioic dichloride		1498-60-8	2
Isopropylphosphonyl difluoride		677-42-9	100g
Lewisite 1	2-Chlorovinyldichloroarsine	541-25-3	100g
Lewisite 2	Bis (2-Chlorovinyl)chloroarsine	40334-69-8	100g
Lewisite 3	Tris (2-Chlorovinyl)chloroarsine	40334-70-1	100g
Methylphosphonothiotic dichloride		676-98-2	2
Sulfur Mustard (mustard gas (H))	Bis (2-chloroethyl) sulfide	505-60-2	100g
O-Mustard (T)	Bis (2-chlorothioethyl) ether	63918-89-8	100g
Nitrogen mustard hydrochloride	Bis (2-chloroethyl)methylamine hydrochloride	55-86-7	2
Propylphosphonothiotice dichloride		2524-01-8	2
Propylphosphonyl difluoride		690-14-2	100g
Sarin	o-Isopropyl methylphosphonofluoridate	107-44-8	100g
Sesquimustard	1,2-Bis(2-chloroethylthio) ethane	3563-36-8	100g
Soman	o-Pinacolyl methylphosphonofluoridate	96-64-0	100g
Tabun	o-Ethyl-N,N-dimethylphosphoramido-cyanidate	77-81-6	100g
Thiodiglycol		111-48-8	2
VX	o-ethyl-S-2-diisopropylaminoethyl methyl phosphonothiolate	50782-69-9	100g

10.3 Hazard Communication Safety Data Sheets – New Format

Taken from OSHA website at:
http://www.osha.gov/Publications/HazComm_QuickCard_SafetyData.html

Hazard Communication Safety Data Sheets – New Format

The Hazard Communication Standard (HCS) requires chemical manufacturers, distributors, or importers to provide Safety Data Sheets (SDSs) (formerly known as Safety Data Sheets or SDSs) to communicate the hazards of hazardous chemical products. As of June 1, 2015, the HCS will require new SDSs to be in a uniform format, and include the section numbers, the headings, and associated information under the headings below:

- **Section 1, Identification** includes product identifier; manufacturer or distributor name, address, phone number; emergency phone number; recommended use; restrictions on use.
- **Section 2, Hazard(s) identification** includes all hazards regarding the chemical; required label elements.
- **Section 3, Composition/information on ingredients** includes information on chemical ingredients; trade secret claims.
- **Section 4, First-aid measures** includes important symptoms/ effects, acute, delayed; required treatment.
- **Section 5, Fire-fighting measures** lists suitable extinguishing techniques, equipment; chemical hazards from fire.
- **Section 6, Accidental release measures** lists emergency procedures; protective equipment; proper methods of containment and cleanup.
- **Section 7, Handling and storage** lists precautions for safe handling and storage, including incompatibilities.
- **Section 8, Exposure controls/personal protection** lists OSHA's Permissible Exposure Limits (PELs); Threshold Limit Values (TLVs); appropriate engineering controls; personal protective equipment (PPE).
- **Section 9, Physical and chemical properties** lists the chemical's characteristics.
- **Section 10, Stability and reactivity** lists chemical stability and possibility of hazardous reactions.
- **Section 11, Toxicological information** includes routes of exposure; related symptoms, acute and chronic effects; numerical measures of toxicity.
- Section 12, Ecological information*
- Section 13, Disposal considerations*
- Section 14, Transport information*
- Section 15, Regulatory information*
- **Section 16, Other information,** includes the date of preparation or last revision.

*Note: Since other Agencies regulate this information, OSHA will not be enforcing Sections 12 through 15(29 CFR 1910.1200(g)(2)).

This is the new standard format for what will now be called Safety Data Sheets, not Safety Data Sheets. More details about content are at http://www.osha.gov/dsg/hazcom/index.html. Some chemical suppliers are already using this format. If you have questions about information or interpretation, contact the MIT EHS Office at 617-452-3477 or environment@mit.edu.

10.4 Hazard Communication Standard Pictogram

Taken from OSHA website at: http://www.osha.gov/Publications/HazComm_QuickCard_Pictogram.html

HCS Pictograms and Hazards

The Hazard Communication Standard (HCS) require pictograms on labels to alert users of the chemical hazards to which they may be exposed. Each pictogram consists of a symbol on a white background framed within a red border and represents a distinct hazard(s). The pictogram on the label is determined by the chemical hazard classification.

Health Hazard  • Carcinogen • Mutagenicity • Reproductive Toxicity • Respiratory Sensitizer • Target Organ Toxicity • Aspiration Toxicity	**Flame**  • Flammables • Pyrophorics • Self-Heating • Emits Flammable Gas • Self-Reactives • Organic Peroxides	**Exclamation Mark**  • Irritant (skin and eye) • Skin Sensitizer • Acute Toxicity (harmful) • Narcotic Effects • Respiratory Tract Irritant • Hazardous to Ozone Layer (Non-Mandatory)
Gas Cylinder  • Gases Under Pressure	**Corrosion**  • Skin Corrosion/ Burns • Eye Damage • Corrosive to Metals	**Exploding Bomb**  • Explosives • Self-Reactives • Organic Peroxides
Flame Over Circle  • Oxidizers	**Environment** (Non-Mandatory)  • Aquatic Toxicity	**Skull and Crossbones**  • Acute Toxicity (fatal or toxic)