Provo, Utah

LABORATORY & CHEMICAL SAFETY PROGRAM

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1.0 OVERVIEW

The Laboratory & Chemical Safety Program (LCSP) outlines the requirements for laboratory-scale use of hazardous chemicals at BYU. The program is based on the OSHA "Occupational exposure to hazardous chemicals in laboratories" standard 29 C.F.R. § 1910.1450 (hereafter called the "Lab Standard") and best practices as found in the latest revision of the National Research Council's "Prudent Practices in the Laboratory: Handling and Disposal of Chemicals" and similar publications.

2.0 POLICY

All principal investigators and/or others at Brigham Young University who have primary responsibility for the laboratory use of hazardous chemicals as defined in the Lab Standard are responsible for all activities performed within their laboratories or workplaces and shall ensure implementation of the provisions of the BYU LCSP.

***Note**: In early 2012, OSHA modified its Hazard Communication Standard by incorporating significant portions of the Globally Harmonized System of Classification and Labeling of Chemicals (GHS). Between 2012 and 2016, chemical manufacturers, importers, and distributors will be transitioning from providing a Material Safety Data Sheet (MSDS) to a Safety Data Sheet (SDS) for each chemical. For the purpose of complying with the requirements of the BYU LCSP and the OSHA Lab Standard during this period, either type of document (MSDS or SDS) is acceptable as long as it meets the applicable rules regarding content. Any reference to "MSDS" information contained hereafter in this document, including appendices, can be substituted with "SDS".*

Acknowledgement from Risk Management is required for the purchase and/or use of:

- Select Agents and Toxins (as defined by the USDA/HHS National Select Agent Registry)
- Highly Toxic substances (as defined in 29 C.F.R. § 1910.1200, Appendix A)
- Pyrophoric substances (as defined in 29 C.F.R. § 1910.1200)
- Explosives (DOT Hazard Class 1 materials)
- Compressed toxic gases (DOT Hazard Class 2.3 materials)
- Select carcinogens (as defined in 29 C.F.R. § 1910.1450)
- Radioactive materials
- BSL-2 and BSL-3 biological agents
- Peroxides (See NFPA 432 (2002) Appendix B, Class I & II formulations)

3.0 REQUIREMENTS

- OSHA regulation 29 C.F.R. § 1910.1450, *Occupational Exposure to Hazardous Chemicals in Laboratories* ("Lab Standard")
- OSHA regulation 29 C.F.R. § 1910.1200 (b)(3), *Hazard Communication*
- General Duty Clause contained in Section 5 of the Occupational Safety and Health Act of 1970
- 29 C.F.R. § 1910.132
- The BYU LCSP and all associated College, Department, and/or Laboratory Chemical Hygiene Plans developed in accordance with the Lab Standard.

4.0 PURPOSE

The BYU LCSP establishes the minimum requirements and procedures that individuals working in laboratories or using hazardous chemicals must use to protect people and property from the physical and health hazards associated with the storage, handling, and use of hazardous chemicals. The program provides a system to:

- Ensure compliance with applicable federal, state, and local laws and regulations,
- Develop and maintain a safe laboratory work environment, and
- Emphasize life safety, preserving property, and avoiding business interruption.

5.0 SCOPE

Unless specifically excepted by the Lab Standard, the BYU LCSP applies to all individuals who enter, work, or perform activities in any BYU laboratory, workplace, or area where relatively small quantities of multiple chemicals (as defined in 29 C.F.R. § 1910.1450(b)) are manipulated or used on a non-production basis; where the containers used for reactions, transfers, and other handling of substances are designed to be safely manipulated by one person; and where protective laboratory practices and equipment are available and in common use. Any hazardous chemical use which does not meet the definition of "laboratory use of hazardous chemicals" (e.g., chemicals used in building maintenance or in a production process) is not regulated by the Lab Standard.

6.0 PROCEDURES

Any use of hazardous chemicals that is within the scope of the Lab Standard will be governed by a Chemical Hygiene Plan which contains, at a minimum, the following elements:
[See also 29 C.F.R. § 1910.1450(e)]

i. Standard Operating Procedures (SOPs):

a. Contain information related to safety and health considerations, including description of work, required equipment (laboratory, safety, and personal protective equipment (PPE)), specific procedure(s) to be followed, waste disposal procedures, special precautions and spill response, and chemicals used (MSDS reference).

b. Are developed in a way that ensures controls and protective equipment are adequate to prevent overexposure. NOTE: In many cases, SOPs for laboratory safety have been developed and implemented for many years and few changes will be necessary to comply with the Lab Standard. Existing SOPs should be re-evaluated to ensure they address the current health and safety requirements for the chemicals in use.

ii. Control Measures:

a. The exposure to hazardous chemicals in the laboratory shall be controlled through the use of engineering controls, good general laboratory practices, PPE, and SOPs specific to an individual laboratory or department.

i. Engineering controls may include dilution ventilation, local exhaust ventilation (lab fume hoods), and proper storage facilities.

ii. General laboratory practices include guidelines on the use of chemicals, accident and spill response, use of personal protective equipment, use of engineering controls, and other good laboratory work practices. For examples, see *Prudent Practices in the Laboratory* and *Safety in Academic Chemistry Laboratories, Vol. 1&2.*

iii. Personal protective equipment: Appropriate PPE will be available to laboratory personnel and shall be inspected regularly and maintained as needed to ensure suitability for use.

iv. Specific laboratory practices: Individual departments or laboratories must develop specialized written safety procedures whenever necessary to protect (laboratory) workers from chemical and physical hazards that are applicable to their particular area of research. Special attention should be given to control measures for operations that involve the use of especially hazardous substances.

iii. Requirements for lab (fume) hoods and other protective equipment:

a. Fume hoods and other protective equipment that are "in service" shall be maintained so that they function properly. Lab (fume) hoods, emergency eyewashes and showers, and similar equipment are inspected regularly to ensure proper functioning and adequate performance. Engineering controls and personal protective equipment must be used in accordance with manufacturer recommendations. When necessary, the repair of these items is coordinated through Risk Management and/or the Physical Facilities Department to ensure a timely and effective repair process.

iv. Information and Training:

a. Prior to working in an area where hazardous chemicals are present, all (laboratory) workers must receive laboratory safety training and be informed of the potential health and safety risks that may be present in their workplace. Laboratories must utilize a written information and training program, and **documentation must be maintained to demonstrate that such training was completed at or before the time of initial assignment to an area where hazardous chemicals are present or when a new hazardous chemical is introduced into the work area**.

b. At a minimum, employee training must satisfy the requirements of 29 C.F.R. § 1910.1450(f). See section 8.0 of this LCSP for additional training information.

v. Prior Approval for High Hazard Work:

a. High hazard activities are identified by the principal investigator or person responsible for the work. Approval procedures for engaging in these activities shall be addressed in the laboratory's or department's standard operating procedures.

b. At a minimum, high hazard activities include using any of the following:
   i. Select carcinogens (as defined in the Lab Standard).
   ii. Acute toxins (per OSHA 1910.1200 App. A "Highly toxic").
   iii. Explosives (Dept. of Transportation (DOT) Class 1).
   iv. DEA controlled substances (Schedules 1-5).
   v. Radioactive materials.
   vi. Materials that are Poison by Inhalation (per 49 C.F.R 172.101 column 7).
   vii. Live vertebrate animals, recombinant DNA, and/or human subjects.
   viii. BSL-2 and/or BSL-3 pathogens.

c. Approval will not be given to work with substances that:
   i. Are illegal to manufacture or possess.
   ii. Exceed the limitations of applicable regulatory permits (e.g., BSL-4 pathogens and certain radionuclides).
   iii. Present an unreasonable risk to health and safety, as determined by the Academic Safety Committee, in consultation with Risk Management and the associated department/principal investigator.

vi. Medical Consultations and Medical Examinations:

a. Provisions for medical consultations and medical examinations will comply with 29 C.F.R. § 1910.1450(g).

b. Employees who work with hazardous chemicals shall be provided with an opportunity to receive medical attention performed by or under the direct supervision of a licensed physician when:
    i. An employee develops signs or symptoms associated with a hazardous chemical to which he/she may have been exposed.
    ii. Where exposure monitoring reveals an exposure level routinely above the action level or permissible exposure limit.
    iii. Whenever an event takes place in the work area resulting in the likelihood of a hazardous exposure.
c. The physician shall be provided with the identity of the hazardous chemical(s), a description of the conditions under which the exposure occurred, and a description of the signs or symptoms of exposure that the employee is experiencing.
d. The physician shall provide BYU with a written opinion that includes any recommendations for further follow-up, examination or test results that are related to the occupational exposure, any conditions revealed in the examination that may place the employee at increased risk, and a statement that the physician has informed the employee of the results of the medical examination.

vii. Personnel Responsible for the Chemical Hygiene Plan (CHP):

a. The University-appointed (institutional) Chemical Hygiene Officer provides technical guidance in the development of CHPs and is responsible for implementing the LCSP.
b. It is the responsibility of the principal investigator, individual supervisor, department, or college to be in compliance with the applicable components of this LCSP. Wherever appropriate, colleges, departments, and/or laboratories shall write and annually review their own chemical hygiene plans that fully satisfy the requirements of the Lab Standard and comply with this LCSP.

viii. Provisions for Additional Employee Protection for Work with Particularly Hazardous Substances:

a. Each chemical hygiene plan developed by a college, department, or laboratory shall include provisions for additional employee protection for work with particularly hazardous substances, including select carcinogens, reproductive toxins, and substances with high acute toxicity. Provision for additional controls may require the expertise and recommendations of various groups including Risk Management and outside consulting companies. All additional provisions for work with particularly hazardous substances must be incorporated into each laboratory's SOPs for those materials.
b. When particularly hazardous substances are used, additional employee protection may require:
    iv. Establishment of a designated area.
    v. Use of containment devices such as fume hoods or glove boxes.
    vi. Procedures for safe removal of contaminated waste.
    vii. Decontamination procedures.

7.0 RESPONSIBILITIES

7.1 Risk Management

- Is responsible for ensuring regulatory compliance with the OSHA Lab Standard for BYU.
- Is available for consultation on the development of chemical hygiene plans and standard operating procedures.

- Upon request, provides technical guidance and training to personnel at all levels of responsibility on matters pertaining to laboratory use of hazardous chemicals.
- Provides industrial hygiene services and expertise, including annual tests to determine the average face velocity of laboratory hoods.
- Maintains records of measurements taken to monitor employee exposures, if such measurements are initiated or conducted by Risk Management.
- Provides evaluation and feedback to help improve safety and health within laboratories.

7.2 Chemical Hygiene Officer

- Is appointed by the university or authorized designee, and provides technical guidance in developing and implementing appropriate chemical hygiene policies and practices as set forth in the provisions of the LCSP and CHPs.
- Possesses knowledge of the current legal requirements concerning regulated substances.
- Reviews the LCSP at least annually, evaluates its effectiveness, and recommends changes/updates to the program as needed.
- Works with the Academic Safety Committee, Colleges, Departments, and PIs to implement the LCSP.

7.3 Departments and/or Colleges, Deans, Directors, and Chairs

- Prior to commissioning or decommissioning a laboratory, ensure that all necessary safety requirements are satisfactorily completed for the laboratory.
- May review, approve, or disallow any laboratory SOP pertaining to the use of highly hazardous materials.
- Ensure that principal investigators and laboratories are in compliance with this and any other applicable safety/hygiene plan(s).
- Ensure that deficiencies found during safety inspections are addressed in a timely and efficient manner, and implement a progressive discipline program to address failure to create a safe laboratory work environment and/or for non-compliance.

7.4 Principal Investigators / Lab Supervisors

- Have responsibility for the health and safety of laboratory personnel doing work in his/her laboratory, and for ensuring appropriate reports are made to Risk Management of incidents involving hazardous exposure.
- Identify all hazardous chemicals, conditions, and operations in the lab, determining the best available procedures and controls for protecting individuals and minimizing exposure, and implementing and enforcing standard safety procedures.
    1. NOTE: A hazard evaluation (e.g., Chemical Hazard Assessment Form (CHAF), "What if" analysis, Hazard and Operability Study (HAZOP), or equivalent) will be completed prior to beginning work with hazardous substances. The analysis shall include consideration of both health and physical hazards.
    2. NOTE: The following methods of exposure control, listed in order of preference, shall be considered: engineering controls, administrative controls, and use of personal protective equipment.
- Establish standard operating procedures (general and protocol-specific) and verify that SOPs are accurate, complete, and provide sufficient detail to ensure a safe work environment.
- **Train laboratory personnel he/she supervises to work safely with hazardous chemicals and operations, and maintain records of training provided locally. This training**

includes informing laboratory personnel of the location and availability of relevant Hazard Information. See section 8 of this LCSP for more details on training requirements.

- Provide laboratory personnel under his/her supervision with access to the BYU LCSP, MSDSs for every chemical in the workplace, any college/department/individual Laboratory Safety Plan or CHP, and current SOPs.
- Notify Risk Management if there is reason to believe that an employee's exposure level to a hazardous chemical exceeds the action level (or in the absence of an action level, the permissible exposure limit as listed in 29 C.F.R. § 1910 subpart Z).
- Ensure employees, students, contractors, vendors, and visitors comply with all applicable rules and utilize all necessary hazard controls while working in lab areas.
- Ensure that food and/or beverages are neither stored nor consumed in any area that is exposed to a toxic material (See 29 C.F.R. § 1910.141).

7.5 Laboratory Employees, Students, and Visitors *(Note: "Employee" includes any paid personnel, including graduate students on stipends.)*

- Receive all applicable safety training before beginning work in the laboratory or where hazardous materials are in use.
- Understand the hazards involved with chemicals they use and are familiar with the location and contents of the MSDS file in their work area.
- Consult their Lab Manager or principal investigator if they are unsure of the safe handling, use, and storage of hazardous chemicals.
- Comply with the CHP, any individual laboratory safety plan, and applicable standard operating procedures (SOPs).
- Promptly report accidents and unsafe conditions to the principal investigator/laboratory supervisor.

7.6 Safety and Compliance Coordinator (SCC) *(Note: This role is optional, but recommended.)*

- Assists the college or department in helping to establish a safe and healthy work environment.
- Acquires specialized training and develops positive relationships with principal investigators, Risk Management, and the Academic Safety Committee (ASC) in order to facilitate the resolution of safety incidents and improve safety awareness.
- Serves on approved safety committees, when authorized by department management.

7.7 Academic Safety Committee (ASC)

- Provides guidance for all Chemical Hygiene Plans at BYU.
- Coordinates CHP-related issues with the members of the committee and their respective organizations.
- Advises colleges, departments, and selected safety committees on the interpretation and application of applicable policies and guidelines to laboratories.

7.8 Chemical Management

- Maintains an up-to-date academic hazardous material inventory.

- Disposes of regulated laboratory wastes.
- Monitors the procurement, handling, and disposal of chemicals.
- Upon request, provides assistance to individuals decommissioning a laboratory.
- Provides training relevant to proper chemical management.

8.0 TRAINING REQUIREMENTS

Specific laboratory safety training must be obtained prior to working with chemicals in a laboratory. This training is provided by the principal investigator/professor who manages the laboratory or his/her designee. At a minimum, specific laboratory safety training must consist of:

- The contents of 29 C.F.R. § 1910.1450, including appendices.
- A review of the CHP and each pertinent written safety & health procedure and their location(s).
- The location of MSDSs and other reference material for the chemicals stored or used in the laboratory.
- The identity and hazards (health and physical) of each chemical being used.
- All hazards being created by the process being performed.
- Hazard controls used and when to use them to control the chemical & process hazards.
- If used, how to properly inspect, use, store, clean, dispose of, and otherwise maintain personal protective equipment.
- Any ACGIH or OSHA exposure limits for the chemicals being used.
- The signs and symptoms of exposure to the chemicals being used.
- How to detect the presence or release of the chemicals being used.
- Measures needed to protect oneself while performing the laboratory work involving hazardous chemicals, including acquisition, transport, use, and disposal of the chemicals, as well as measures needed to protect against physical hazards (i.e. pressure, steam, electrical, etc.).
- What to do if a spill or accidental release of a chemical substance occurs in the area.
- The location and use of the following emergency equipment:
    - Emergency Eyewash
    - Emergency Shower
    - Fire Alarm Systems
    - Spill Kit(s)
    - Telephone
- Waste disposal procedures.

After receiving specific laboratory safety training, those trained must be able to identify the procedures they will perform, the hazards of the processes performed and chemicals they will use, and the measures they will take to protect themselves from the hazards presented by the chemicals used and processes being performed.

Training should be a continuing, regular activity; however, individuals must be retrained when changes occur to the chemicals being used, there are process changes, and/or any individual is found working in an unsafe manner.

Principal investigators or the department must maintain comprehensive training records for individuals working in their laboratories. Training records must include the name and BYU ID number of the attendee, the name of the training course, the name of the instructor (if applicable)

and the date on which the course was administered. Training content must be maintained for review.

9.0 MONITORING

- Risk Management, SCCs, or other authorized personnel will perform laboratory assessments to determine compliance with this LCSP. These assessments will include an inspection of training records, written safety & health procedures, and completed annual safety inspection forms (see Appendix A).
- This LSCP will be reviewed annually by the University CHO. Chemical Hygiene Plans will be reviewed at least annually by the authoring entity (College, Department, etc.) or a qualified and authorized designee.
- Incident and near-miss reports, in addition to other relevant documentation provided to the ASC, will be included in evaluating the efficacy of the LCSP.

10.0 APPENDICES

Appendix A: Guidelines for local Chemical Hygiene Plans

OSHA has adopted a health standard to protect laboratory workers from chemical hazards in their workplace. 29 CFR 1910.1450, "Occupational Exposure to Hazardous Chemicals in Laboratories," mandates health and safety practices and procedures in laboratories that use hazardous chemicals. The Standard requires that a Chemical Hygiene Plan be developed for each laboratory workplace. Most laboratories at BYU that use chemicals are subject to the requirements of the Laboratory Standard. In addition to employees who ordinarily work full time within a laboratory space, for the purposes of the Standard, "laboratory employee" may include employees such as office, custodial, maintenance and repair personnel, and others, who as part of their duties regularly spend a significant amount of their time within a laboratory environment. OSHA considers graduate students who get paid for working in a lab as employees and thus they are also subject to the requirements of the Laboratory Standard. The Laboratory Standard is a performance standard. That is, there are few specific requirements to carry out certain procedures in a certain way; instead, specific results to be achieved are denoted but the manner by which the results are to be accomplished is not delineated. The primary emphasis is on administrative controls necessary to protect workers from overexposure to hazardous substances in laboratories.

The chemical hygiene plan for a laboratory must (1) be capable of protecting employees from health hazards associated with hazardous chemicals in that laboratory, (2) be capable of keeping exposures below specified limits (e.g., PELs), (3) include all of the elements listed in 29 C.F.R. § 1910.1450 (e)(3) and section 6 of the BYU LCSP, and (4) be reviewed and evaluated for effectiveness at least annually by the employer, and updated if necessary.

The following information is presented to assist users in developing a chemical hygiene plan and can be used as a "starting point" or "template" for a fully developed CHP, knowing that additions, deletions, and modifications will need to be made where appropriate. Section 1 is taken from the Non-Mandatory Appendix A to §1910.1450 and Section 2 is an example of a generic CHP:

Section 1:

Appendix A to §1910.1450—National Research Council Recommendations Concerning Chemical Hygiene in Laboratories (Non-Mandatory)

To assist employers in developing an appropriate laboratory Chemical Hygiene Plan (CHP), the following non-mandatory recommendations were based on the National Research Council's (NRC) 2011 edition of "Prudent Practices in the Laboratory: Handling and Management of Chemical Hazards." This reference, henceforth referred to as "Prudent Practices," is available from the National Academies Press, 500 Fifth Street NW., Washington DC 20001 (*www.nap.edu*). "Prudent Practices" is cited because of its wide distribution and acceptance and because of its preparation by recognized authorities in the laboratory community through the sponsorship of the NRC. However, these recommendations do not modify any requirements of the OSHA Laboratory standard. This appendix presents pertinent recommendations from "Prudent Practices," organized into a form convenient for quick reference during operation of a laboratory and during development and application of a CHP. For a detailed explanation and justification for each recommendation, consult "Prudent Practices."

"Prudent Practices" deals with both general laboratory safety and many types of chemical hazards, while the Laboratory standard is concerned primarily with chemical health hazards as a result of chemical

exposures. The recommendations from “Prudent Practices” have been paraphrased, combined, or otherwise reorganized in order to adapt them for this purpose. However, their sense has not been changed.

Section F contains information from the U.S. Chemical Safety Board's (CSB) Fiscal Year 2011 Annual Performance and Accountability report and Section F contains recommendations extracted from the CSB's 2011 case study, “Texas Tech University Laboratory Explosion,” available from: *http://www.csb.gov/*.

CULTURE OF SAFETY

With the promulgation of the Occupational Safety and Health Administration (OSHA) Laboratory standard (29 CFR 1910.1450), a culture of safety consciousness, accountability, organization, and education has developed in industrial, governmental, and academic laboratories. Safety and training programs have been implemented to promote the safe handling of chemicals from ordering to disposal, and to train laboratory personnel in safe practices. Laboratory personnel must realize that the welfare and safety of each individual depends on clearly defined attitudes of teamwork and personal responsibility. Learning to participate in this culture of habitual risk assessment, experiment planning, and consideration of worst-case possibilities—for oneself and one's fellow workers—is as much part of a scientific education as learning the theoretical background of experiments or the step-by-step protocols for doing them in a professional manner. A crucial component of chemical education for all personnel is to nurture basic attitudes and habits of prudent behavior so that safety is a valued and inseparable part of all laboratory activities throughout their career.

Over the years, special techniques have been developed for handling chemicals safely. Local, state, and federal regulations hold institutions that sponsor chemical laboratories accountable for providing safe working environments. Beyond regulation, employers and scientists also hold themselves personally responsible for their own safety, the safety of their colleagues and the safety of the general public. A sound safety organization that is respected by all requires the participation and support of laboratory administrators, workers, and students. A successful health and safety program requires a daily commitment from everyone in the organization. To be most effective, safety and health must be balanced with, and incorporated into, laboratory processes. A strong safety and health culture is the result of positive workplace attitudes—from the chief executive officer to the newest hire; involvement and buy-in of all members of the workforce; mutual, meaningful, and measurable safety and health improvement goals; and policies and procedures that serve as reference tools, rather than obscure rules.

In order to perform their work in a prudent manner, laboratory personnel must consider the health, physical, and environmental hazards of the chemicals they plan to use in an experiment. However, the ability to accurately identify and assess laboratory hazards must be taught and encouraged through training and ongoing organizational support. This training must be at the core of every good health and safety program. For management to lead, personnel to assess worksite hazards, and hazards to be eliminated or controlled, everyone involved must be trained.

A. General Principles

1. Minimize All Chemical Exposures and Risks

Because few laboratory chemicals are without hazards, general precautions for handling all laboratory chemicals should be adopted. In addition to these general guidelines, specific guidelines for chemicals that are used frequently or are particularly hazardous should be adopted.

Laboratory personnel should conduct their work under conditions that minimize the risks from both known and unknown hazardous substances. Before beginning any laboratory work, the hazards and risks associated with an experiment or activity should be determined and the necessary safety precautions implemented. Every laboratory should develop facility-specific policies and procedures for the highest-risk materials and procedures used in their laboratory. To identify these, consideration should be given to past accidents, process conditions, chemicals used in large volumes, and particularly hazardous chemicals.

Perform Risk Assessments for Hazardous Chemicals and Procedures Prior to Laboratory Work:

(a) Identify chemicals to be used, amounts required, and circumstances of use in the experiment. Consider any special employee or laboratory conditions that could create or increase a hazard. Consult sources of safety and health information and experienced scientists to ensure that those conducting the risk assessment have sufficient expertise.

(b) Evaluate the hazards posed by the chemicals and the experimental conditions. The evaluation should cover toxic, physical, reactive, flammable, explosive, radiation, and biological hazards, as well as any other potential hazards posed by the chemicals.

(c) For a variety of physical and chemical reasons, reaction scale-ups pose special risks, which merit additional prior review and precautions.

(d) Select appropriate controls to minimize risk, including use of engineering controls, administrative controls, and personal protective equipment (PPE) to protect workers from hazards. The controls must ensure that OSHA's Permissible Exposure Limits (PELs) are not exceeded. Prepare for contingencies and be aware of the institutional procedures in the event of emergencies and accidents.

One sample approach to risk assessment is to answer these five questions:

(a) What are the hazards?

(b) What is the worst thing that could happen?

(c) What can be done to prevent this from happening?

(d) What can be done to protect from these hazards?

(e) What should be done if something goes wrong?

2. Avoid Underestimation of Risk

Even for substances of no known significant hazard, exposure should be minimized; when working with substances that present special hazards, special precautions should be taken. Reference should be made to the safety data sheet (SDS) that is provided for each chemical. Unless otherwise known, one should assume that any mixture will be more toxic than its most toxic component and that all substances of unknown toxicity are toxic.

Determine the physical and health hazards associated with chemicals before working with them. This determination may involve consulting literature references, laboratory chemical safety summaries

(LCSSs), SDSs, or other reference materials. Consider how the chemicals will be processed and determine whether the changing states or forms will change the nature of the hazard. Review your plan, operating limits, chemical evaluations and detailed risk assessment with other chemists, especially those with experience with similar materials and protocols.

Before working with chemicals, know your facility's policies and procedures for how to handle an accidental spill or fire. Emergency telephone numbers should be posted in a prominent area. Know the location of all safety equipment and the nearest fire alarm and telephone.

3. Adhere to the Hierarchy of Controls

The hierarchy of controls prioritizes intervention strategies based on the premise that the best way to control a hazard is to systematically remove it from the workplace, rather than relying on employees to reduce their exposure. The types of measures that may be used to protect employees (listed from most effective to least effective) are: engineering controls, administrative controls, work practices, and PPE. Engineering controls, such as chemical hoods, physically separate the employee from the hazard. Administrative controls, such as employee scheduling, are established by management to help minimize the employees' exposure time to hazardous chemicals. Work practice controls are tasks that are performed in a designated way to minimize or eliminate hazards. Personal protective equipment and apparel are additional protection provided under special circumstances and when exposure is unavoidable.

Face and eye protection is necessary to prevent ingestion and skin absorption of hazardous chemicals. At a minimum, safety glasses, with side shields, should be used for all laboratory work. Chemical splash goggles are more appropriate than regular safety glasses to protect against hazards such as projectiles, as well as when working with glassware under reduced or elevated pressures (e.g., sealed tube reactions), when handling potentially explosive compounds (particularly during distillations), and when using glassware in high-temperature operations. Do not allow laboratory chemicals to come in contact with skin. Select gloves carefully to ensure that they are impervious to the chemicals being used and are of correct thickness to allow reasonable dexterity while also ensuring adequate barrier protection.

Lab coats and gloves should be worn when working with hazardous materials in a laboratory. Wear closed-toe shoes and long pants or other clothing that covers the legs when in a laboratory where hazardous chemicals are used. Additional protective clothing should be used when there is significant potential for skin-contact exposure to chemicals. The protective characteristics of this clothing must be matched to the hazard. Never wear gloves or laboratory coats outside the laboratory or into areas where food is stored and consumed.

4. Provide Laboratory Ventilation

The best way to prevent exposure to airborne substances is to prevent their escape into the working atmosphere by the use of hoods and other ventilation devices. To determine the best choice for laboratory ventilation using engineering controls for personal protection, employers are referred to Table 9.3 of the 2011 edition of “Prudent Practices.” Laboratory chemical hoods are the most important components used to protect laboratory personnel from exposure to hazardous chemicals.

(a) Toxic or corrosive chemicals that require vented storage should be stored in vented cabinets instead of in a chemical hood.

(b) Chemical waste should not be disposed of by evaporation in a chemical hood.

(c) Keep chemical hood areas clean and free of debris at all times.

(d) Solid objects and materials, such as paper, should be prevented from entering the exhaust ducts as they can reduce the air flow.

(e) Chemical hoods should be maintained, monitored and routinely tested for proper performance.

A laboratory ventilation system should include the following characteristics and practices:

(a) Heating and cooling should be adequate for the comfort of workers and operation of equipment. Before modification of any building HVAC, the impact on laboratory or hood ventilation should be considered, as well as how laboratory ventilation changes may affect the building HVAC.

(b) A negative pressure differential should exist between the amount of air exhausted from the laboratory and the amount supplied to the laboratory to prevent uncontrolled chemical vapors from leaving the laboratory.

(c) Local exhaust ventilation devices should be appropriate to the materials and operations in the laboratory.

(d) The air in chemical laboratories should be continuously replaced so that concentrations of odoriferous or toxic substances do not increase during the workday.

(e) Laboratory air should not be recirculated but exhausted directly outdoors.

(f) Air pressure should be negative with respect to the rest of the building. Local capture equipment and systems should be designed only by an experienced engineer or industrial hygienist.

(g) Ventilation systems should be inspected and maintained on a regular basis. There should be no areas where air remains static or areas that have unusually high airflow velocities.

Before work begins, laboratory workers should be provided with proper training that includes how to use the ventilation equipment, how to ensure that it is functioning properly, the consequences of improper use, what to do in the event of a system failure or power outage, special considerations, and the importance of signage and postings.

5. Institute a Chemical Hygiene Program

A comprehensive chemical hygiene program is required. It should be designed to minimize exposures, injuries, illnesses and incidents. There should be a regular, continuing effort that includes program oversight, safe facilities, chemical hygiene planning, training, emergency preparedness and chemical security. The chemical hygiene program must be reviewed annually and updated as necessary whenever new processes, chemicals, or equipment is implemented. Its recommendations should be followed in all laboratories.

6. Observe the PELs and TLVs

OSHA's Permissible Exposure Limits (PELs) must not be exceeded. The American Conference of Governmental Industrial Hygienists' Threshold Limit Values (TLVs) should also not be exceeded.

B. Responsibilities

Persons responsible for chemical hygiene include, but are not limited to, the following:

1. Chemical Hygiene Officer

(a) Establishes, maintains, and revises the chemical hygiene plan (CHP).

(b) Creates and revises safety rules and regulations.

(c) Monitors procurement, use, storage, and disposal of chemicals.

(d) Conducts regular inspections of the laboratories, preparations rooms, and chemical storage rooms, and submits detailed laboratory inspection reports to administration.

(e) Maintains inspection, personnel training, and inventory records.

(f) Assists laboratory supervisors in developing and maintaining adequate facilities.

(g) Seeks ways to improve the chemical hygiene program.

2. Department Chairperson or Director

(a) Assumes responsibility for personnel engaged in the laboratory use of hazardous chemicals.

(b) Provides the chemical hygiene officer (CHO) with the support necessary to implement and maintain the CHP.

(c) After receipt of laboratory inspection report from the CHO, meets with laboratory supervisors to discuss cited violations and to ensure timely actions to protect trained laboratory personnel and facilities and to ensure that the department remains in compliance with all applicable federal, state, university, local and departmental codes and regulations.

(d) Provides budgetary arrangements to ensure the health and safety of the departmental personnel, visitors, and students.

3. Departmental Safety Committee reviews accident reports and makes appropriate recommendations to the department chairperson regarding proposed changes in the laboratory procedures.

4. Laboratory Supervisor or Principal Investigator has overall responsibility for chemical hygiene in the laboratory, including responsibility to:

(a) Ensure that laboratory personnel comply with the departmental CHP and do not operate equipment or handle hazardous chemicals without proper training and authorization.

(b) Always wear personal protective equipment (PPE) that is compatible to the degree of hazard of the chemical.

(c) Follow all pertinent safety rules when working in the laboratory to set an example.

(d) Review laboratory procedures for potential safety problems before assigning to other laboratory personnel.

(e) Ensure that visitors follow the laboratory rules and assumes responsibility for laboratory visitors.

(f) Ensure that PPE is available and properly used by each laboratory employee and visitor.

(g) Maintain and implement safe laboratory practices.

(h) Provide regular, formal chemical hygiene and housekeeping inspections, including routine inspections of emergency equipment;

(i) Monitor the facilities and the chemical fume hoods to ensure that they are maintained and function properly. Contact the appropriate person, as designated by the department chairperson, to report problems with the facilities or the chemical fume hoods.

5. Laboratory Personnel

(a) Read, understand, and follow all safety rules and regulations that apply to the work area;

(b) Plan and conduct each operation in accordance with the institutional chemical hygiene procedures;

(c) Promote good housekeeping practices in the laboratory or work area.

(d) Notify the supervisor of any hazardous conditions or unsafe work practices in the work area.

(e) Use PPE as appropriate for each procedure that involves hazardous chemicals.

C. The Laboratory Facility

General Laboratory Design Considerations

Wet chemical spaces and those with a higher degree of hazard should be separated from other spaces by a wall or protective barrier wherever possible. If the areas cannot be separated, then workers in lower hazard spaces may require additional protection from the hazards in connected spaces.

1. Laboratory Layout and Furnishing

(a) Work surfaces should be chemically resistant, smooth, and easy to clean.

(b) Hand washing sinks for hazardous materials may require elbow, foot, or electronic controls for safe operation.

(c) Wet laboratory areas should have chemically resistant, impermeable, slip-resistant flooring.

(d) Walls should be finished with a material that is easy to clean and maintain.

(e) Doors should have view panels to prevent accidents and should open in the direction of egress.

(f) Operable windows should not be present in laboratories, particularly if there are chemical hoods or other local ventilation systems present.

2. Safety Equipment and Utilities

(a) An adequate number and placement of safety showers, eyewash units, and fire extinguishers should be provided for the laboratory.

(b) Use of water sprinkler systems is resisted by some laboratories because of the presence of electrical equipment or water-reactive materials, but it is still generally safer to have sprinkler systems installed. A fire large enough to trigger the sprinkler system would have the potential to cause far more destruction than the local water damage.

D. Chemical Hygiene Plan (CHP)

The OSHA Laboratory standard defines a CHP as "a written program developed and implemented by the employer which sets forth procedures, equipment, personal protective equipment and work practices that are capable of protecting employees from the health hazards presented by hazardous chemicals used in that particular workplace." (29 CFR 1910.1450(b)). The Laboratory Standard requires a CHP: "Where hazardous chemicals as defined by this standard are used in the workplace, the employer shall develop and carry out the provisions of a written Chemical Hygiene Plan." (29 CFR 1910.1450(e)(1)). The CHP is the foundation of the laboratory safety program and must be reviewed and updated, as needed, and at least on an annual basis to reflect changes in policies and personnel. A CHP should be facility specific and can assist in promoting a culture of safety to protect workers from exposure to hazardous materials.

1. The Laboratory's CHP must be readily available to workers and capable of protecting workers from health hazards and minimizing exposure. Include the following topics in the CHP:

(a) Individual chemical hygiene responsibilities;

(b) Standard operating procedures;

(c) Personal protective equipment, engineering controls and apparel;

(d) Laboratory equipment;

(e) Safety equipment;

(f) Chemical management;

(g) Housekeeping;

(h) Emergency procedures for accidents and spills;

(i) Chemical waste;

(j) Training;

(k) Safety rules and regulations;

(l) Laboratory design and ventilation;

(m) Exposure monitoring;

(n) Compressed gas safety;

(o) Medical consultation and examination.

It should be noted that the nature of laboratory work may necessitate addressing biological safety, radiation safety and security issues.

2. Chemical Procurement, Distribution, and Storage

Prudent chemical management includes the following processes:

Chemical Procurement:

(a) Information on proper handling, storage, and disposal should be known to those who will be involved before a substance is received.

(b) Only containers with adequate identifying labels should be accepted.

(c) Ideally, a central location should be used for receiving all chemical shipments.

(d) Shipments with breakage or leakage should be refused or opened in a chemical hood.

(e) Only the minimum amount of the chemical needed to perform the planned work should be ordered.

(f) Purchases of high risk chemicals should be reviewed and approved by the CHO.

(g) Proper protective equipment and handling and storage procedures should be in place before receiving a shipment.

Chemical Storage:

(a) Chemicals should be separated and stored according to hazard category and compatibility.

(b) SDS and label information should be followed for storage requirements.

(c) Maintain existing labels on incoming containers of chemicals and other materials.

(d) Labels on containers used for storing hazardous chemicals must include the chemical identification and appropriate hazard warnings.

(e) The contents of all other chemical containers and transfer vessels, including, but not limited to, beakers, flasks, reaction vessels, and process equipment, should be properly identified.

(f) Chemical shipments should be dated upon receipt and stock rotated.

(g) Peroxide formers should be dated upon receipt, again dated upon opening, and stored away from heat and light with tight-fitting, nonmetal lids.

(h) Open shelves used for chemical storage should be secured to the wall and contain ¾ -inch lips. Secondary containment devices should be used as necessary.

(i) Consult the SDS and keep incompatibles separate during transport, storage, use, and disposal.

(j) Oxidizers, reducing agents, and fuels should be stored separately to prevent contact in the event of an accident.

(k) Chemicals should not be stored in the chemical hood, on the floor, in areas of egress, on the benchtop, or in areas near heat or in direct sunlight.

(l) Laboratory-grade, flammable-rated refrigerators and freezers should be used to store sealed chemical containers of flammable liquids that require cool storage. Do not store food or beverages in the laboratory refrigerator.

(m) Highly hazardous chemicals should be stored in a well-ventilated and secure area designated for that purpose.

(n) Flammable chemicals should be stored in a spark-free environment and in approved flammable-liquid containers and storage cabinets. Grounding and bonding should be used to prevent static charge buildups when dispensing solvents.

(o) Chemical storage and handling rooms should be controlled-access areas. They should have proper ventilation, appropriate signage, diked floors, and fire suppression systems.

Chemical Handling:

(a) As described above, a risk assessment should be conducted prior to beginning work with any hazardous chemical for the first time.

(b) All SDS and label information should be read before using a chemical for the first time.

(c) Trained laboratory workers should ensure that proper engineering controls (ventilation) and PPE are in place.

Chemical Inventory:

(a) Prudent management of chemicals in any laboratory is greatly facilitated by keeping an accurate inventory of the chemicals stored.

(b) Unneeded items should be discarded or returned to the storeroom.

Transporting Chemicals:

(a) Secondary containment devices should be used when transporting chemicals.

(b) When transporting chemicals outside of the laboratory or between stockrooms and laboratories, the transport container should be break-resistant.

(c) High-traffic areas should be avoided.

Transferring Chemicals:

(a) Use adequate ventilation (such as a fume hood) when transferring even a small amount of a particularly hazardous substance (PHS).

(b) While drum storage is not appropriate for laboratories, chemical stockrooms may purchase drum quantities of solvents used in high volumes. Ground and bond the drum and receiving vessel when transferring flammable liquids from a drum to prevent static charge buildup.

(c) If chemicals from commercial sources are repackaged into transfer vessels, the new containers should be labeled with all essential information on the original container.

Shipping Chemicals: Outgoing chemical shipments must meet all applicable Department of Transportation (DOT) regulations and should be authorized and handled by the institutional shipper.

3. Waste Management

A waste management plan should be in place before work begins on any laboratory activity. The plan should utilize the following hierarchy of practices:

(a) Reduce waste sources. The best approach to minimize waste generation is by reducing the scale of operations, reducing its formation during operations, and, if possible, substituting less hazardous chemicals for a particular operation.

(b) Reuse surplus materials. Only the amount of material necessary for an experiment should be purchased, and, if possible, materials should be reused.

(c) Recycle waste. If waste cannot be prevented or minimized, the organization should consider recycling chemicals that can be safely recovered or used as fuel.

(d) Dispose of waste properly. Sink disposal may not be appropriate. Proper waste disposal methods include incineration, treatment, and land disposal. The organization's environmental health and safety (EHS) office should be consulted in determining which methods are appropriate for different types of waste.

Collection and Storage of Waste:

(a) Chemical waste should be accumulated at or near the point of generation, under the control of laboratory workers.

(b) Each waste type should be stored in a compatible container pending transfer or disposal. Waste containers should be clearly labeled and kept sealed when not in use.

(c) Incompatible waste types should be kept separate to ensure that heat generation, gas evolution, or another reaction does not occur.

(d) Waste containers should be segregated by how they will be managed. Waste containers should be stored in a designated location that does not interfere with normal laboratory operations. Ventilated storage and secondary containment may be appropriate for certain waste types.

(e) Waste containers should be clearly labeled and kept sealed when not in use. Labels should include the accumulation start date and hazard warnings as appropriate.

(f) Non-explosive electrical systems, grounding and bonding between floors and containers, and non-sparking conductive floors and containers should be used in the central waste accumulation area to minimize fire and explosion hazards. Fire suppression systems, specialized ventilation systems, and dikes should be installed in the central waste accumulation area. Waste management workers should be trained in proper waste handling procedures as well as contingency planning and emergency response. Trained laboratory workers most familiar with the waste should be actively involved in waste management decisions to ensure that the waste is managed safely and efficiently. Engineering controls should be implemented as necessary, and personal protective equipment should be worn by workers involved in waste management.

4. Inspection Program

Maintenance and regular inspection of laboratory equipment are essential parts of the laboratory safety program. Management should participate in the design of a laboratory inspection program to ensure that the facility is safe and healthy, workers are adequately trained, and proper procedures are being followed.

Types of inspections: The program should include an appropriate combination of routine inspections, self-audits, program audits, peer inspections, EHS inspections, and inspections by external entities.

Elements of an inspection:

(a) Inspectors should bring a checklist to ensure that all issues are covered and a camera to document issues that require correction.

(b) Conversations with workers should occur during the inspection, as they can provide valuable information and allow inspectors an opportunity to show workers how to fix problems.

(c) Issues resolved during the inspection should be noted.

(d) An inspection report containing all findings and recommendations should be prepared for management and other appropriate workers.

(e) Management should follow-up on the inspection to ensure that all corrections are implemented.

5. Medical Consultation and Examination

The employer must provide all employees who work with hazardous chemicals an opportunity to receive medical attention, including any follow-up examinations that the examining physician determines to be necessary, whenever an employee develops signs or symptoms associated with a hazardous chemical to

which the employee may have been exposed in the laboratory. If an employee encounters a spill, leak, explosion or other occurrence resulting in the likelihood of a hazardous exposure, the affected employee must be provided an opportunity for a medical consultation by a licensed physician. All medical examinations and consultations must be performed by or under the direct supervision of a licensed physician and must be provided without cost to the employee, without loss of pay and at a reasonable time and place. The identity of the hazardous chemical, a description of the incident, and any signs and symptoms that the employee may experience must be relayed to the physician.

6. Records

All accident, fatality, illness, injury, and medical records and exposure monitoring records must be retained by the institution in accordance with the requirements of state and federal regulations (see 29 CFR part 1904 and § 1910.1450(j)). Any exposure monitoring results must be provided to affected laboratory staff within 15 working days after receipt of the results (29 CFR 1910.1450(d)(4)).

7. Signs

Prominent signs of the following types should be posted:

(a) Emergency telephone numbers of emergency personnel/facilities, supervisors, and laboratory workers;

(b) Location signs for safety showers, eyewash stations, other safety and first aid equipment, and exits; and

(c) Warnings at areas or equipment where special or unusual hazards exist.

8. Spills and Accidents

Before beginning an experiment, know your facility's policies and procedures for how to handle an accidental release of a hazardous substance, a spill or a fire. Emergency response planning and training are especially important when working with highly toxic compounds. Emergency telephone numbers should be posted in a prominent area. Know the location of all safety equipment and the nearest fire alarm and telephone. Know who to notify in the event of an emergency. Be prepared to provide basic emergency treatment. Keep your co-workers informed of your activities so they can respond appropriately. Safety equipment, including spill control kits, safety shields, fire safety equipment, PPE, safety showers and eyewash units, and emergency equipment should be available in well-marked highly visible locations in all chemical laboratories. The laboratory supervisor or CHO is responsible for ensuring that all personnel are aware of the locations of fire extinguishers and are trained in their use. After an extinguisher has been used, designated personnel must promptly recharge or replace it (29 CFR 1910.157(c)(4)). The laboratory supervisor or CHO is also responsible for ensuring proper training and providing supplementary equipment as needed.

Special care must be used when handling solutions of chemicals in syringes with needles. Do not recap needles, especially when they have been in contact with chemicals. Remove the needle and discard it immediately after use in the appropriate sharps containers. Blunt-tip needles are available from a number of commercial sources and should be used unless a sharp needle is required to puncture rubber septa or for subcutaneous injection.

For unattended operations, laboratory lights should be left on, and signs should be posted to identify the nature of the experiment and the hazardous substances in use. Arrangements should be made, if possible,

for other workers to periodically inspect the operation. Information should be clearly posted indicating who to contact in the event of an emergency. Depending on the nature of the hazard, special rules, precautions, and alert systems may be necessary.

9. Training and Information

Personnel training at all levels within the organization, is essential. Responsibility and accountability throughout the organization are key elements in a strong safety and health program. The employer is required to provide employees with information and training to ensure that they are apprised of the hazards of chemicals present in their work area (29 CFR 1910.1450(f)). This information must be provided at the time of an employee's initial assignment to a work area where hazardous chemicals are present and prior to assignments involving new exposure situations. The frequency of refresher information and training should be determined by the employer. At a minimum, laboratory personnel should be trained on their facility's specific CHP, methods and observations that may be used to detect the presence or release of a hazardous chemical (such as monitoring conducted by the employer, continuous monitoring devices, visual appearance or odor of hazardous chemicals when being released), the physical and health hazards of chemicals in the work area and means to protect themselves from these hazards. Trained laboratory personnel must know shut-off procedures in case of an emergency. All SDSs must be made available to the employees.

E. General Procedures for Working With Chemicals

The risk of laboratory injuries can be reduced through adequate training, improved engineering, good housekeeping, safe work practice and personal behavior.

1. General Rules for Laboratory Work With Chemicals

(a) Assigned work schedules should be followed unless a deviation is authorized by the laboratory supervisor.

(b) Unauthorized experiments should not be performed.

(c) Plan safety procedures before beginning any operation.

(d) Follow standard operating procedures at all times.

(e) Always read the SDS and label before using a chemical.

(f) Wear appropriate PPE at all times.

(g) To protect your skin from splashes, spills and drips, always wear long pants and closed-toe shoes.

(h) Use appropriate ventilation when working with hazardous chemicals.

(i) Pipetting should never be done by mouth.

(j) Hands should be washed with soap and water immediately after working with any laboratory chemicals, even if gloves have been worn.

(k) Eating, drinking, smoking, gum chewing, applying cosmetics, and taking medicine in laboratories where hazardous chemicals are used or stored should be strictly prohibited.

(l) Food, beverages, cups, and other drinking and eating utensils should not be stored in areas where hazardous chemicals are handled or stored.

(m) Laboratory refrigerators, ice chests, cold rooms, and ovens should not be used for food storage or preparation.

(n) Contact the laboratory supervisor, Principal Investigator, CHO or EHS office with all safety questions or concerns.

(o) Know the location and proper use of safety equipment.

(p) Maintain situational awareness.

(q) Make others aware of special hazards associated with your work.

(r) Notify supervisors of chemical sensitivities or allergies.

(s) Report all injuries, accidents, incidents, and near misses.

(t) Unauthorized persons should not be allowed in the laboratory.

(u) Report unsafe conditions to the laboratory supervisor or CHO.

(v) Properly dispose of chemical wastes.

Working Alone in the Laboratory

Working alone in a laboratory is dangerous and should be strictly avoided. There have been many tragic accidents that illustrate this danger. Accidents are unexpected by definition, which is why coworkers should always be present. Workers should coordinate schedules to avoid working alone.

Housekeeping

Housekeeping can help reduce or eliminate a number of laboratory hazards. Proper housekeeping includes appropriate labeling and storage of chemicals, safe and regular cleaning of the facility, and proper arrangement of laboratory equipment.

2. Nanoparticles and Nanomaterials

Nanoparticles and nanomaterials have different reactivities and interactions with biological systems than bulk materials, and understanding and exploiting these differences is an active area of research. However, these differences also mean that the risks and hazards associated with exposure to engineered nanomaterials are not well known. Because this is an area of ongoing research, consult trusted sources for the most up to date information available. Note that the higher reactivity of many nanoscale materials suggests that they should be treated as potential sources of ignition, accelerants, and fuel that could result in fire or explosion. Easily dispersed dry nanomaterials may pose the greatest health hazard because of

the risk of inhalation. Operations involving these nanomaterials deserve more attention and more stringent controls than those where the nanomaterials are embedded in solid or suspended in liquid matrixes.

Consideration should be given to all possible routes of exposure to nanomaterials including inhalation, ingestion, injection, and dermal contact (including eye and mucous membranes). Avoid handling nanomaterials in the open air in a free-particle state. Whenever possible, handle and store dispersible nanomaterials, whether suspended in liquids or in a dry particle form, in closed (tightly-sealed) containers. Unless cutting or grinding occurs, nanomaterials that are not in a free form (encapsulated in a solid or a nanocomposite) typically will not require engineering controls. If a synthesis is being performed to create nanomaterials, it is not enough to only consider the final material in the risk assessment, but consider the hazardous properties of the precursor materials as well.

To minimize laboratory personnel exposure, conduct any work that could generate engineered nanoparticles in an enclosure that operates at a negative pressure differential compared to the laboratory personnel breathing zone. Limited data exist regarding the efficacy of PPE and ventilation systems against exposure to nanoparticles. However, until further information is available, it is prudent to follow standard chemical hygiene practices. Conduct a hazard evaluation to determine PPE appropriate for the level of hazard according to the requirements set forth in OSHA's Personal Protective Equipment standard (29 CFR 1910.132).

3. Highly Toxic and Explosive/Reactive Chemicals/Materials

The use of highly toxic and explosive/reactive chemicals and materials has been an area of growing concern. The frequency of academic laboratory incidents in the U.S. is an area of significant concern for the Chemical Safety Board (CSB). The CSB issued a case study on an explosion at Texas Tech University in Lubbock, Texas, which severely injured a graduate student handling a high-energy metal compound. Since 2001, the CSB has gathered preliminary information on 120 different university laboratory incidents that resulted in 87 evacuations, 96 injuries, and three deaths.

It is recommended that each facility keep a detailed inventory of highly toxic chemicals and explosive/reactive materials. There should be a record of the date of receipt, amount, location, and responsible individual for all acquisitions, syntheses, and disposal of these chemicals. A physical inventory should be performed annually to verify active inventory records. There should be a procedure in place to report security breaches, inventory discrepancies, losses, diversions, or suspected thefts.

Procedures for disposal of highly toxic materials should be established before any experiments begin, possibly even before the chemicals are ordered. The procedures should address methods for decontamination of any laboratory equipment that comes into contact with highly toxic chemicals. All waste should be accumulated in clearly labeled impervious containers that are stored in unbreakable secondary containment.

Highly reactive and explosive materials that may be used in the laboratory require appropriate procedures and training. An explosion can occur when a material undergoes a rapid reaction that results in a violent release of energy. Such reactions can happen spontaneously and can produce pressures, gases, and fumes that are hazardous. Some reagents pose a risk on contact with the atmosphere. It is prudent laboratory practice to use a safer alternative whenever possible.

If at all possible, substitutes for highly acute, chronic, explosive, or reactive chemicals should be considered prior to beginning work and used whenever possible.

4. Compressed Gas

Compressed gases expose laboratory personnel to both chemical and physical hazards. It is essential that these are monitored for leaks and have the proper labeling. By monitoring compressed gas inventories and disposing of or returning gases for which there is no immediate need, the laboratory can substantially reduce these risks. Leaking gas cylinders can cause serious hazards that may require an immediate evacuation of the area and activation of the emergency response system. Only appropriately trained hazmat responders may respond to stop a leaking gas cylinder under this situation.

F. Safety Recommendations—Physical Hazards

Physical hazards in the laboratory include combustible liquids, compressed gases, reactives, explosives and flammable chemicals, as well as high pressure/energy procedures, sharp objects and moving equipment. Injuries can result from bodily contact with rotating or moving objects, including mechanical equipment, parts, and devices. Personnel should not wear loose-fitting clothing, jewelry, or unrestrained long hair around machinery with moving parts.

The Chemical Safety Board has identified the following key lessons for laboratories that address both physical and other hazards:

(1) Ensure that research-specific hazards are evaluated and then controlled by developing specific written protocols and training.

(2) Expand existing laboratory safety plans to ensure that all safety hazards, including physical hazards of chemicals, are addressed.

(3) Ensure that the organization's EHS office reports directly to an identified individual/office with organizational authority to implement safety improvements.

(4) Develop a verification program that ensures that the safety provisions of the CHP are communicated, followed, and enforced at all levels within the organization.

(5) Document and communicate all laboratory near-misses and previous incidents to track safety, provide opportunities for education and improvement to drive safety changes at the university.

(6) Manage the hazards unique to laboratory chemical research in the academic environment. Utilize available practice guidance that identifies and describes methodologies to assess and control hazards.

(7) Written safety protocols and training are necessary to manage laboratory risk.

G. Emergency Planning

In addition to laboratory safety issues, laboratory personnel should be familiar with established facility policies and procedures regarding emergency situations. Topics may include, but are not limited to:

(1) Evacuation procedures—when it is appropriate and alternate routes;

(2) Emergency shutdown procedures—equipment shutdown and materials that should be stored safely;

(3) Communications during an emergency—what to expect, how to report, where to call or look for information;

(4) How and when to use a fire extinguisher;

(5) Security issues—preventing tailgating and unauthorized access;

(6) Protocol for absences due to travel restrictions or illness;

(7) Safe practices for power outage;

(8) Shelter in place—when it is appropriate;

(9) Handling suspicious mail or phone calls;

(10) Laboratory-specific protocols relating to emergency planning and response;

(11) Handling violent behavior in the workplace; and

(12) First-aid and CPR training, including automated external defibrillator training if available.

It is prudent that laboratory personnel are also trained in how to respond to short-term, long-term and large-scale emergencies. Laboratory security can play a role in reducing the likelihood of some emergencies and assisting in preparation and response for others. Every institution, department, and individual laboratory should consider having an emergency preparedness plan. The level of detail of the plan will vary depending on the function of the group and institutional planning efforts already in place.

Emergency planning is a dynamic process. As personnel, operations, and events change, plans will need to be updated and modified. To determine the type and level of emergency planning needed, laboratory personnel need to perform a vulnerability assessment. Periodic drills to assist in training and evaluation of the emergency plan are recommended as part of the training program.

H. Emergency Procedures

(1) Fire alarm policy. Most organizations use fire alarms whenever a building needs to be evacuated—for any reason. When a fire alarm sounds in the facility, evacuate immediately after extinguishing all equipment flames. Check on and assist others who may require help evacuating.

(2) Emergency safety equipment. The following safety elements should be met:

a. A written emergency action plan has been provided to workers;

b. Fire extinguishers, eyewash units, and safety showers are available and tested on a regular basis; and

c. Fire blankets, first-aid equipment, fire alarms, and telephones are available and accessible.

(3) Chemical spills. Workers should contact the CHO or EHS office for instructions before cleaning up a chemical spill. All SDS and label instructions should be followed, and appropriate PPE should be worn during spill cleanup.

(4) Accident procedures. In the event of an accident, immediately notify appropriate personnel and local emergency responders. Provide an SDS of any chemical involved to the attending physician. Complete an accident report and submit it to the appropriate office or individual within 24 hours.

(5) Employee safety training program. New workers should attend safety training before they begin any activities. Additional training should be provided when they advance in their duties or are required to perform a task for the first time. Training documents should be recorded and maintained. Training should include hands-on instruction of how to use safety equipment appropriately.

(6) Conduct drills. Practice building evacuations, including the use of alternate routes. Practice shelter-in-place, including plans for extended stays. Walk the fastest route from your work area to the nearest fire alarm, emergency eye wash and emergency shower. Learn how each is activated. In the excitement of an actual emergency, people rely on what they learned from drills, practice and training.

(7) Contingency plans. All laboratories should have long-term contingency plans in place (e.g., for pandemics). Scheduling, workload, utilities and alternate work sites may need to be considered.

I. Laboratory Security

Laboratory security has evolved in the past decade, reducing the likelihood of some emergencies and assisting in preparation and response for others. Most security measures are based on the laboratory's vulnerability. Risks to laboratory security include, but are not limited to:

(1) Theft or diversion of chemicals, biologicals, and radioactive or proprietary materials, mission-critical or high-value equipment;

(2) Threats from activist groups;

(3) Intentional release of, or exposure to, hazardous materials;

(4) Sabotage or vandalism of chemicals or high-value equipment;

(5) Loss or release of sensitive information; and

(6) Rogue work or unauthorized laboratory experimentation. Security systems in the laboratory are used to detect and respond to a security breach, or a potential security breach, as well as to delay criminal activity by imposing multiple layered barriers of increasing stringency. A good laboratory security system will increase overall safety for laboratory personnel and the public, improve emergency preparedness by assisting with preplanning, and lower the organization's liability by incorporating more rigorous planning, staffing, training, and command systems and implementing emergency communications protocols, drills, background checks, card access systems, video surveillance, and other measures. The security plan should clearly delineate response to security issues, including the coordination of institution and laboratory personnel with both internal and external responders.

Section 2:
Generic Chemical Hygiene Plan Example

REMINDER: All laboratory chemical use areas must maintain a work-area specific Chemical Hygiene Plan which conforms to the requirements of the OSHA Laboratory Standard 29 CFR 1910.1450(e). BYU laboratories may use this document as a starting point for creating their work-area specific CHP.

CHEMICAL HYGIENE PLAN AND HAZARDOUS MATERIALS SAFETY MANUAL FOR BRIGHAM YOUNG UNIVERSITY LABORATORIES

This is the Chemical Hygiene Plan specific to the following areas:

Laboratory name or room number(s): _____

Building: _____

Supervisor: _____

Department: _____

Telephone numbers
911 for Emergency and urgent consultation
2-2222 Campus Police
2-4468 Risk Management & Safety

Revised on: **Enter a revision date here.**

BYU CHEMICAL HYGIENE PLAN
AWARENESS CERTIFICATION

For CHP of: _____

Principal Investigator, building, rooms

The Occupational Safety and Health Administration (OSHA) requires that laboratory employees be made aware of the Chemical Hygiene Plan at their place of employment (29 CFR 1910.1450).

The *CHEMICAL HYGIENE PLAN AND HAZARDOUS MATERIALS SAFETY MANUAL FOR BRIGHAM YOUNG UNIVERSITY LABORATORIES* serves as the written Chemical Hygiene Plan (CHP) for the specified laboratories at BYU. The CHP is a regular, continuing effort, not a standby or short term activity. Departments, divisions, sections, or other work units engaged in laboratory work whose hazards are not sufficiently covered in this written manual must customize it by adding their own sections as appropriate (e.g. standard operating procedures, emergency procedures, identifying activities requiring prior approval).

After reading the "*CHEMICAL HYGIENE PLAN AND HAZARDOUS MATERIALS SAFETY MANUAL FOR BRIGHAM YOUNG UNIVERSITY LABORATORIES*," complete and return a copy of this form to your supervisor or to your department's Safety Committee Chair. By signing below you acknowledge that you are aware of the Chemical Hygiene Plan and the policies and procedures applicable to the OSHA standard (29 CFR 1910.1450). Your supervisor will provide additional information and training as appropriate.

Please type or print legibly.

Name:_____ Work Phone:_____

Student or staff ID number:_____

Email address:_____

Department:_____

Job Classification (if employee):_____

Building:_____ Room:_____

Supervisor, instructor, or P.I. for your work area:_____

Signature:_____ Date:_____

Completed CHP Awareness Certifications are to be filed in a central administrative location within the staff member's department. These and all safety training records should be organized in a way that allows original records to be retrieved quickly and efficiently on request by an OSHA inspector or other authorized individual, and to be retrieved for a single staff member or for an entire work group (identified by supervisor).

SCOPE AND APPLICATION

The CHP applies to all personnel at BYU who are involved in the laboratory use of hazardous chemicals at the location(s) specified by the plan. (See the Title/Cover page).

The CHP does not apply to:

1. Uses of hazardous chemicals which do not meet the definition of laboratory use.
2. Laboratory uses of hazardous chemicals which provide no potential for employee exposure. Examples of such conditions might include:
    a. Procedures using chemically-impregnated test media such as Dip-and-Read tests where a reagent strip is dipped into the specimen to be tested and the results are interpreted by comparing the color reaction to a color chart supplied by the manufacturer of the test strip, and
    b. Commercially prepared kits such as those used in performing pregnancy tests in which all of the reagents needed to conduct the test are contained in the kit.

Laboratory uses of chemicals not covered by the CHP are subject to the full provisions of the OSHA Hazard Communication Standard. Contact the Risk Management Department for additional information.

EMPLOYEE RIGHTS AND RESPONSIBILITIES

Employees have the right to be informed about the known physical and health hazards of the chemical substances in their work areas and to be properly trained to work safely with these substances.

The Chemical Hygiene Plan must be readily available to employees and employee representatives.

Employees have the right to file a complaint with appropriate authorities if they feel they are being exposed to unsafe or unhealthy work conditions. Employees cannot be discharged, suspended, or otherwise discriminated against by their employer because of filing a complaint, or exercising their rights under the law.

Employees have the responsibility to receive training on the Laboratory Standard and Chemical Hygiene Plan and to stay informed about the chemicals used in their work areas. They have the responsibility to use safe work practices and protective equipment required for safe performance of their job. Finally they have the responsibility to inform their supervisors of accidents and conditions or work practices they believe to be a hazard to their health or to the health of others.

HAZARDOUS CHEMICALS

The Laboratory Standard defines a hazardous chemical as any element, chemical compound, or mixture of elements and/or compounds which is a physical or health hazard.

"Physical hazard" refers to a chemical for which there is scientifically valid evidence that it is a combustible liquid, a compressed gas, explosive, flammable, an organic peroxide, an oxidizer, pyrophoric, unstable (reactive) or water-reactive. Materials which present a physical hazard can usually be safely used if the specific hazard(s) are understood, and measures are taken to address the hazards. If appropriate precautions are not taken, a fire, an explosion, unwanted corrosion, personal injury, or property damage could occur.

A chemical is a **health hazard** if 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. Included are:

- carcinogens
- reproductive toxins
- sensitizers
- neurotoxins (nerve)
- hepatotoxins (liver)
- agents that act on the hematopoietic system (blood)
- irritants
- corrosives
- radioactive material
- biohazards
- nephrotoxins (kidney)
- agents that damage the lungs, skin, eyes, or mucous membranes

In most cases, the label will indicate if the chemical is hazardous. Look for key words like **caution, hazardous, toxic, dangerous, corrosive, irritant, carcinogen**, etc. Old containers of hazardous chemicals (before 1985) may not contain hazard warnings.

If you are not sure a chemical you are using is hazardous, review the **Material Safety Data Sheet (MSDS)** or contact your supervisor, instructor, or the Risk Management Department.

MATERIAL SAFETY DATA SHEETS (MSDSs)

A Material Safety Data Sheet (MSDS) is a document containing chemical hazard and safe handling information prepared in accordance with the OSHA Hazard Communication Standard.

Chemical manufacturers and distributors must provide a MSDS the first time a hazardous chemical/product is shipped to a facility. (Many manufacturers and distributors consider BYU the facility.)

You can request an MSDS for any laboratory chemical from the manufacturer or distributor.

If you want to review an MSDS, contact your supervisor, instructor, or Risk Management. If you need an MSDS for your work area file, contact the chemical supplier or Risk Management.

CHEMICAL INVENTORIES

The OSHA Laboratory Standard does not require chemical inventories; however, it is prudent to adopt this practice. An annual inventory can reduce the number of unknowns and the tendency to stockpile chemicals.

EXPOSURE LIMITS

For laboratory uses of hazardous substances, departments must ensure that laboratory employees' exposures to such substances do not exceed either the permissible exposure limits (PELs) specified in 29 CFR 1910, subpart Z, which are set by the Occupational Safety and Health Administration (OSHA), or the Threshold Limit Values (TLVs) published by the American Conference of Governmental Industrial Hygienists (ACGIH), whichever is lower.

HAZARD IDENTIFICATION

With respect to labels and Material Safety Data Sheets:

1. Departments must ensure that labels on incoming containers of hazardous chemicals are not removed or defaced.
2. Departments must ensure that laboratory containers of chemicals are labeled where required. Laboratory containers, including bottles, flasks, sample vials, etc., must be marked, labeled, or coded **in all cases**. (If codes or markings other than chemical names are used, a code key or legend must be available in the workplace where it may be found quickly and easily by emergency responders or other interested parties.) Labels should bear a date of receipt and should identify the owner of the material.
3. Departments must maintain any Material Safety Data Sheets that are received with incoming shipments of hazardous chemicals, and ensure that they are readily accessible to laboratory employees.

Note: The Chemicals Management Department has an extensive inventory of Material Safety Data Sheets. Material Safety Data Sheets are also available from the supplier. Material Safety Data Sheets for chemicals in use should be maintained in the laboratory.

CHEMICALS DEVELOPED IN THE LABORATORY

The following requirements apply to chemical substances developed in the laboratory:

1. If the composition of the chemical substance which is produced exclusively for the laboratory's use is known, the principal investigator must determine if it is a hazardous chemical (e.g., by literature search). If the chemical is determined to be hazardous, the principal investigator must provide appropriate training to protect employees.
2. If the chemical produced is a by-product whose composition is not known, the principal investigator must assume that the substance is hazardous and must comply with the requirements of the CHP.
3. If the chemical substance is produced for another user outside of the laboratory, the principal investigator must comply with the Hazard Communication Standard (29 CFR 1910.1200) including the requirements for preparation of Material Safety Data Sheets and labeling.

Note: Item 1 does not require the principal investigator to conduct toxicological testing. However, if a Material Safety Data Sheet or hazard information is available for the chemical, the information must be made available to employees.

USE OF RESPIRATORS

Where the use of respirators is necessary to maintain exposure below permissible exposure limits (PELs) or the Threshold Value Limits (TLVs), whichever is lower, the department must provide, at no cost to the employee, the proper respiratory protective equipment. Respirators must be selected and used in accordance with the requirements of the BYU Respiratory Protection Program (contact Risk Management for additional information).

CHEMICAL STORAGE

- Carefully read the label before storing a hazardous chemical. The MSDS will provide any special storage information and incompatibilities.
- Ensure all containers are in good condition and **properly labeled**.
- Do not store unsegregated chemicals in alphabetical order.
- Do not store incompatible chemicals in close proximity to each other.
- Whenever possible, separate chemicals into the following general hazard classes:
    - Flammable/combustible liquids
    - Flammable solids
    - Mineral acids
    - Organic acids (liquid)
    - Caustics
    - Oxidizers
    - Perchloric acid
    - Water-reactive
    - Air-reactive
    - Heat-reactive (require refrigeration)
    - Unstable (shock-sensitive, explosive)
    - Others
    - Gases:
        - toxic
        - flammable
        - oxidizers and inert
- Once separated into hazard classes, chemicals may be stored alphabetically.
- Determine what equipment and space is needed for safe storage of chemicals.
- Except when material is being transferred, keep chemical containers tightly closed.
- Use approved storage cabinets, containers, and safety cans for flammable liquids.
- Refrigerators and freezers used for the storage of chemicals or other laboratory supplies must be posted “No flammables or combustibles” if they have internal sources of ignition.
- Do not store chemicals on refrigerator door shelves. Containers could fall when the door is opened or closed.
- Do not store food, beverages, or food/beverage preparation supplies or equipment in an area (e.g., cabinet, shelf, refrigerator, or drawer) that is used for storage of chemicals or equipment used in chemical work.
- Flammable liquids stored in glass containers should not exceed 1 gallon (4 liters).
- Corrosion resistant cabinets are recommended for storage of corrosives.
- Use spill trays under containers of reagents which can cause spill problems.
- Dispose of old chemicals promptly.
- Recycle excess chemicals no longer being used in your area. Contact Risk Management for recycling information.
- Do not store liquids above eye level.
- For more information on chemical storage, contact your supervisor, instructor, or Risk Management.

TRANSPORTATION OF HAZARDOUS MATERIALS

OVER THE ROAD

Any container of hazardous material transported on a road accessible to or used by the public is subject to the regulation by the U.S. Department of Transportation (DOT). DOT regulations require, in part, that no person may offer or accept a hazardous material for transportation unless the material is properly classified, described, packaged, marked, labeled, manifested, and in condition for shipment. This includes hazardous materials transported between the various University buildings and campuses.

Prior to shipping or transporting a hazardous material, contact the Chemicals Management Department or Risk Management.

TRANSPORTATION INSIDE BUILDINGS AND BY FOOT

a. Chemicals should be transported in an approved transport container. *Approved transport container* means a commercially available bottle carrier made of rubber, metal, or plastic with carrying handle(s) which is large enough to hold the contents of the container if broken in transit. Carrier lids or covers are recommended, but not required. Rubber or plastic should be used for acids/alkalies; and metal, rubber, or plastic for organic solvents.
b. Laboratory Carts used to transport chemicals from one area to another shall be stable and in good condition. Transport only a quantity which can be handled easily. Plan the route ahead of time so as to avoid all steps or stairs.
c. Freight Elevators, Not Passenger Elevators, should be used to transport hazardous chemicals whenever possible. The individual transporting the hazardous chemicals should operate the elevator alone if possible. Avoid getting on an elevator when a person is transporting hazardous chemicals.

WASTE DISPOSAL

Hazardous chemical disposal must be conducted in accordance with procedures established by Chemicals Management (101 CMB). Contact Chemicals Management for specific information on disposal procedures.

Unless approved by Chemicals Management, disposal of chemicals via the sanitary sewer system is not permitted.

Disposal of radioactive material and infectious waste requires special procedures. Contact Chemicals Management before proceeding.

EMERGENCY RESPONSE

Plan in advance for an emergency. What are the possible emergencies which could occur during your work, e.g., fire, spill, high level chemical exposure? Are systems available to alert you to an emergency situation, e.g., chemical exposure monitoring systems? What supplies and equipment should you maintain in your area to assist you or emergency response personnel in the event of an emergency, e.g., eyewash and safety shower, spill control materials, personal protective clothing? What training do you need to handle an emergency in your area, e.g., emergency first aid or respirator use training? Is it safe for you to work alone?

BASIC STEPS FOR EMERGENCY RESPONSE

Determine the nature of the emergency.

- **High hazard emergency**. If the emergency is immediately dangerous to life and health, involves a large area, major injury to personnel, is a threat to personnel and the public, involves radioactive material, involves an infectious agent, or involves a highly toxic, corrosive, or reactive hazardous material, then proceed with **Plan A** below.
- **Low hazard emergency**. If the emergency is small, there is no fire hazard, involves low to moderately toxic materials in small amounts, or involves a readily treatable injury, proceed with **Plan B** below.
- **Fire and fire-related emergencies.** If the emergency involves a fire or fire-related situation such as abnormal heating of material, hazardous gas leaks, flammable liquid spill, smoke, or odor of burning, proceed with steps in the **"FIRE AND FIRE-RELATED EMERGENCIES"** section below.
- If the emergency involves a mercury spill, see section headed **"MERCURY SPILLS."**
- **Unknown.** If you do not know the nature of the emergency or are in any way uncertain as to how to handle the emergency, proceed with **Plan A** below.

PLAN A, HIGH HAZARD EMERGENCIES

- **Isolate** the area, if possible, and evacuate.
- Keep others out of the area and take action to protect life and limb.
- Call **emergency response** numbers (see cover page) and activate the building fire system. **When you call:**

  - Identify yourself and the reason you are calling.
  - Identify the exact location of the emergency.
  - Identify the nature of the emergency, any injuries or symptoms involved, and any hazardous materials involved if you know them.

- Provide rescue **only** if you are properly protected from the hazard. **Never attempt to rescue someone who is unconscious unless you know what the problem is and you know you are properly protected from the hazard.**

  - Do not move a seriously injured person unless he/she is in further danger.
  - Anyone overcome with smoke or chemical gases or vapors should be removed to uncontaminated air and treated for shock.

- Provide first aid if you have the capability.

- **For chemical splash in the eyes or on the skin**, remove contact lenses and rinse affected area for at least 15 minutes in emergency eyewash or shower, or use other water source. Remove any contaminated clothing, including undergarments and jewelry. Call 911.
- Identify yourself and be available to provide emergency response personnel information when they arrive. If possible, collect Material Safety Data Sheets for chemicals involved and provide these to the emergency response personnel.

PLAN B, LOW HAZARD EMERGENCIES

- For a **minor injury**, report to the Student Health Center or local emergency room for treatment. Injuries which occur on the job should be treated at the Student Health Center (preferred) or hospital. First aid kits are generally not recommended except for remote operations where emergency care is not readily available. If a department or lab desires a first aid kit, it must be maintained with essential supplies at all times. For specific first aid information, contact your supervisor, instructor, or Risk Management.
- For a **small spill**, use an absorbent material that will neutralize the spill, if available. Spill kits are available from safety equipment supply companies, or the following materials can be maintained:

  - trisodium phosphate
  - sand (not for use with HF)
  - sodium bicarbonate
  - powdered citric acid
  - "Oil-Dri," "Zorb-All," "Speedi-Dri," etc.
  - absorbent paper towels
  - bentonite, kitty litter, sand and soda ash mixture

A dustpan and brush should be used, and protective clothing (e.g., rubber gloves and goggles) should be worn. The area should be decontaminated with soap and water after clean-up. Residue should be placed in an appropriate container for waste collection. Contact the Chemicals Management Department for disposal information.

FIRE AND FIRE-RELATED EMERGENCIES

If you discover a fire or fire-related emergency such as abnormal heating of material, hazardous gas leaks, hazardous material or flammable liquid spill, smoke, or odor of burning, immediately follow these procedures:

- Activate the building fire alarm system (fire pull station). If not available or operational, verbally notify persons in the building.
- Call 911.
- Isolate the area and evacuate the building:
  - Shut down equipment in the immediate area, if possible
  - Close doors to isolate the area
  - If appropriate, use a portable fire extinguisher to:
    - Assist oneself to evacuate
    - Assist another to evacuate
    - Control a small fire, if possible

- Provide the fire/police teams with the details of the problem upon their arrival. Special hazard information you may know is essential.

If fire alarms are ringing in your building:

- evacuate the building
- move at least 200 feet away from the building
- stay clear of driveways, sidewalks and other access ways to the building
- if you are a supervisor, try to account for your employees and report any missing persons to the emergency personnel at the scene.
- Assist emergency personnel, as requested.
- Do not reenter the building until directed to do so.

Follow any special procedures established for your unit.

MERCURY SPILLS

For **small spills**, such as a thermometer break, use a mercury spill clean-up kit (available in the main chemistry stockroom).

- Do not use a domestic or commercial vacuum cleaner.
- Follow the instructions provided with the mercury spill kit
- Place residue in a sealable container for hazardous waste collection.

For **larger spills**, or any spill for which you believe unrecovered mercury might remain, contact Risk Management for spill clean-up, instructions, or assistance (2-4468).

INJURY AND ILLNESS

GENERAL

Employees and students must notify their immediate supervisor or instructor of all illnesses and injuries related to exposure to hazardous chemicals. Employees and students should report to the BYU Student Health Center if medical attention is required. Students should be accompanied by a friend, teaching assistant or instructor.

If transportation is necessary, the University Police (see cover page) should be called to get transportation for the victim.

Do not move a seriously injured person unless he/she is in further danger.

Do not transport injured person(s) in personal or department vehicles. Call 911 for ambulance transportation.

In cases of serious injury or illness, it is imperative that appropriate actions be followed immediately. When in doubt as to what should be done, telephone the University Police at 2-2222 for assistance.

Give emergency and medical personnel the following information:

- your name, location and nature of the emergency
- the name of the chemical involved
- the amount involved
- area of the body affected
- symptoms

The supervisor or instructor must ensure the appropriate injury report forms are completed.

If you have any questions regarding injury and illness procedures, contact your supervisor, instructor, or the University Police.

GENERAL SAFETY GUIDELINES for work with laboratory chemicals

The following are general safety and health rules that must be followed for essentially all laboratory work with hazardous chemicals. It is required that laboratories review and comply with these basic safety rules. Laboratories may need to modify these rules to provide additional controls to protect employees from chemical and physical hazards associated with the particular operation being conducted.

- Accidents and spills:
  - Eye Contact: Promptly flush eyes with water for at least 15 minutes. Use both hands to hold the eyelids open so that the entire surface of the eye may be rinsed. Seek immediate medical attention.
  - Inhalation or Ingestion: Seek medical attention.
  - Skin Contact: Promptly flush the affected area with water and remove any contaminated clothing. If symptoms persist after washing for 15 minutes or longer, seek medical attention.
  - If medical attention is necessary, call 911 or contact BYU campus police at 2-2222.
  - For large spills call 911. For assistance with clean-up of incidental spills and disposal of chemical waste, contact Risk Management at 2-4468.
  - In the event of a fire call 911. If you extinguish a small fire with a portable fire extinguisher it must be reported to Risk Management at 2-4468.
- Know the hazards associated with the materials you are using. Carefully read the label before using a chemical. Review the Material Safety Data Sheet (MSDS) for any special handling information. In some cases it may be necessary to do additional research. Contact Risk Management for assistance with the evaluation of hazards associated with a specific material.
- Use only those chemicals for which controls are available to minimize exposure to employees and students.
- Minimize all chemical exposures. Avoid unnecessary exposure to chemicals by any route (inhalation, absorption through skin, injection, or ingestion).
- Avoid underestimation of risk. Even for substances of no known significant hazard, exposure shall be minimized; for work with substances which present special hazards, special precautions shall be taken. One should assume that any mixture may be more toxic than the most toxic individual component, and that all substances of unknown toxicity are potentially toxic.
- Provide adequate ventilation: The best way to prevent exposure to airborne substances is to prevent their escape into the working atmosphere by the use of hoods and other ventilation devices.
- Observe exposure limits. The Permissible Exposure Limits (PELs) of OSHA and the current Threshold Limit Values (TLVs) of the American Conference of Governmental Industrial Hygienists shall not be exceeded. The PELs and TLVs can be obtained by contacting the Risk Management Department.
- Substitute less hazardous chemicals for high hazard chemicals whenever possible.

- Use the smallest possible quantities of chemicals feasible for a protocol.
- Whenever possible, do not generate mixed hazardous wastes, for example, radioactive materials with a flammable solvent.
- Search existing inventories and use chemicals in stock before purchasing new chemicals.
- Seek information and advice about hazards, plan appropriate protective procedures, and plan positioning of equipment before beginning any new operation.
- Be prepared for hazardous material emergencies and know what action to take in the event of an emergency. Be certain that necessary supplies and equipment are available for handling small spills of hazardous materials.
- Be alert to unsafe conditions and see that they are corrected when detected.
- Know the location of safety equipment: emergency shower, eye wash, fire extinguisher, fire alarm pull station.
- Do not work alone in the laboratory if you are working with hazardous materials or processes. Use a buddy system or a notification protocol with others in a facility if you must work alone.
- Limit access to areas where chemicals are used or stored by posting signs and/or locking doors when areas are unattended. Do not permit children in the laboratory.
- Purchase the minimum amount of hazardous materials necessary to accomplish your work and dispense only the minimum amount necessary for immediate use.
- Use equipment and/or hazardous chemicals only as directed and for their intended purpose.
- Handle and store laboratory glassware with care to avoid damage.
- Inspect all glassware for damage prior to each use. Do not use damaged glassware.
- Use extra care with Dewar flasks and other evacuated (high vacuum) glass apparatus. Shield or wrap them to contain chemicals and fragments should an implosion occur.
- Never smell or taste a hazardous chemical.
- Vent apparatus which may discharge toxic chemicals (vacuum pumps, distillation columns, etc.) into local exhaust devices.
- Inspect eye and all other personal protective equipment before use.
- Appropriate eye protection must be worn by all persons, including visitors, where chemicals are stored or handled.
- Wear appropriate gloves when the potential for contact with toxic materials exists. Inspect the gloves before use and replace them periodically. Discard disposable gloves immediately following overt contamination with highly toxic materials.
- Use appropriate respiratory personal protective equipment only when air contaminant exposure levels cannot be sufficiently controlled by engineering, work practice, or administrative controls. Remove laboratory coats immediately on significant contamination. Contaminated lab coats must be designated as such before being removed to a commercial laundry to protect workers in such establishments.
- On equipment such as hoods and biosafety cabinets, be familiar with the certification date or "to be tested again" date given on the test sticker.
- Perchloric acid must be used only in specially-designed perchloric acid fume hoods that have built-in wash down systems to remove shock-sensitive deposits. Before purchasing this acid, laboratory supervisors must arrange for use of an approved perchloric acid hood.

- Use the fume hood for operations that might result in the release of toxic chemical vapors, fumes or dust. Confirm adequate hood performance before use. Keep the hood sash lowered to the recommended height. Keep materials stored in hoods to a minimum and do not allow them to block vents or airflow.
- Bench-top use of chemicals that present an inhalation hazard is prohibited.
- Do not store cryogens or dry ice in non-ventilated rooms.
- Inspect equipment or apparatus for damage before adding a hazardous chemical or beginning a hazardous procedure. Do not use damaged equipment.
- Glass vacuum lines, pressure lines, and Dewar flasks should be taped or caged.
- Ensure that ventilation is adequate for the materials used. Refer to the MSDS for information on ventilation requirements, or contact Risk Management.
- Avoid practical jokes or other behavior which might confuse, startle, or distract another worker.
- Confine long hair and loose clothing. Wear shoes at all times in the laboratory, but do not wear sandals, open-toed, or perforated shoes.
- Wear a lab coat when working with chemicals. Shorts should not be worn in a lab when using corrosives or other chemicals that present a skin contact hazard.
- Keep the work area clean and uncluttered with chemicals and equipment. Clean up the work area on completion of an operation or at the end of each work day.
- Use required personal protective equipment. Remove laboratory coats immediately on significant contamination.
- Label all secondary containers with appropriate hazard information. Make sure that labels on primary and secondary containers do not become damaged. Replace them when necessary.
- Use good hygiene. Keep your hands and face clean. Wash thoroughly with soap and water after handling any chemical.
- Drinking, eating, gum chewing, smoking, and the application of cosmetics are forbidden in areas where hazardous chemicals are in use.
- Do not store food or drink for human consumption, or utensils or equipment for preparing food or drink, in the same cabinet, drawer, refrigerator or freezer with chemicals or equipment used with chemicals.
- Never use mouth suction to fill a pipette or to start a siphon.
- Electrically ground and bond containers using approved methods before transferring or dispensing a flammable liquid from a large container.
- Promptly clean up spills, using appropriate protective apparel, equipment and procedures. See the "Emergency Response" section of the booklet.
- Ensure that adequate storage facilities and containers are provided for hazardous materials.
- Ensure that hazardous materials are properly segregated into compatible categories.
- Comply with all waste disposal procedures provided by the Chemicals Management Department.
- For unattended operations, leave lights on, place an appropriate sign on the door, and provide for containment of toxic substances in the event of a utility service failure (e.g., loss of cooling water). Plans to conduct unattended operations should be reviewed with the supervisor, or principal investigator. Whenever possible, use automatic shutoff safety devices on long term or unattended operations.

- For specific information regarding chemical handling, contact your supervisor, instructor, or Risk Management.

Standard Operating Procedures

Many departments and labs have developed comprehensive safety and health manuals. These manuals address specific safety rules, regulations, and standard operating procedures for laboratory workers in the department or college. Most of the laboratories have referred to widely known and accepted laboratory safety practices referenced in *Prudent Practices in the Laboratory,* published by the National Research Council, or *Safety in Academic Chemical Laboratories,* published by the American Chemical Society.

Due to the large variety of research and the number of laboratories involved, it will be the responsibility of each laboratory, department, or college to ensure that their practices and procedures are adequate to protect their workers who use hazardous chemicals. It is the responsibility of the principal investigator or department head to ensure that written safety procedures are developed for work in their labs and that controls and protective equipment are adequate to prevent overexposure. In many cases, standard operating procedures for laboratory safety have been developed and implemented for years and few changes will be necessary to comply with the Lab Standard. Existing standard operating procedures may need to be evaluated to ensure that they address the health and safety requirements for the chemicals in use.

Appendix B of the BYU LCSP can be used to assist laboratories personnel in developing general and specific standard operating procedures for chemical use in laboratories.

Control Measures

Whenever employee exposures exceed the action level (or in the absence of an action level, the lower of the PEL or TLV), the department must implement control measures to reduce employee exposure to the associated hazardous chemical(s). The exposure to hazardous chemicals in the laboratory shall be controlled through the use of good general laboratory practices, standard operating procedures specific to an individual laboratory or department, engineering controls, and personal protective equipment. Exposures to extremely toxic materials, select carcinogens, and reproductive toxins must be maintained as low as reasonably achievable.

Information about general laboratory work practices and rules that are recognized as effective control measures to minimize exposure to hazardous chemicals in the laboratory are referenced from *Prudent Practices in the Laboratory* and *Safety in Academic Chemistry Laboratories.* These general procedures include guidelines on use of chemicals, accidents and spills, personal protection, use of fume hoods, and other good laboratory practice information.

Individual departments or laboratories must develop additional written safety procedures whenever necessary to protect laboratory workers from specific chemical hazards that are unique to their particular area of research. Particular attention should be given to control measures for operations that involve the use of select carcinogens or acutely toxic chemicals. Risk Management and Safety can assist researchers in developing safety procedures for specific hazards.

There are a variety of engineering controls that can be used in the laboratory to control exposures to hazardous chemicals. Some of the engineering controls that will be used in laboratories at BYU may include dilution ventilation, local exhaust ventilation (fume hoods), and proper storage facilities.

Exposure to hazardous materials will be controlled to the greatest extent feasible by use of engineering controls. Engineering controls to reduce or eliminate exposures to hazardous chemicals include:

- substitution of less hazardous equipment, chemical or process (e.g., safety cans for glass bottles)
- isolation of the operator or the process (e.g., use of barriers when handling explosives, or completely enclosing process in glove box or other enclosure)
- local and general exhaust ventilation (e.g., use of fume hoods)

As a rule of thumb, use a hood or other local ventilation device when working with any volatile substance. Do not work with hazardous materials if the required ventilation system is not working. Ventilation systems must be properly configured. Be sure you know how to properly use the system in your area for the work you are doing. For use of laboratory fume hoods, the following guidelines should be followed:

1. Fume hoods should be marked to indicate proper sash position for optimum hood performance. The hood sash should be set at this point for procedures which could generate toxic aerosols, gases or vapors. If it is not possible to do work with the sash height set at the point marked, or if there is no marking on the hood, contact Risk Management. In general, the sash height should be set at a level where the operator is shielded to some degree from any explosions or violent reactions which could occur and where optimum air flow dynamics are achieved. Most fume hoods are not intended to be used with the sash fully open.
2. Only apparatus and chemicals essential to the specific procedure or process should be placed in the hood. Extraneous materials from previous experiments or procedures should be removed and stored in a safe location outside the hood. Hoods used for experimental work should not be used for chemical or material storage. Hoods used for chemical storage should be dedicated to chemical storage. No experimental work should be conducted in these hoods.

If there are any questions concerning the adequacy of a fume hood or the procedures for safe use of a fume hood, contact Risk Management.

Administrative controls include the following:

- Careful planning of experiments and procedures with safety in mind. Planning includes the development of written work procedures for safe performance of the work.
- Restricting access to areas in which hazardous materials are used.
- Using signs or placards to identify hazardous areas (designated areas).
- Use of labels on hazardous materials.
- Good housekeeping.
- Good hygiene (e.g., washing hands and other areas of possible chemical contact).
- Prohibiting the storage and preparation of food in areas where chemicals are used or stored.

- Prohibiting eating and/or drinking where chemicals are used or stored, and providing break areas for this purpose.
- No mouth pipetting.
- Ensuring that employees are provided adequate training for safe work with hazardous materials.

Personal protective equipment will be available to laboratory workers for use to reduce exposures to hazardous chemicals in the laboratory. Common personal protective equipment such as goggles, gloves, face shields, and aprons are recommended for use with hazardous chemicals. Other personal protective equipment such as respirators will be available and recommended for use if necessary. Risk Management and Safety can assist in the proper selection, use, and care of personal protective equipment. Personal protective equipment will be readily available and most equipment is provided at no cost to the employee.

Departments must provide required personal protective equipment to employees, and supervisors must ensure that employees are trained in all necessary aspects of its proper use and care. This training must be documented. **Failure to prescribe, provide, and properly use required personal protective equipment can result in personal injury and disciplinary action.**

Respirators are not to be used except in conjunction with a comprehensive respiratory protection program. Such a program includes a review of the process to ensure that proper equipment is selected for the job; training of all respiratory protective equipment users concerning the methods for proper use and care of such equipment; fitting of respirator users when required; and medical surveillance of respirator users when required. Types of respiratory protective equipment include:

- particle-removing air-purifying respirators
- gas and vapor-removing air-purifying respirators
- atmosphere-supplying respirators

If your work requires the use of a respirator or you suspect your work requires the use of a respirator, you should contact your supervisor. He/she will contact Risk Management for an evaluation of the exposure and will schedule a medical physical examination to determine that you are physically fit to wear respiratory protection, and respirator fit-testing and training.
Do not use respiratory protective equipment until you have received proper training. If you are currently using a respirator and you have not received training in its use and care, contact Risk Management immediately.
In some cases, respiratory protective equipment may be kept on-hand for an emergency. In this situation, all potential users must receive training in its use. In addition, the equipment must be inspected on a monthly basis and this inspection must be documented. If you have respiratory protective equipment on-hand for use in an emergency and you have not received training in its use and care, contact Risk Management immediately.

Eye and face injuries can be prevented by the use of the following:

- safety glasses with side shields for dust and flying object hazards
- splash-proof goggles for chemical splash, spray and mist hazards

- full-face and neck shields for head and neck protection from various hazards (must be used with safety glasses or goggles)

Splash-proof goggles provide superior protection against dust, flying objects, and splash, spray and mist hazards. They should be the first choice for primary eye protection.

Cover all unprotected skin surfaces. Do not wear open-toe shoes, sandals, shorts, etc. in a chemical laboratory.
Even when there is minimal danger of skin contact with a hazardous substance, lab coats, coveralls, aprons, or protective suits should be used. General categories of contaminants include:

- toxic dusts (e.g. asbestos)
- bacteriological agents
- lab chemicals
- radioactive materials

Garments contaminated with hazardous materials should not be taken home by staff for laundering. They should be laundered on-site or by a commercial laundry which has been apprised of potential hazards.

Exposures to strong acids and acid gases, organic chemicals and strong oxidizing agents, carcinogens, and mutagens require the use of protective equipment that prevents skin contamination. Impervious protective equipment must be utilized. Examples include:

- rubber gloves
- rubber boots
- rubberized suits
- special protective equipment

Protective garments are not equally effective for every hazardous chemical. Some chemicals will "break through" the garment in a very short time; therefore, garment selection is based on the specific chemical utilized.

Where splash or spill of hazardous chemicals on clothing or protective equipment occurs, the clothing/equipment should be removed and placed in a closed container which prevents dispersion of the hazardous chemical. The clothing/equipment should be disposed of, cleaned, or laundered as appropriate. Employees should not take contaminated clothing/equipment home for cleaning or laundering. Persons or companies cleaning or laundering contaminated clothing or equipment must be informed of the potentially harmful effects of exposure to the chemical contaminant and must be advised of the measures necessary to protect themselves.

Other control methods that will be used to determine and reduce employee exposures to hazardous chemicals in the laboratory may include exposure monitoring, testing eyewash and emergency shower facilities, developing emergency procedures, proper container selection, and substitution of less toxic chemicals whenever possible.

Fume Hoods
The fume hood inspection program at BYU consists of an initial comprehensive inspection followed by annual standardized inspections for all campus fume hoods. This initial inspection will provide baseline information including but not limited to hood usage, type of hood, room and building information, as well as average face velocity measurements. Follow-up inspection for proper use and face velocity measurements will be done routinely each year or when requests for inspections are made. After each inspection, hoods will be labeled with inspection stickers

regarding face velocity measurements. All inspection information will be recorded on a standard form and will be kept on file at Risk Management.

The fume hood inspections consist of three parts:
1. Recording of information identifying building, room, hood usage, type of hood, person in charge, etc.
2. Measurement of hood average face velocity.
3. Determination of acceptability of hood and discussion of results with hood operator and/or person in charge.
Hoods will be classified as acceptable or unacceptable based, in part, on the face velocity measurement. If a hood is found to be unacceptable, a warning sign indicating that the hood has been inspected and found not to provide optimum protection will then be attached to the center of the sash window or another suitable and conspicuous location. Risk Management can assist the principal investigator in coordinating the necessary repairs with Physical Facilities and/or a suitable hood maintenance vendor, and help to ensure a timely and accurate repair process. Upon completion of these services, Risk Management must be contacted to re-inspect the hood.

The proper functioning and maintenance of other protective equipment used in the lab, such as fire extinguishers, eyewash/shower facilities, spill response equipment, and mechanical ventilation, is the responsibility of a variety of service groups. Periodic inspections and maintenance by these groups ensure proper functioning and adequate performance of the equipment.

Information and Training
Employees are provided with information and training to ensure that they are apprised of the hazards of chemicals present in their work area. This training and information will come from a variety of sources.

Risk Management and Safety has been providing training programs for laboratory workers for several years. These programs include information on chemical safety, Right-to-Know, Hazard Communication, the Lab Standard, radiation safety, spill response, eye protection, and how to obtain additional safety information. Resources for laboratory safety training are also available online at http://ytrain.byu.edu and in the HBL Library.

Material Safety Data Sheets (MSDSs) for chemicals used in laboratories can be obtained by contacting the principal investigator, the Chemicals Management Department, or Risk Management.

Risk Management and Safety personnel are available on a daily basis to answer questions and provide information to employees about chemical safety in laboratories.

Other sources of information and training may include informal group or individual discussions with a supervisor, posted notices, and handout booklets. Properly labeled containers will give immediate warning information to workers about specific chemical hazards. Many departments have safety committees and/or coordinators that can provide information on laboratory safety.

Employees are encouraged to contact their department safety representative and/or Risk Management for information about safety in laboratories.

Employees must be provided with information and training to ensure that they are apprised of the hazards of chemicals present in their work area and the steps they should take to protect themselves from these hazards. Training may take the form of individual instruction, group seminars, audio-visual presentations, handout material, or any combination of the above. However, the training must include the specific hazards associated with the chemicals in the work area when generic training is insufficient (e.g., extremely toxic materials, carcinogens, reproductive hazards) to address specific hazards.

Such information must be provided at the time of an employee's initial assignment to a work area where hazardous chemicals are present and prior to assignment involving new exposure situations. Employees should receive periodic refresher information and training.

The frequency of periodic refresher information and training will vary with the severity of the hazard(s); however, the length of time between training sessions should not exceed three years.

Information provided to employees must include:

1. The contents of the OSHA standard 29 CFR 1910.1450 and its appendices which shall be available to employees (available from REM);
2. The location and availability of the applicable Chemical Hygiene Plan;
3. The permissible exposure limits for OSHA regulated substances or published exposure limits for other hazardous chemicals where there is no applicable OSHA standard;
4. Signs and symptoms associated with exposures to hazardous chemicals used in the laboratory (available on container labels and Material Safety Data Sheets);
5. The location and availability of known reference material on the hazards, safe handling, storage and disposal of hazardous chemicals found in the laboratory including, but not limited to, Material Safety Data Sheets received from the supplier.

Training provided to employees must include:

1. Methods and observations that may be used to detect the presence or release of a hazardous chemical (such as monitoring conducted by the University, continuous monitoring devices, visual appearance or odor of hazardous chemicals when being released, etc.);
2. The physical and health hazards of chemicals in the work area;
3. The measures employees can take to protect themselves from these hazards, including specific procedures the University or department has implemented to protect employees from exposure to hazardous chemicals, such as appropriate work practices, emergency procedures, and personal protective equipment to be used;
4. The applicable details of the Chemical Hygiene Plan.

Awareness of the CHP should be documented using the form on page (i) of this document. All CHP training records belonging to a department or other administrative unit should be held in a central administrative location (e.g., by Safety Committee Chair or in Department Head or Business Office), organized in any convenient manner provided the training record(s) for an individual, a research group, or department can be made immediately available during an inspection.

Prior Approval for High Hazard Work

The principal investigator or laboratory supervisor will define which if any activities, operations, or procedures constitute circumstances under which prior approval must be obtained by employees before implementation. Any type of approval process should be addressed in the laboratory's or Department's standard operating procedures. Risk Management and Safety can assist in identifying circumstances when there should be prior approval before implementation of a particular laboratory operation; however, in most cases "employer approval" will occur at the local level (e.g., Supervisor, Department Head, Department Safety and Health Committee).

Risk Management and Safety can assist in providing information to researchers about work with select carcinogens, highly toxic gases, and other high hazard chemicals. General guidelines and recommendations for the safe handling, use and control of high hazard materials can be provided through MSDSs, and reference sources such as *Prudent Practices in the Laboratory,* and *Safety in Academic Chemistry Laboratories*.

In certain instances, prior approval from a research related committee may be required before beginning an operation or activity. These include:

- Research using live vertebrate animals.
- Biohazards and/or Recombinant DNA use.
- Use of Radioactive Materials.

Risk Management will be contacted if these situations apply.

Medical Consultation and Medical Examinations

Departments must provide all employees who work with hazardous chemicals an opportunity to receive medical attention, including any follow-up examinations which the examining physician determines to be necessary, under the following circumstances:

1. Whenever an employee develops signs or symptoms associated with a hazardous chemical to which the employee may have been exposed in the laboratory, the employee must be provided an opportunity to receive an appropriate examination.
2. Where exposure monitoring reveals an exposure level routinely above the action level (or in the absence of an action level, the PEL) for an OSHA regulated substance for which there are exposure monitoring and medical surveillance requirements, medical surveillance shall be established for the affected employee as prescribed by the particular standard.
3. Whenever an event takes place in the work area such as a spill, leak, explosion or other occurrence resulting in the likelihood of a hazardous exposure, the affected employee shall be provided an opportunity for a medical consultation. Such consultations shall be for the purpose of determining the need for a medical examination.

All medical examinations and consultations must be performed by or under the direct supervision of a licensed physician and must be provided without cost to the employee, without loss of pay and at a reasonable time and place.

All records of medical consultation, examinations, tests or written opinions shall be maintained at Student Health Center or other suitable location, in accordance with 29 CFR 1910.20.

Exposure monitoring records of contaminate levels in laboratories will be maintained by Risk Management (250 FB)

Personnel Responsible for the Chemical Hygiene Plan
The college/department/ laboratory chemical hygiene officer, or authorized designee, will develop the provisions of the location-specific CHP.

Risk Management and the institutional (BYU) Chemical Hygiene Officer will provide technical information and program support to assist in compliance with the OSHA Laboratory Standard: However, it is the responsibility of the individual laboratory supervisor (usually the principal investigator), department, or college to develop area-specific CHPs, complete annual reviews of those plans, and ensure compliance with the components of the plan.

An annual review of the Chemical Hygiene Plan is required. The review process will utilize such resources as results of internal and external audits, accident reports, notices of violation, customer satisfaction surveys, and other information and tracking reports which may become available. The focus of the annual review is to evaluate program effectiveness and to identify strengths and weaknesses which may be updated to improve the program. The written annual review will be made available to the institutional Chemical Hygiene Officer and other individuals or entities, as appropriate.

Provisions for Additional Employee Protection for Work with Particularly Hazardous Substances
Research involving the use of particularly hazardous substances, such as select carcinogens, reproductive toxins, or acutely toxic chemicals may require prior review to ensure that adequate controls are in place which will protect the worker. Upon request, Risk Management will assist with the review and make recommendations for additional employee protection.
Additional employee protection may require the use of additional provisions such as:
• Establishment of a designated area
• Use of containment devices such as fume hoods or glove boxes
• Procedures for safe removal of contaminated waste
• Decontamination procedures
• Personal and area air monitoring
• Leak detection systems
The provision for additional controls may require the expertise and recommendations of various groups including Facilities Engineering, technical committees, and outside consulting companies. All additional provisions for work with particularly hazardous materials must be incorporated into the standard operation procedures for those materials.

Appendix B: Laboratory Standard Operating Procedure (SOP) Guidelines

An SOP is a set of written instructions that document an activity followed by an organization. The development and use of SOPs provides individuals with the information to perform a job properly and safely, and facilitates consistency in the quality and integrity of a product or end-result. For this document, SOPs are written safety and health guidelines to be followed when laboratory work involves the use of hazardous chemicals, and are **required** as a part of a laboratory-specific Chemical Hygiene Plan. They provide detailed instruction on how to work safely with hazardous chemicals or processes. The Principal Investigator (PI) or laboratory supervisor determines which laboratory activities need an SOP. The OSHA Laboratory Standard explicitly requires "*standard operating procedures relevant to safety and health considerations to be followed when laboratory work involves the use of hazardous chemicals.*" SOPs must be written to fulfill this requirement.

GUIDELINES FOR COMPLETING LABORATORY SPECIFIC SOPs

Standard Operating Procedures can be written in one or more of the following ways:
1. By process or task (e.g. distillation, peptide synthesis, glove box use, etc.).
2. By specific chemical (e.g. benzene, perchloric acid, chloroform, etc.).
3. By class of hazardous chemicals (e.g. corrosive, flammable, peroxidizable, etc.).

Laboratories that already have written Standard Operating Procedures may attach the procedure(s) to the appropriate portion of the Chemical Hygiene Plan.

An SOP may be organized or formatted in any way that makes it useful to laboratory personnel; however, sections 1 through 12 should be completed for each process, class of chemicals, or individual chemical. Four additional sections, 13 through 16, can be included in *any* SOP, but they should receive specific consideration and incorporation in any SOP that involves the use of particularly hazardous substances such as select carcinogens, reproductive toxins, and substances with a high degree of acute toxicity.

Sections of the SOP:

Section 1: Introduction

- Indicate the SOPs' title, author, revision number, scope, applicability, location of use, and summary.

Section 2: Required Equipment

- List all equipment, tools, and supplies required to safely complete the procedure.

Section 3: Description of Hazards

- Chemical Hazards
  - List all chemicals used (including common names and abbreviations, if applicable), the Chemical Abstract Service (CAS) number (if available), and the known or expected significant hazards of each chemical.

        - NOTE: Procedures that involve newly synthesized chemicals or byproducts whose composition is unknown are assumed hazardous until the chemical and physical properties can be determined.
    - Physical Hazards
        - Describe the physical hazards, precautions, and prohibited activities for the process, procedure or operation.
    - Risk Assessment
        - Describe any potential hazards (not listed or described previously) that exist or could foreseeably exist as a result of performing the work described in the SOP.

Section 4: Personal Protective Equipment

- Identify and describe the specific personal protective equipment and hygiene practices needed with each process, class of chemical, or individual chemical.
    - NOTE: Standard PPE for most laboratory operations includes closed-toe shoes, long pants, lab coat/apron, gloves (specify type), and eye/face protection. Additional PPE may be required.
- If you think that your process may require respirator use, contact Risk Management for assistance.

Section 5: Engineering Controls

- Indicate the engineering control that will be used to prevent or reduce employee exposure to hazardous chemicals and the location of the engineering control. This includes ventilation devices such as fume hoods, glove boxes, etc., and safety features on equipment.

Section 6: Special Handling and Storage Requirements

- Labeling/Identification of Chemical and Hazard
    - Indicate labeling requirements for hazardous chemicals involved in the SOP. Indicate special procedures such as dating peroxide forming chemicals upon receipt.
- Handling Procedure
    - Indicate special handling procedures (e.g., handle only in fume hood or glove box, restricted access plans, special containment devices, etc.)
- Storage
    - List storage requirements for chemicals involved in the SOP, including specific storage areas, storage according to compatibility, and policies regarding access to chemicals. Indicate special procedures such as dating peroxide forming chemicals upon receipt, testing for peroxide formation after the appropriate date, or monitoring chemicals for signs of degradation.

Section 7: Spill and Accident Procedures

- Indicate how spills or accidental releases will be handled and by whom. List the location of appropriate emergency equipment (spill kits, showers, eye washes, and fire equipment). Any special requirements for limiting personnel exposure should also be identified in this section. Identify the location of emergency response phone numbers.

Section 8: Waste Disposal Procedures

- Describe the proper waste disposal procedures for each chemical, indicating which materials will require disposal as hazardous waste. Contact Chemicals Management or Risk Management for assistance in developing specific disposal instructions.

Section 9: Safety Data Information

- Indicate the location where material safety data sheets (or safety data sheets) are stored in laboratory.
- Indicate the location of other pertinent safety information (e.g., equipment manuals, chemical references, emergency procedures, etc.)

Section 10: Special Emergency Procedures

- Indicate special procedures for emergencies such as fire, evacuation of the laboratory or building, medical emergencies, etc.

Section 11: Detailed ("step-by-step") Procedure

- Include a detailed, sequential list of the steps taken to safely accomplish the operation.

Section 12: SOP Training Record

- The PI, lab supervisor, or authorized designee will train all personnel in the lab prior to beginning work with hazardous materials listed in the SOP. Refresher training will be provided when there is a change to the procedure, an accident occurs, or non-compliance is observed.
- Individuals who have been trained on the SOP shall certify that he/she has **read** and **understood** the SOP by completing a sign-in roster that includes a description of the training and the individual's printed name, signature, and date of training.

As noted previously, the following four additional sections can be included in *any* SOP, but they should receive specific consideration and incorporation in any SOP that involves the use of particularly hazardous substances such as select carcinogens, reproductive toxins, and substances with a high degree of acute toxicity.

Section 13: Prior Approval Required

- Discuss the circumstances under which a particular laboratory procedure or activity will require approval from the PI or laboratory supervisor prior to beginning.

Section 14: Designated Area

- Indicate the specific area of the laboratory that is designated for work with particularly hazardous substances and any restrictions regarding access to or use of that area. The

entire laboratory, a fume hood, a portion of the laboratory, or a containment device such as a glove box may be considered a designated area.

Section 15: Decontamination and/or Removal of Contaminated Waste

- Discuss decontamination procedures for all affected work surfaces, equipment, glassware, etc. If specialized cleaning solutions are used, indicate which solutions and the appropriate contact time. Discuss proper disposal of decontaminated waste.
- Discuss the procedures for safely removing waste that is not (or cannot be) fully decontaminated.

Section 16: Special Precautions and Training

- Describe any special permits, notifications, warning devices, or other items that must be in place before work begins.
- Indicate if medical surveillance for employees or other special precautions are necessary.
- Discuss any unique training or experience requirements that must be fulfilled before working with highly hazardous materials.
- The special precautions described below can be used as part of an SOP, in conjunction with other detailed safety guidelines:
  - **Special Precautions for Working with Flammables and Combustibles**: Flammable/combustible materials are materials which under standard conditions can generate sufficient vapor to cause a fire in the presence of an ignition source. Flammable materials can generate sufficient vapors at temperatures below 100oF (38oC); combustibles, at temperatures at or above 100oF (38oC) and below 140oF (60oC). The vapors of these materials are invisible, and a vapor trail to an ignition source away from the immediate area can result in a flashback. Flammables are more hazardous at elevated temperatures due to more rapid vaporization. In addition, flammable and combustible materials react with oxidizers which can result in a fire. Observe the following special precautions.
  - Eliminate ignition sources such as open flames, smoking materials, hot surfaces, sparks from welding or cutting, operation of electrical equipment, and static electricity.
  - Minimize the quantity kept in the work area.
  - Store in approved flammable liquid containers (safety cans) and storage cabinets, or in a special storage room designed for that purpose. Store away from oxidizers.
  - Flammable liquids stored in glass containers shall not exceed 1 gallon.
  - Refrigerators and freezers used for the storage of flammable or combustible liquids must have no internal sources of ignition (lab-safe).
  - Ensure that there is proper bonding and grounding when it is required, such as when transferring or dispensing a flammable liquid from a large container or drum. Bonding and grounding must be checked regularly.
  - Ensure that appropriate fire control systems or extinguishers are available.

- **Special Precautions for Working with Corrosives**:
- Corrosives are materials which can react with the skin causing burns similar to thermal burns, and/or which can react with metal causing deterioration of the metal surface. Acids and bases are corrosives. Observe the following special precautions.
- Containers and equipment used for storage and processing of corrosive materials should be corrosion resistant.
- Eye protection and rubber gloves should always be used when handling corrosive materials. A face shield, rubber apron, and rubber boots may also be appropriate, depending on the work performed.
- When mixing concentrated acids (caustics) with water, add the acid (caustic) slowly to water. Never add water to acid (caustic).
- Acids and bases should be stored separately from each other. Organic acids should be stored with flammable materials, separate from oxidizers and oxidizing acids.

- **Special Precautions for Working with Oxidizers:**
- Oxidizers are materials which readily yield oxygen or another oxidizing gas, or that readily react to promote or initiate combustion of flammable/combustible materials. Oxidation reactions are a frequent cause of chemical accidents. Observe these precautions to reduce risk when storing or handling oxidizers.
- Know the reactivity of the materials involved in experiment or process. Make sure that there are no extraneous materials in the area which could become involved in a reaction.
- If the reaction can be violent or explosive, use shields or other methods for isolating the materials or the process.
- Use the minimum amounts necessary for the procedure. Do not keep excessive amounts of the material in the vicinity of the process.
- Store properly, away from organic materials, flammable materials and other reducing agents.
- Perchloric acid should be used only in specially-designed perchloric acid fume hoods equipped with wash-down systems to prevent deposition of shock-sensitive perchlorates in the ductwork and machinery. Before purchasing perchloric acid, the laboratory supervisor should arrange for use of an approved perchloric acid hood.

- **Special Precautions for Working with Water-Reactive Materials:**
- Materials which react with water to produce a flammable or toxic gas, or other hazardous condition are said to be water-reactive. Fire and explosion are serious concerns when working with these materials. Special precautions for safe handling of water-reactive materials will depend on the specific material, and the conditions of use and storage. Contact REM for information on the safe use of a specific material. Examples of water-reactives include alkali and alkaline earth metals (e.g. Li, Na, K, Ca, Mg), metal hydrides, some metal and nonmetal chlorides (e.g. SiCl4, PCl3, AlCl3), calcium carbide, acid halides and acid anhydrides.

- **Special Precautions for Working with Pyrophoric Materials:**
- Pyrophoric materials ignite spontaneously upon contact with air. The flame may or may not be visible. Examples include butyllithium, silane, and yellow phosphorous. Store and use all pyrophorics in an inert atmosphere.

- **Special Precautions for Working with Peroxidizables:**
- Peroxidizables are substances or mixtures which react with oxygen to form peroxides. Some peroxides can explode with impact, heat, or friction such as that caused by removing a lid. Peroxides form inside the containers of some materials even if they have not been opened. Examples include ethyl ether, tetrahydrofuran, liquid paraffins (alkanes), and olefins (alkenes). See Appendix C for additional materials which may form peroxides. Precautions are given below.
- Date all peroxidizables upon receipt and upon opening. Unless an inhibitor has been added by the manufacturer, materials should be properly disposed of after 18 months from date of receipt or 3 months from date of opening.
- Do not open any container having obvious crystal formation around the lid.
- Other special precautions are similar to those used for flammables.

- **Special Precautions for Working with Light-Sensitive Materials:**
- Light-sensitive materials are unstable with respect to light energy. They tend to degrade in the presence of light, forming new compounds which can be hazardous, or resulting in conditions such as pressure build-up inside a container which may be hazardous. Observe the following precautions.
- Store light-sensitive materials in a cool, dark place in amber colored bottles or other containers which reduce or eliminate penetration of light.
- Date containers on receipt and upon opening, and dispose of surplus material after one year if unopened or 6 months if opened.

- **Special Precautions for Working with Shock-Sensitive or Explosive Materials:**
- Shock-sensitive/explosive materials are substances or mixtures which can spontaneously release large amounts of energy under normal conditions, or when struck, vibrated, or otherwise agitated. Some materials become increasingly shock-sensitive with age and/or loss of moisture. The inadvertent formation of shock-sensitive/explosive materials such as peroxides, perchlorates, picrates and azides is of great concern in the laboratory.
- Contact Risk Management when work with shock-sensitive or explosive materials is planned or when it is suspected that the inadvertent formation of shock-sensitive materials in ductwork, piping, or chemicals being stored has occurred.
- Date all containers of explosive or shock-sensitive materials upon receipt and when opened. Unless an inhibitor has been added, unopened shock-sensitive materials should be discarded within 12 months after receipt. Open containers of

shock-sensitive materials should be discarded within 6 months of the date opened.
- Use the minimum amount of materials necessary for a procedure. Keep a minimum amount of material on hand.
- If there is a chance of explosion, use barriers or other methods for isolating the materials or the process.

- **Special Precautions for Working with Compressed Gases:**
- Special systems are needed for handling materials under pressure. Toxic and corrosive gases present special problems in designing engineering controls. The physical and health hazards of any material are typically compounded by the pressure hazard. Carefully observe special precautions.
- Always use the smallest size cylinder required to perform the work.
- Cylinders of compressed gases must be handled as high energy sources.
- Cylinders on wheeled carts must be capped and secured by an approved cylinder support strap or chain. The cart must be an approved cylinder cart. Do not attempt to take a loaded cylinder cart up or down a stairway.
- All uncapped cylinders must be secured independently (not ganged behind a single chain) to a solid element of the lab structure. Carts are not acceptable for supporting uncapped or in-use cylinders.
- Never bleed a cylinder completely empty. Leave a slight pressure to keep contaminants out.
- Oil or grease on the high pressure side of an oxygen cylinder can cause an explosion. Do not lubricate an oxygen regulator or use a fuel gas regulator on an oxygen cylinder.
- Always wear goggles or safety glasses with side shields when handling compressed gases.
- Always use appropriate gauges, fittings, and materials compatible with the particular gas being handled. Regulators must be compatible with gas cylinders (do not use adapters).
- When work with toxic, corrosive, or reactive gases is planned, Risk Management should be contacted for information concerning specific handling requirements for the gas involved. Generally, these gases will need to be used and stored with local exhaust ventilation such as a lab hood or a gas cabinet designed for that purpose.

- **Special Precautions for Working with Allergens:**
- The term allergen describes a wide variety of substances that can produce skin and lung hypersensitivity. Examples include diazomethane, chromium, nickel bichromates, formaldehyde, isocyanates, and certain phenols. Wear suitable gloves to prevent hand contact with allergens or substances of unknown allergenic activity. Conduct aerosol producing procedures in a fume hood.

- **Special Precautions for Working with Cryogens:**

- Some of the hazards associated with cryogens (fluids used to maintain extremely low temperatures) are fire, pressure, embrittlement of materials, and skin or eye burns upon contact with the liquid. Cryogens can condense nearly pure liquid oxygen from the air, creating a severe fire risk. A pressure hazard exists because of the large expansion ratio from liquid to gas, causing pressure build up in containers. Many materials become brittle at extreme low temperatures. Brief contact with materials at extreme low temperatures can cause burns similar to thermal burns. Carefully observe all special precautions.
- Equipment should be kept clean, especially when working with liquid or gaseous oxygen.
- Mixtures of gases or fluids should be strictly controlled to prevent formation of flammable or explosive mixtures.
- For flammable cryogens the precautions provided in the "Flammable/Combustible Materials" section of this booklet should be used.
- Always wear goggles when handling cryogens. If there is a splash or spray hazard, a face shield over the goggles, an impervious apron or coat, cuffless trousers, and fully-covering, non-lacing shoes should be worn. Watches, rings, and other jewelry should not be worn. Gloves should be impervious and sufficiently large to be readily thrown off should a cryogen be spilled. Cryo-gloves or pot holders should also be used. Respirators may be required if the cryogen is toxic and sufficient local exhaust ventilation is not available. Contact Risk Management for exposure monitoring.
- Containers and systems containing cryogens should have pressure relief mechanisms.
- Containers and systems should be capable of withstanding extreme cold without becoming brittle. Glass containers should be taped solidly around the outside or encased in plastic mesh.
- Funnels should not be used for pouring liquid nitrogen or any other cryogen.
- Large mobile Dewars or LN2 refrigerators (or the trolleys carrying these) used for transporting cryogens within a building or between buildings should be equipped with a braking mechanism.
- Large mobile Dewars at risk for tipping should be transported on appropriate carts. Wheeled trolleys may not be used if the vessel must pass over elevator thresholds or other slots/crevasses wider than 25% of the wheel width.
- Dispensing stations designed to allow research staff to fill smaller vessels from a larger self-pressurizing Dewar must be located in non-public areas, and should be posted with standard operating procedures.
- Smaller vessels of liquid nitrogen or other cryogens transported by hand within or between buildings must have a handle or bail, and must be covered.

- **Special Precautions for Working with Embryotoxins and Reproductive Toxins:**
- Substances that act during pregnancy to cause adverse effects on the fetus are referred to as embryotoxins. These effects include embryolethality (death of the fertilized egg, the embryo, or the fetus), malformation (teratologic effects), retard growth, and postnatal functional deficits. Examples include organo-mercurials, lead compounds, and formamide. Because the period of greatest susceptibility to embryotoxins is the first 8-12 weeks of pregnancy, which includes a period when a woman may not know she is pregnant, women of child-bearing potential should

take care to avoid skin contact with all chemicals. The term "reproductive toxins" is used to describe substances which cause harmful effects on the male or female reproductive system or the developing embryo and fetus. These effects include but are not limited to menstrual irregularity, lowered fertility, testicular atrophy, and birth defects.

- Review each use of embryotoxins with the research supervisor and Risk Management. Review continuing uses annually or whenever a procedural change is made.
- Label embryotoxins as follows: EMBRYOTOXIN: READ SPECIFIC PROCEDURES FOR USE.
- Store embryotoxins and reproductive toxins in unbreakable containers or unbreakable secondary containers in a well-ventilated area.
- Guard against spills and splashes. Appropriate safety apparel, especially gloves, should be worn. All hoods, glove boxes, or other essential engineering controls should be known to be operating properly before work is started.
- Notify your supervisor and Risk Management of all incidents of exposure or spills. Risk Management will arrange for a medical consultation.

- **Special Precautions for Working with Chemicals of Moderate Chronic or High Acute Toxicity:**
- Examples of chemicals of moderate chronic toxicity or high acute toxicity include diisopropylfluorophosphate, hydrofluoric acid, and hydrogen cyanide.
- Consult one of the standard compilations that list toxic properties of known substances and learn what is known about the substance that will be used. Follow the specific precautions and procedures for the chemical.
- Use and store these substances only in designated (restricted access) areas placarded with appropriate warning signs.
- Use a hood or other containment device for procedures which may result in the generation of aerosols or vapors; trap released vapors to prevent their discharge with fume hood exhaust.
- Avoid skin contact by use of gloves and long sleeves and other protective apparel as appropriate.
- Maintain records of the amounts of materials on hand, amounts used, and the names of the workers involved.
- Be prepared for accidents and spills. At least two people should be present at all times if compounds in use are highly toxic or of unknown toxicity.
- Store breakable containers in chemically resistant trays; also work and mount apparatus above such trays or cover work and storage surfaces with removable, absorbent, plastic backed paper.
- If a major spill occurs outside the hood, evacuate the area and call for assistance (See cover page).
- Thoroughly decontaminate or dispose of contaminated clothing or shoes. If possible, chemically decontaminate by chemical conversion to a less toxic product.
- Store contaminated waste in closed, suitably labeled, impervious containers.

- **<u>Special Precautions for Working with Chemicals of High Chronic Toxicity:</u>**
- Examples of chemicals exhibiting high chronic toxicity include dimethylmercury, nickel carbonyl, benzo-a-pyrene, N-nitrosodiethylamine, and other human carcinogens or substances with high carcinogenic potency in animals.
- Conduct all transfers and work in designated (restricted access) areas: a restricted access hood, glove box, or portion of a lab, designated for use of highly toxic substances, for which all persons with access are aware of the substances being used and necessary precautions.
- Protect vacuum pumps against contamination with scrubbers or HEPA filters and vent effluent into the hood..
- Decontaminate vacuum pumps or other contaminated equipment, including glassware, before removing them from the designated area. Decontaminate the designated area before normal work is resumed there.
- On leaving the area, remove protective apparel (placing it in an appropriate, labeled container) and thoroughly wash hands, forearms, face, and neck.
- Use a wet mop or a vacuum cleaner equipped with a HEPA filter to decontaminate surfaces. DO NOT DRY SWEEP SPILLED POWDERS.
- If using toxicologically significant quantities of a substance on a regular basis (in quantities above a few milligrams to a few grams, depending on the substance, 3 or more times per week), contact Risk Management. Risk Management will arrange for a medical consultation, if appropriate.
- Keep accurate records of the amounts of these substances stored and used, the dates of use, and names of users.
- The designated area must be conspicuously marked with warning and restricted access signs and all containers should be appropriately labeled with identity and warning labels (e.g., CANCER-SUSPECT AGENT).
- Ensure that contingency plans, equipment, and materials to minimize exposures of people and property in case of accident are available.
- For a negative pressure glove box, ventilation rate must be at least 2 volume changes/hour and at a pressure of at least 0.5 inches of water gauge. For a positive pressure glove box, thoroughly test for leaks before each use. In either case, trap the exit gases or filter them through a HEPA filter and then release them into a fume hood.
- Use chemical decontamination whenever possible; ensure that containers of contaminated wasted are transferred from the designated area under the supervision of authorized personnel.