



MASSACHUSETTS INSTITUTE OF TECHNOLOGY

# Chemical Hygiene Plan

Effective April 1, 2011

Research Laboratory of Electronics



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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 within MIT's Research Laboratory of Electronics 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 MIT'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 is located on-line at <http://www.rle.mit.edu/ehs/> and can also be accessed by contacting EHS Coordinator Dan Herrick ([herrickd@mit.edu](mailto:herrickd@mit.edu), x3-2338). This Plan applies to all laboratories in the Research Laboratory of Electronics, and to all personnel who supervise or work in these labs. For the Research Laboratory of Electronics, 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.

### 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** contains standard operating procedures generated by the Department, Laboratory, or Center 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 to customize this Chemical Hygiene Plan for their specific operations and hazards. A Standard Operating Procedure (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 objective.

### **2.1 The DEPARTMENT, LAB, or CENTER CHAIR**

The DIRECTOR of the Research Laboratory of Electronics (Professor Jeffrey Shapiro) 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 OFFICER for the Research Laboratory of Electronics (RLE) is Mary Market Murphy. The Chemical Hygiene Officer shall:

- A. Know and understand the requirements of the OSHA Laboratory Standard regulation (29CFR 1910.1450) and the RLE Chemical Hygiene Plan.
- B. Oversee the implementation of the CHP in RLE 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 RLE 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.
- J. Assist PI/Supervisors, as needed, with obtaining services or supplies and equipment for correcting chemical hygiene problems or addressing chemical hygiene needs.
- K. Ensure periodic exposure monitoring requirements are met and maintain monitoring records.
- L. If requested, review proposed experiments for significant environment, health, and safety issues, and/or contact the EHS Office to address concerns.
- M. Co-Chair the DLC-EHS Committee with the EHS Coordinator.
- N. Attend annual CHO meeting conducted by the EHS Office.

### **2.3. The EHS COORDINATOR**

The ENVIRONMENT, HEALTH AND SAFETY (EHS) COORDINATORS for the Research Laboratory of Electronics are Al McGurl and Dan Herrick. The EHS Coordinators 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 receive 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. 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, Standard Operating Procedures (SOPs) for research activities involving hazardous chemicals, when needed. See Part II. Section 3 for more information on when additional 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.
- C. Ensure new processes or experiments involving hazardous materials are planned carefully and appropriate hazard information, safety equipment, and SOPs are available prior to commencing work. Always seek to minimize the amount of hazardous chemicals purchased and used for experiments or processes.
- D. 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.
- E. 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.
- F. 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.
- G. 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.
- H. 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.

- I. 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.
- J. 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.
- K. Ensure employees who suspect they may have received an excessive exposure to a hazardous chemical report to the MIT Medical Department for assessment. Such exposures may occur through accidental inoculation, ingestion, or inhalation of the chemical.
- L. 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.
- M. 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.
- N. Ensure unwanted or excess hazardous chemicals and materials are properly disposed according to all MIT, state, and federal procedures.
- O. Assist the EHS Office, EHS Coordinator, and CHO as requested.
- P. 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.

## **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/site/content/chemical-hygiene-program>) 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 standard operating procedures (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 RLE-specific accidents and incidents, as appropriate, to the RLE EHS Coordinator.

## **2.7. EMPLOYEES, STAFF, STUDENTS**

Employees, staff, students, and visitors working with or around hazardous chemicals in a laboratory shall:

- 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, MINORS, TOURS and PETS

To ensure the health and safety of visitors, minors and tours to laboratories where potential hazards may exist guidelines should be followed which can be found in an EHS SOPs titled Visitors and Tours Guideline # EHS-0036 and Minors and Pets in Laboratories, and other areas using or storing hazardous materials # EHS-0069 both located at <http://ehs.mit.edu/site/sops>

Please note that there are special requirements for individuals who wish to work in laboratories who are under the age of 18 and are not MIT students (eg, high school students during the summer). Please contact EHS Coordinator Dan Herrick ([herrickd@mit.edu](mailto:herrickd@mit.edu); 3-2338) for assistance with this process.

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. The exception is for service dogs, police dogs and animals used in research and teaching. Additional guidance can be found in EHS SOP # EHS-0069 mentioned above.

## 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 <http://ehs.mit.edu/site/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 <http://ehs.mit.edu/site/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. See <https://meche.mit.edu/resources/ehs/> for the departmental web-based confirmation form.
- C. Lab-Specific Chemical Hygiene Training** – provided by the Principal Investigator, lab EHS Representative, or his or her designee on lab-specific 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. Other non-chemical topics may be covered (laser safety, biosafety, emergency preparedness) and 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”.
- 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.

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

#### Material Safety Data Sheets (MSDSs)

Material Safety Data Sheets (MSDSs) 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. MSDSs also provide information about first aid, emergency procedures, and waste disposal.

An MSDS 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 MSDS 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 MSDS 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	

MSDSs 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 MSDSs. This list can be accessed at <http://ehs.mit.edu/site/content/msds-and-chemical-safety-information> . Alternately, [Google](#) “name of substance” is often the simplest way to pull up MSDSs.
- 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 MSDSs 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 MSDS information.

### **Newly Synthesized Chemicals and 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 a Material Safety Data Sheet for each synthesized substance and labeling of containers containing the chemical substance.

### **Laboratory Chemical Safety Summaries (LCSS)**

The LCSSs 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.

### **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 complete and accurate chemical waste labels.

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

#### **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) is 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 standard operating procedures 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 development of SOPs is an essential administrative tool to be used in the laboratory and is a tool that is required by the OSHA Laboratory Standard.

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 standard operating procedures 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 written standard operating procedures 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. SOPs must be developed prior to initiating any significantly hazardous procedures. Please discuss initiation of any significantly hazardous procedures with your PI, EHS Rep, and EHS Coordinator to establish safe procedures and draft an SOP if needed.

Guidelines and a template for preparing SOPs when required as noted above, are contained in Part III. of this Plan. A copy of all 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 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 eye exposure, symptoms include pain, blood shot eyes, tearing, and blurring of vision. For skin exposure, symptoms 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 for assistance before contemplating use.

## **2.6. Hazardous Substances with Toxic Effects on Specific Organs**

Substances included in this category include

- hepatotoxins: substances that produce liver damage such as nitrosamines and carbon tetrachloride.
- nephrotoxins: agents causing damage to the kidneys such as certain halogenated hydrocarbons.
- neurotoxins: substances which produce their primary toxic effects on the nervous system such as mercury, acrylamide, and carbon disulfide.
- agents which act on the hematopoietic system such as carbon monoxide and cyanides which decrease hemoglobin function and deprive the body tissues of oxygen.
- 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 a list of PHSs, see <http://ehs.mit.edu/site/content/particularly-hazardous-substance-review-160-mit-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/m<sup>3</sup>;
  - 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 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)

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

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 affects 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 Material 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<sub>50</sub>) values in the following ranges:

Test	Toxic	Highly Toxic
Oral LD <sub>50</sub> (albino rats)	50-500 mg/kg	<50 mg/kg
Skin Contact LD <sub>50</sub> (albino rabbits)	200-1000 mg/kg	<200 mg/kg
Inhalation LC <sub>50</sub> (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<sub>50</sub> 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 MSDSs. LD<sub>50</sub> values can be found in MSDSs 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	nitrogen dioxide
acrolein	osmium tetroxide
arsine	ozone
chlorine	phosgene
diazomethane	ricin
diborane (gas)	sodium azide
hydrogen cyanide	sodium cyanide (and other cyanide salts)
hydrogen fluoride	strychnine
methyl fluorosulfonate	
nickel carbonyl	

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.

## 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 due to high acute toxicity, carcinogenicity, and/or reproductive toxicity. If so, 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. Use this information to determine whether it is appropriate to apply the “Additional Procedures for Work with Particularly Hazardous Substances” outlined in Part II. Section 3.3. For very toxic or hazardous substances, or specialized practices, consideration must be given to whether additional consultation with safety professionals and development of specialized SOPs is warranted or required.

#### **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 MSDS 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 by using MIT's Green Chemical Alternative Wizard at <http://ehs.mit.edu/site/content/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 MSDS, 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 type 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 <http://ehs.mit.edu/site/content/respiratory-protection>

**B. Personal Protective Equipment For Eyes and Skin**

*Note: More details regarding RLE 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. Certain laboratories and shops within RLE require eye protection at all times 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 in the laboratory when working with hazardous substances.**

Wear shoes that cover your feet while working in any lab – **no flip-flops, sandals, or open-toed shoes**. Wear clothing that fully covers your legs and arms when handling hazardous chemicals. As noted in 4. below: “A laboratory coat is required for work with particularly hazardous substances

(PHS's), unsealed radioactive materials, and biological agents at BL2 or greater. It is strongly advised that researchers wear a laboratory coat when working with hazardous substances. In some cases laboratory supervisors may identify situations where the use of lab coats or more protective apparel is *mandatory*." Confine long hair and loose clothing.

**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. 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. Most gloves come in more than one size; evaluate the size you need and ensure gloves of that size are available in your laboratory.

You should also evaluate need for hand protection from physical hazards like extreme heat (such as removing materials from a furnace or autoclave) or cold (such as use of cryogenics), and make sure you use appropriate gloves.

Please contact the EHS Office or your EHS Coordinator if you have questions about selecting the proper gloves.

- ❑ 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 <http://ehs.mit.edu/site/content/personal-protective-equipment-ppe>

## 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 including fire blankets, 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 all accidents requiring emergency police, fire, or medical response, 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 [http://ehs.mit.edu/site/emergency\\_management](http://ehs.mit.edu/site/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.

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

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*.

### B. Material Safety Data Sheets (MSDS)

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

**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 clean up 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 is spilled in large quantity, 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 clean up 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 and safety equipment such as fire extinguishers, eyewashes, and safety showers. Do not store materials in a way that will block access to exits or safety equipment.
- Ensure all compressed gas tanks are properly secured to walls or benches.
- Chemical storage refrigerators should be defrosted periodically and should not be overcrowded.

#### **3.2.3. Avoid work conducted outside normal hours.**

**Researchers should avoid conducting work with hazardous substances when they are alone in the laboratory.** When working alone, arrange with Campus Police or workers in other laboratories to check on you periodically. Some experiments are too hazardous to be conducted alone under any circumstances; it is the responsibility of researchers to consult with their supervisor to identify such high hazard operations or experiments.

Laboratory operations involving hazardous substances are sometimes carried out continuously or overnight. It is the responsibility of the researcher to design these 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 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 left indicating how to contact you in the event of an emergency.

#### **3.2.4. Discourage children and pets in laboratories.**

Prudent safety practices discourage allowing children and pets in laboratories where hazardous substances are stored or are in use. In fact, regulations prohibit pets from certain biosafety-rated laboratories. It is therefore urged that children and pets 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: [http://ehs.mit.edu/site/chem\\_storage](http://ehs.mit.edu/site/chem_storage) and the standard operating procedure (SOP) on Chemical Storage at <http://ehs.mit.edu/site/sops> 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 and other peroxide-forming compounds, see 3.2.9), 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. For flammable or explosive chemicals, special refrigerators are required. See flammables and explosives section below. 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 peroxidizable 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.
- ❑ Use or dispose of peroxides within time limits recommended on the label or MSDS.
- ❑ 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.
- ❑ 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.

Segregate acids from bases. Segregate oxidizing acids, such as nitric acid from organic acids, such as acetic acid.

- ❑ Store by compatibility.
- ❑ Segregate acids from bases, and 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
- ❑ Seek medical attention immediately in the event of a potentially injurious exposure.

### 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. Appendix II-C 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 accidental skin contact, the affected areas should be flushed with water and medical attention should be obtained as soon as possible.

#### 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 than 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.**

Every research group in the department should 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. EHS Representatives or another designee should 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*. Note that this will automatically be done by complying with the MIT requirement of each lab having an inventory of **all** hazardous chemicals.

### **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 <http://ehs.mit.edu/site/content/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 standard operating procedure (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 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 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 HF 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 treated at 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 (<http://ehs.mit.edu/site/training>) to register 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 at 617-452-3477.

**Within RLE, all work involving HF-containing materials must include a written SOP. This SOP must be reviewed by the EHS Coordinator prior to starting work with HF.**

### 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 substances* 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: <http://ehs.mit.edu/site/content/working-safely-nanomaterials>

This article also lists good reference sources for researchers to consult to keep up with toxicity information on their materials as it develops. Currently, nanoparticles and solutions containing them are being disposed of as hazardous waste. Please call the EHS Office at 617-253-0344 for exposure evaluation of experimental setups and additional information. \*Label all containers of nanomaterials (including waste) with the designation "nano".

## 4. PERSONAL PROTECTIVE EQUIPMENT

Personal protective equipment (PPE), including 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. 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 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 <http://ehs.mit.edu/site/content/personal-protective-equipment-ppe>

**4.1 Laboratory coats.** The MIT Committee on Toxic Chemicals has established the following policy with respect to laboratory coats: "A laboratory coat is **required** for work with particularly hazardous substances (PHS's), unsealed radioactive materials, and biological agents at BL2 or greater. It is strongly advised that researchers wear a laboratory coat when working with hazardous substances. In some cases laboratory supervisors may identify situations where the use of lab coats or more protective apparel is *mandatory*." The Guidance Document "Laboratory Coat Selection, Use, and Care" at <http://ehs.mit.edu/site/content/clothing-such-lab-coats-smocks-and-coveralls-personal-protection>

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.

**4.2 Eye Protection:** The MIT 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 determination of the level of eye protection required for each laboratory room shall be made by **the principal investigator** in charge of the laboratory or supervisor in charge of the work area, in consultation with and with the approval of the DLC EHS Coordinator. 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.

In the Research Laboratory of Electronics, safety glasses must be worn at all times when working with any chemicals and while performing any procedure or working with any equipment that has the potential to cause eye damage. Specific Laser Safety Glasses must always be worn in laboratories where lasers are in use. It is mandatory that safety glasses be worn whenever laboratory Standard Operating Procedures call for eye protection or when directed by the Principal Investigator (PI) of the laboratory.

Hazard assessments have been conducted in RLE to determine the eye protection required in all labs. In many cases (but not all) these assessments are documented on PPE Requirements signage which are printed on yellow paper, reviewed and signed by the PI, and posted in the laboratories.

Procedures regarding Personal Protective Equipment, including Eye Protection, are reviewed with each new member of each lab as part of their initial Lab Specific Chemical Hygiene Training. PPE is also covered in the annual Lab Specific refresher training.

When new experiments or procedures are introduced to the lab, an assessment of hazards for this particular experiment or procedure is made and the signage is updated. Personnel are informed of any changes.

The EHS Office Guidance Document “Eye Protection in Laboratories Assessment, Selection, Use and Maintenance” is used to guide eye protection selection. It is available at: <http://ehs.mit.edu/site/sites/default/files/files/EyeProtectionGuidance.pdf>

All personnel in the lab must be provided safety glasses. The procedure for obtaining prescription glasses is described at: <http://ehs.mit.edu/site/content/prescription-safety-glasses>. Eye protection provided shall meet the requirements of ANSI 787.1 – 1989, or equivalent.

Other eye protection such as goggles or faceshields must be available where it is needed (for example, use of cryogenic materials or when splash potential is high). Guidance for assessing the level of additional eye protection required is available at: <http://ehs.mit.edu/site/content/eye-and-face-protection>

Visitor glasses should be provided in individual lab spaces for visitors to the lab.

If you are concerned that your labmates are not wearing the required eye protection, discuss it with your EHS Rep, EHS Coordinator, and PI. The PI is responsible for enforcing eye protection requirements.

## 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 adsorbers).

*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 <http://ehs.mit.edu/site/content/fume-hoodslaboratory-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 personnel are not required to extinguish fires that occur in their work areas. Researchers are not permitted to use fire extinguishers unless they have attended a Fire Extinguisher Training Session presented by the MIT EHS Office. Refer to MIT's standard operating procedure on Portable Fire Extinguishers available at <http://ehs.mit.edu/site/sops> Any time a fire extinguisher is used, no matter for how brief a period, it should be inspected and recharged.

### 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)). The EHS Representative, as part of the Weekly Level I Inspection, should check eyewashes once a week by running the water for one minute. This will ensure proper operation of the eyewash unit and flush out any bacteria that grow in the stagnant water or any rust buildup in piping. If an eyewash or safety shower needs to be tested or repaired, call the Department of Facilities and give the operator the location of the defective equipment and (for safety showers) the number on the blue preventive maintenance tag.

Facilities tests safety showers at least once per year. Lab personnel should not test safety showers.

## 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 rooms unless the cold room has 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 sublimates, 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 <http://ehs.mit.edu/site/content/warm-and-cold-environmental-rooms-safe-use> .

## 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.

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 <http://ehs.mit.edu/site/sops>. Refer also to <http://ehs.mit.edu/site/content/compressed-gases-gas-cylinders> for securing 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

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 <http://ehs.mit.edu/site/content/chemical-waste-collection-form> ).

#### 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 <http://ehs.mit.edu/site/content/chemical-waste-collection-form> 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. As of Jan 2011, RLE does not have any 90 Day Storage Areas.

## **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.

The EHS Representative, as part of the Weekly Level I Inspection, should inspect any Satellite Accumulation Areas in their areas of responsibility and correct any issues immediately.

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, biohazardous, or hazardous chemical contaminants. In addition any waste material contaminated with radioactive, biohazardous 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: <http://ehs.mit.edu/site/content/lab-waste-stream-fact-sheet>

Some of these waste streams are detailed below:

Radioactive waste disposal is handled in accordance with procedures established by the EHS Office Radiation Protection Program (617-452-3477). Wastes marked as radioactive *must not be sent to the waste chemical storage area*.

Biological waste is handled in accordance with procedures set forth by the EHS Office Biosafety Program (617-452-3477). Wastes marked as biohazardous *must not be sent to the waste chemical storage area*. In RLE, biohazardous liquids are collected by the lab, neutralized with a bleach solution, and disposed. Non-sharp biohazardous solids are generally disposed in a burn box. Sharp biohazardous waste **MUST** be placed in a biosharps bin and collected by EHS.

Sharps waste - chemically contaminated must be packaged in puncture proof containers and must be labeled as Hazardous Waste with the chemical contaminants listed. Containers must be managed in accordance with hazardous waste regulations. *Chemically contaminated sharps waste must not be packaged in Biohazard containers*.

Sharps waste - biohazardous and infectious must be packaged in puncture proof containers and is handled in accordance with procedures set forth by the Environmental Management Program (617-452-3477). *All non-chemically contaminated sharps waste originating from a Biosafety Level (BL) rated laboratory is considered to be biohazardous*.

Sharps waste – clean needles and syringes are considered to be “medical waste” and must be packaged in puncture proof containers. No tags are needed, but the laboratory building, room number, and PI/Supervisor’s name must be marked on the container. If the lab produces a large volume of needles and syringes, a container will be provided and a regular pick-up schedule will be arranged.

Sharps waste – cleaned and rinsed glass bottles, glassware, broken glass, wires, razor blades, tooth picks and other sharps from non-BL rated laboratories shall be collected in a in a VWR vendor glass box or other sturdy puncture resistant cardboard or plastic container. Any chemical labels must be defaced. Mark the box “clean broken glass” and note the laboratory building, room number, and PI/Supervisor’s name. When full, tape shut and secure. Place containers in the hall. Custodians will pick up. If there are any problems or questions, contact the EHS Office. *This waste shall contain no chemical, radioactive, biological or hazardous waste residue*.

#### 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® /Cetylcode 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 <sup>3+</sup>	Borate, BO <sub>3</sub> <sup>3-</sup> , B <sub>4</sub> O <sub>7</sub> <sup>2-</sup>
Ammonium, NH <sub>4</sub> <sup>+</sup>	Bromide, Br <sup>-</sup>
Calcium, Ca <sup>2+</sup>	Carbonate, CO <sub>3</sub> <sup>2-</sup>
Cesium, Cs <sup>+</sup>	Chloride, Cl <sup>-</sup>
Iron, Fe <sup>+</sup>	Bicarbonate, HCO <sub>3</sub> <sup>-</sup>
Lithium, Li <sup>+</sup>	Bisulfite, HSO <sub>3</sub> <sup>-</sup> , Bisulfate, HSO <sub>4</sub> <sup>-</sup>
Magnesium, Mg <sup>2+</sup>	Fluoride, F <sup>-</sup>
Manganese, Mn <sup>2+</sup> , Mn <sup>3+</sup> , Mn <sup>4+</sup> , Mn <sup>7+</sup>	Hydroxide, OH <sup>-</sup>
Potassium, K <sup>+</sup>	Iodide, I <sup>-</sup>
Sodium, Na <sup>+</sup>	Nitrate, NO <sub>3</sub> <sup>-</sup> , Nitrite, NO <sub>2</sub> <sup>-</sup>
Strontium, Sr <sup>2+</sup>	Oxide, O <sup>2-</sup>
Tin, Sn <sup>2+</sup>	Phosphate, PO <sub>4</sub> <sup>3-</sup>
Titanium, Ti <sup>3+</sup> , Ti <sup>4+</sup>	Sulfate, SO <sub>4</sub> <sup>2-</sup> , Sulfide, SO <sub>3</sub> <sup>2-</sup>
Zirconium, Zr <sup>2+</sup>	Thiosulfate, S <sub>2</sub> O <sub>3</sub> <sup>2-</sup>

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 <http://hazmat.dot.gov/>.

**Individuals affiliated with the Research Laboratory of Electronics who intend to ship any of these types of materials by air or land, domestically or internationally, or convey these items over public roads by Institute or personal vehicles must contact the EHS Office or your EHS Coordinator. Failure to do so is likely to cause refusal or (often excessive) delays in shipment, and may lead to severe fines and criminal penalties.**

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 <http://ehs.mit.edu/site/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 details and guidance regarding shipping hazardous materials and the EHS Office service can be found on the EHS Website at: <http://ehs.mit.edu/site/content/hazardous-materials-shipping-mit>

## 10. APPENDICES

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

Most MSDSs provide PELs for individual chemicals, if a PEL has been established. For a complete list of all PELs, consult the OSHA web site at <http://www.osha.gov/SLTC/pel/>

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

Most MSDSs 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 <http://www.acgih.org/home.htm>.

### 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 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 (<http://ehs.mit.edu/site/content/chemical-hygiene-program>). 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 at <http://www.osha.gov/SLTC/carcinogens/index.html>.

NTP and IARC Carcinogens: The MSDS for an individual chemical frequently lists whether the chemical is an NTP or IARC carcinogen. If not provided on the MSDS, 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: <http://ehp.niehs.nih.gov/roc/toc10.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.

MSDSs will often indicate if the chemical has been found to have reproductive health effects. If there is no information on the MSDS, 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: <http://www.oehha.org/prop65.html>.

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<sub>50</sub> or the LC<sub>50</sub>. The LD<sub>50</sub> is the Lethal Dose that kills 50 percent of the animals when the chemical is given orally or applied to the skin. The LC<sub>50</sub> 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<sub>50</sub> and LC<sub>50</sub> animal tests as follows:

**Compounds with High Degree of Acute Toxicity:**

TEST	TOXIC	HIGHLY TOXIC
Oral LD <sub>50</sub> (albino rats)	50-500 mg/kg	<50 mg/kg
Skin Contact LD <sub>50</sub> (albino rabbits)	200-1000 mg/kg	<200 mg/kg
Inhalation LC <sub>50</sub> (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 MSDSs. If not provided on the MSDS, 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<sub>50</sub> and LC<sub>50</sub> 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. Research Laboratory of Electronics (RLE) Chemical Hygiene Practices**

## **1. INTRODUCTION**

This Part contains policies, procedures or precautions that are required by the Research Laboratory of Electronics (RLE). This Part is provided to enable individual laboratories to customize this Chemical Hygiene Plan for their operations. A template for developing specific Standard Operating Procedures (SOPs) is included in this Part to provide assistance to laboratory personnel generating specific safety procedures.

Additional 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 SOP must be reviewed by the Chemical Hygiene Officer (CHO).

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

## **2. STANDARD OPERATING PROCEDURE (SOP) TEMPLATE INSTRUCTIONS**

### **2.1. SOP Title, Authors, Reviewers and Date**

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 Chemical Hygiene Officer.

### **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.

### **2.3. Chemical Hazards**

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

The description of equipment and instrumentation should be limited to any items utilized to control or monitor specific hazards associated with the material or the operation. Conduct a comprehensive Personal Protective Equipment (PPE) evaluation for the referenced materials or operation. The determination should include both the type of equipment, as well as the clothing materials. The results from this evaluation should be identified by completing the PPE and Clothing tables. Questions regarding the selection or procurement process should be directed to the Chemical Hygiene Officer, EHS Coordinator, or the EHS Office.

#### **2.4. Step by Step Hazard Summary**

This section is appropriate for a procedure involving several steps or tasks. List the step, hazards associated with the step, and the controls to contain the hazard. Examples are SOPs are provided at: <http://ehs.mit.edu/site/content/chemical-hygiene-program>

#### **2.5. Personal Protective Equipment (PPE)**

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: <http://ehs.mit.edu/site/content/personal-protective-equipment-ppe>

#### **2.6. Special Precautions**

Provide general information on 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 referenced materials or operation in this SOP.

### **3. STANDARD OPERATING PROCEDURES**

This section contains procedures developed for specific laboratories, experiments or operations.

[Note: Insert your custom SOPs to this section here, if applicable, based on the template that follows in 4.a Appendix IIIA]

**4. APPENDICES**

**4.1. Appendix III-A DLC-Specific Standard Operating Procedure (SOP) Template**

This template form is available at: <http://ehs.mit.edu/site/content/chemical-hygiene-program>

Please mark an 'X' in the gray boxes where appropriate to indicate selection.

<b>SOP Title</b>														
<b>Author(s):</b>							<b>Date:</b>							
<b>Reviewed by(PI/EHS/CHO):</b> __Yes __ No							<b>Signature (optional):</b>						<b>Name:</b>	
<b>SCOPE AND APPLICABILITY</b>														
<b>Department, Lab or Center:</b>														
<b>Research Group:</b>														
<b>Lab Bldg., Room(s):</b>														
<b>Brief Description of Operation/Experiment , key hazards and summary of controls:</b>														
<b>CHEMICAL HAZARDS</b>														
Principal Chemicals Used	Flammable	Corrosive	Sensitizer	Carcinogen	Teratogen;/Mutagen	Biological Toxin	Acutely Toxic	Pyrophoric	Water-Reactive	Shock Sensitive	Unstable	Penetrates Skin	Other Comments	
<b>Describe how and where MSDS information for above chemicals is maintained in the lab (notebook or on computer or attached to this SOP)</b>														

### STEP BY STEP HAZARD SUMMARY

Enumerate 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. Include in procedure waste management requirements.

Task	Hazards	Precautions

### PERSONAL PROTECTIVE EQUIPMENT

Special PPE required is noted below. **Note:** Standard PPE, listed in Part II of the Department CHP should always be worn in the lab. The section below is for additional PPE required due to the unusual nature of materials involved. If no additional PPE is needed, this section can be deleted.

<input type="checkbox"/>	Goggles	<input type="checkbox"/>	Faceshield
<input type="checkbox"/>	Protective Clothing, Special lab coat, chemical resistant apron, etc. (list type)		
<input type="checkbox"/>	Other (list item or items)		
<input type="checkbox"/>	Gloves (thickness, length, and whether disposable or reusable should also be considered in gloves selected.)		
<input type="checkbox"/>	Butyl	<input type="checkbox"/>	Neoprene
<input type="checkbox"/>	Nitrile	<input type="checkbox"/>	Silver shield or 4H
<input type="checkbox"/>	PVC	<input type="checkbox"/>	Kevlar
<input type="checkbox"/>	Latex	<input type="checkbox"/>	Other (list)
<input type="checkbox"/>	Respirator (If checked, contact EHS Office for additional assistance)		

### SPECIAL PRECAUTIONS

<input type="checkbox"/>	Training:
<input type="checkbox"/>	Medical Surveillance:
<input type="checkbox"/>	Other:

### SPECIAL EMERGENCY PROCEDURES

Fire/Explosion:	
Chemical Spill:	
Personal exposure or other medical emergency:	

## 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 <http://ehs.mit.edu/site/content/ehs-management-system>

### 2. SECURITY, PRIOR APPROVALS, INVENTORIES AND PROCUREMENT

#### 2.1. Laboratory and Chemical Security

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

1. **Inventories must be maintained for all 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. The use of the ChemTracker inventory system is recommended but not required. For more information on the ChemTracker system contact the EHS Office at 2-3477. In addition please indicate whether a chemical substance is an engineered nanomaterial, having at least one dimension in the nano range (1 to 100 nm), by adding the designation "nano" to the name. This includes engineered nanoparticles, wires, tubes, and other nano structures.
2. Access to all hazardous chemicals, including toxic and corrosive substances, should be restricted. Specifically, these materials should be stored in laboratories or storerooms that are kept locked when laboratory personnel are not present.
3. In the case of unusually toxic or hazardous materials, additional precautions are advisable, such as keeping the materials in locked storage cabinets or storerooms. Unusually toxic or hazardous materials 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).
4. Areas where biological agents and radioactive material are stored should be kept secure when not in use.
5. Restrict access to the laboratory to authorized personnel only and become familiar with these people.
6. Ship chemicals by following requirements in Part II section 9 to ensure safety and security.

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

The Department of Homeland Security (DHS) has established a list of chemicals of interest (COI). Researchers must obtain prior approval from the RLE EHS Coordinator before purchasing any of the 41 chemicals with low threshold reporting quantities from this list (see Part IV Appendix 9.1). 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).

## 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 Poisons
- Nitrous Oxide Gas
- Explosives
- Liquid Petroleum Gases
- Certain Biological Materials

Detailed information on the purchase of these materials can be found on the Procurement Department's website at

[http://vpf.mit.edu/site/procurement/policies\\_procedures/policies\\_and\\_procedure\\_manual/4\\_0\\_requisitions\\_other\\_special\\_processing/4\\_2\\_requisitions\\_for\\_hazardous\\_or\\_dangerous\\_materials\\_processing\\_procedures\\_09\\_06](http://vpf.mit.edu/site/procurement/policies_procedures/policies_and_procedure_manual/4_0_requisitions_other_special_processing/4_2_requisitions_for_hazardous_or_dangerous_materials_processing_procedures_09_06)

## 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 <http://ehs.mit.edu/site/sops>
- ❑ Refer to the EHS Office *Hazardous Waste Management SOP* when applicable. EHS Office SOPs are available at <http://ehs.mit.edu/site/sops>

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 <http://ehs.mit.edu/site/content/select-agent-toxins>.

# 3. MEDICAL EVALUATION, EXAMINATION AND SURVEILLANCE

## 3.1. Medical Evaluation

Employees or students who wish to discuss occupationally-related medical issues with the MIT Medical Department may do so. During this medical evaluation, the clinician will determine if a medical examination is necessary. Medical evaluations and examinations may be arranged by contacting the Medical Department, Occupational Medicine Service at 617-253-8552.

### When a Medical Evaluation May be Necessary

Any employee who exhibits adverse health effects from a chemical or hazardous material exposure as a result of MIT-related research or work should report to the Medical Department immediately for a medical evaluation.

Employees or students who work with hazardous materials are entitled to a medical evaluation when any of the following conditions occur:

- ❑ The individual(s) develops signs/symptoms associated with hazardous chemicals to which they were exposed;
- ❑ Exposure monitoring results are routinely above action level or PEL (permissible exposure limit) for a substance for which there are monitoring/medical surveillance requirements; or
- ❑ A spill, leak, explosion or other incident creates a likelihood of exposure.

### 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 (MSDS, or Material 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 report, to be completed by the Supervisor, is available online at the secure MIT Human Resources website "[https://web.mit.edu/hr/restrictforms/injury\\_report.html](https://web.mit.edu/hr/restrictforms/injury_report.html)". 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 <http://ehs.mit.edu/site/sops>.

## **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](http://medweb.mit.edu/directory/services/occupational_medicine.html)

### **3.3. Researchers with Medical Conditions**

Individuals with medical conditions who are required to work with hazardous materials or processes during the course of their research may be at increased risk for injury to themselves or others. It is recommended that anyone with a pre-existing medical condition or who develops a condition and believes that they may be at increased risk of injury because of their condition contact MIT occupational Medicine services (E23-171, 3-8552) for consultation and advice on how they may safely perform their work. Supervisors who have concerns about an individual's condition and their ability to safely work in a laboratory should contact MIT Occupational Medicine Services and provide a detailed job description of his/her position.

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 the individual's condition or 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.

## **4. EXPOSURE ASSESSMENT (MONITORING & REPORTING)**

### **4.2. 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.

## **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. Laboratory-Specific Policies and SOPs**

If standard operating procedures (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 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 <http://ehs.mit.edu/site/content/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 <http://ehs.mit.edu/site/content/ehs-management-system> and click on "Roles and Responsibilities" in the *EHS-MS Manual*.

## 7. 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 known, commercially distributed chemical and experience unusual health effects or observe unusual environmental effects which are not already documented in the environmental, health and safety risk information currently available
- 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.

## 8. ANNUAL SARA III CHEMICAL INVENTORY

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 quantities greater than the "Threshold Planning Quantity" 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 on March 1 that covers both its facilities and laboratory operations. The EHS Representative in each laboratory receives a list of approximately 40 SARA Title III chemicals in December. The quantity of each SARA Title III chemical on hand must be inventoried and reported back to the EHS Office. The EHS Office tabulates the lab inventories 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 includes only those chemicals that are in wide use on campus and is most likely only a partial list of all the *particularly hazardous substances* that may be in use in a lab. A separate list of all *particularly hazardous substances* is recommended under the OSHA *Laboratory Standard* but does not require quantity information to be tabulated.

**9. Appendix I: DHS chemicals**

**DHS List of 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-Chlorovinylchloroarsine	541-25-3	100g
Lewisite 2	Bis (2-Chlorovinyl)chloroarsine	40334-69-8	100g
Lewisite 3	Tris (2-Chlorovinyl)chloroarsine	40334-70-1	100g
Methylphosphonothioic 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
Propylphosphonothioic 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. APPENDIX II. List of EHS Representatives in the Research Laboratory of Electronics**

<b>Roomset Name</b>	<b>PI/Supervisor</b>	<b>Rooms</b>	<b>EHS Rep</b>
10-050 and attached (LEES)	Joel Schindall	10-007 => 10-097	Dave Otten
BEC1	Martin Zwierlein	26-248(L), 26-244	Ariel Sommer
BEC2	Wolfgang Ketterle	26-256, 36-268	Aviv Keshet
BEC3	Wolfgang Ketterle	26-248R	Tout Wang
BEC4	Wolfgang Ketterle	36-236	Hiro Miyake
BEC5	Wolfgang Ketterle	26-240	not yet active
Baldo lab	Marc Baldo	26-440	Phil Reusswig
Berggren lab	Karl Berggren	26-068; 38-161,173,189	Hasan Korre
Bulovic lab	Vladimir Bulovic	26-444	Jill Rowehl
Cappellaro Lab	Paola Cappellaro	26-305, 26-311	Masashi Hirose
Chuang lab	Isaac Chuang	36-258,258A,272,276	Molu Shi
Fink lab	Yoel fink	36-261A	Dana Shemuly
Freeman lab	Dennis Freeman	36-863, 869, 879, 897	Scott Page
Fujimoto lab - BL2	James Fujimoto	26-370; 36-364,368,376	Chao Zhou
Han lab - BL2	Jongyoon Han	36-831, 831A	Leon Li
Hu lab	Qing Hu	26-460, 468, 470	David Burghoff
Ippen lab	Erich Peter Ippen	36-312,324,330,336,338,342,344,362	Jonathan Morse
Kaertner lab	Franz X Kaertner	26-352,356; 36-189	Billy Putnam
Lu Lab	Tim Lu	E17-342	Sam Perli
N-10_Cooke	Chathan Cooke	N10-1st floor	Chathan Cooke
N-10_Zahn	Markus Zahn	N10-2nd floor	Markus Zahn
NanoPrecision Deposition Lab	Leslie A Kolodziejski	36-165, 38-160, 38-184, 38-192	Gale Petrich
RLE facilities machine shop	Al McGurl	36-172	Al McGurl
Ram lab - BL1	Rajeev J Ram	26-422, 428, 428A, 428B, 448	Shireen Goh
SEBL facility - no lasers (?)	Mark Mondol	38-181, 38-185	Mark Mondol
Sarpeshkar lab - BL1	Rahul Sarpeshkar	38-273, 273A, 285, 285A, 285B	Benjamin Rapoport
Shapiro lab	Jeffrey H Shapiro	26-368, 36-468, 36-476	Franco Wong
Smith lab	Henry I Smith	26-465, 38-177	James M Daley
Voldman lab - BL2	Joel Voldman	36-838, 838A, 854, 854A, 854B	Sarvesh Varma
Vuletic lab	Vladan Vuletic	26-222, 228, 228A, 348	Dorian Gangloff
Watts lab	Michael Watts	26-363, 365	not yet active
Yanik lab - BL2	Mehmet Yanik	36-847,888,890; 36-769	Matthew Angel
Zwierlein lab	Martin Zwierlein	26-268, 36-212	Cheng-Hsun Wu