Chemical Hygiene Plan

Purdue Chemical and Laboratory Safety Committee
Adopted: February 2014
Revised: June 14, 2024

PURDUE UNIVERSITY
Chemical Hygiene Plan

Lab-Specific Plan

This is the Chemical Hygiene Plan (CHP) specific to the following areas:

Building(s): ______________________________

Room Number(s): ______________________________

Principal Investigator (Lab Supervisor): ______________________________

Department: ______________________________

Revised *(Must be reviewed at least annually.)*: ______________________________

Important Telephone Numbers:

- 911 for All Emergencies
- 765-494-8221 Purdue Police Department (Non-Emergency Line)
- 765-494-6919 Purdue Fire Department (Non-Emergency Line)
- 765-494-6371 Purdue EHS (Do Not Use for an Emergency)

Laboratories engaged in the laboratory use of hazardous chemicals must maintain a lab-specific Chemical Hygiene Plan (CHP) which conforms to the requirements of 29 CFR 1910.1450, the Occupational Safety and Health Administration (OSHA) Occupational Exposure to Hazardous Chemicals in Laboratories Standard (Lab Standard). Purdue University laboratories may use this document as a starting point for creating their lab-specific CHP. At a minimum, this cover page must be edited for location specificity (laboratories on campuses other than West Lafayette must replace emergency, fire, and police telephone numbers with those used at their specific campus or location). In addition, all lab employees must complete a Lab-Specific Training Certification form. This instruction and information box should remain. This model Chemical Hygiene Plan is the 2014 version; the most current version can also be found on the Environmental Health and Safety website EHS Forms page.

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CHP Document Abbreviations List

ANSI	American National Standards Institute
ASTM	American Society of Testing and Materials
CFR	Code of Federal Regulations
CHO	Chemical Hygiene Officer
CHP	Chemical Hygiene Plan
CLSC	Chemical and Laboratory Safety Committee
DOT	Department of Transportation
EHS	Environmental Health and Safety
EPA	Environmental Protection Agency
GFCI	Ground Fault Circuit Interrupter
GHS	Globally Harmonized System of Classification and Labeling of Chemicals
HBr	Hydrogen Bromide
HF	Hydrofluoric Acid
HEPA	High-Efficiency Particulate Air
HPLC	High Performance Liquid Chromatography
IBC	Institutional Biosafety Committee
IDEM	Indiana Department of Environmental Management
ISP	Integrated Safety Plan
LC	Liquid Chromatography
LC50	Lethal Concentration 50%
LD50	Lethal Dose 50%
LEL	Lower Explosive Limit
LSC	Laser Safety Committee
MSDS	Material Safety Data Sheet
NFPA	National Fire Protection Association
OSHA	Occupational Safety and Health Administration
PCB	Polychlorinated Biphenyl
PHS	Particularly Hazardous Substance
PI	Principal Investigator
PPE	Personal Protective Equipment
RCRA	Resource Conservation and Recovery Act
rDNA	Recombinant Deoxyribonucleic Acid
RSC	Radiation Safety Committee
SAA	Satellite Accumulation Area
SDS	Safety Data Sheet
SOP	Standard Operating Procedure
UEL	Upper Explosive limit

Chapter 1: Introduction

Laboratory safety is an integral part of laboratory research and is essential to ensure that Purdue University's compliance with all applicable environmental, health and safety laws, regulations and requirements are met. The risks associated with laboratory research (workplace injuries, environmental incidents, and property losses or damage) are greatly reduced or eliminated when proper precautions and practices are observed in the laboratory. To better manage and mitigate these risks, Purdue University Environmental Health and Safety (EHS) has developed the Chemical Hygiene Plan (CHP), which is intended to be the cornerstone of your laboratory safety program and is designed to aid faculty, staff, and students in maintaining a safe environment in which to teach and conduct research. Each laboratory using hazardous materials is required to have a copy of the CHP readily available to all laboratory personnel. Each laboratory worker must be familiar with the contents of the CHP and the procedures for obtaining additional safety information needed to perform their duties safely.

1.1 Purpose

Purdue University is committed to providing a healthy and safe work environment for the campus community. The Purdue University CHP establishes a formal written program for protecting laboratory personnel against health and safety hazards associated with exposure to hazardous chemicals and must be made available to all employees working with hazardous chemicals in a laboratory setting. The CHP describes the proper use and handling procedures to be followed by faculty, staff, and all other personnel working with hazardous chemicals in laboratory settings.

1.2 Scope

The CHP applies to all laboratories that use, store, or handle hazardous chemicals and all personnel who work in these facilities. The information presented in the CHP represents best practices and provides a broad overview of the information necessary for the safe operation of laboratories that utilize hazardous chemicals. Laboratory use of hazardous chemicals is defined as handling or use of such chemicals in which all of the following conditions are met:

1. Chemical manipulations are carried out on a laboratory scale;
2. Multiple chemical procedures or chemicals are used;
3. The procedures involved are not part of a production process, nor in any way simulate a production process; and
4. Protective laboratory practices and equipment are made available and in common use to minimize the potential for employee exposure to hazardous chemicals.

The CHP was prepared in accordance with the requirements of the Occupational Safety and Health Administration (OSHA) Occupational Exposure to Hazardous Chemicals in Laboratories Standard (Lab Standard) found in 29 CFR 1910.1450, and is based on best practices identified in, among other sources, the "Global Harmonized System of Classification and Labeling of

Chemicals"; "Prudent Practices for Handling Hazardous Chemicals in Laboratories", published by the National Research Council, the American Chemistry Society Task Force on Laboratory Chemical and Waste Management's "Laboratory Waste Management, A Guidebook"; the Princeton University "Laboratory Safety Manual"; and the University of California – Los Angeles "Chemical Hygiene Plan".

1.3 CHP Use Instructions

The information presented in the CHP represents best practices and provides a broad overview of the information necessary for the safe operation of laboratories that utilize hazardous chemicals. It is not intended to be all inclusive. Departments engaged in work with hazardous chemicals or hazardous operations that are not sufficiently covered by the CHP must customize this document by adding appropriate sections, in the form of standard operating procedures (SOPs), hazard assessments, and any other written (or referenced) lab-specific operating procedures or protocols that address the hazards and how to mitigate risks. The following instructions detail how this CHP template should be used and customized by each laboratory:

- Review this template CHP provided by EHS.
- Insert your lab-specific standard operating procedures (SOPs) into your customized CHP under Tab 1 located in the back of the CHP document. More details regarding SOPs can be found in Chapter 4 of the CHP.
- Insert all other documented lab-specific rules, requirements, and procedures (e.g., equipment protocols, chemical experiment protocols, internal lab inspections or rules, etc.,) under Tab 2.
- Insert your lab-specific hazard assessments under Tab 3. More details regarding hazard assessments can be found in Chapter 6 of the CHP.
- Once each lab employee has reviewed and is familiar with the contents of the lab-specific CHP, document the training using the CHP Training Certification Form found in Appendix A of the CHP. See Chapter 9 for additional detail regarding CHP training.
- Review, update (if necessary), and retrain all employees on the lab-specific CHP at least annually and document this training.

1.4 Employee Rights and Responsibilities

As part of the OSHA Laboratory Standard, employees and other personnel who work in laboratories have the right to be informed about the potential hazards of the chemicals in their work areas and to be properly trained to work safely with these substances. This includes custodial and maintenance personnel (support staff) who work to maintain laboratories. All personnel, including principal investigators, laboratory supervisors, laboratory technicians, student workers, and support staff have a responsibility to maintain a safe work environment. All personnel working with chemicals are responsible for staying informed on the chemicals in their work areas, safe work practices and SOPs, and proper personal protective equipment (PPE) required for the safe performance of their laboratory work.

1.4.1 Laboratory Supervisor Responsibilities

The Laboratory Supervisor is the individual that is ultimately responsible for the overall laboratory operation, including the lab safety program and ensuring that the requirements of the CHP are followed by all staff members that work in the lab. For most research laboratories, the Principal Investigator (PI) is the Laboratory Supervisor. In cases where the PI has hired an individual such as a lab manager or postdoctoral scholar to manage the daily operations of the lab, the PI is still ultimately responsible for the overall operation of the lab and is considered to be the Laboratory Supervisor. The Laboratory Supervisor may delegate some safety duties to a qualified individual, but ultimately remains responsible for the safety of all personnel working in the laboratory. Specifically, the Laboratory Supervisor must:

- Understand applicable environmental health and safety rules, including the contents of the CHP;
- Identify hazardous conditions or operations in the laboratory and establish SOPs and hazard assessments to effectively control or reduce hazards;
- Ensure that all laboratory personnel that work with hazardous chemicals receive appropriate training (refer to Chapter 9 for detailed training requirements);
- Maintain written records of lab-specific training (e.g., PPE training);
- Ensure that appropriate PPE (e.g., laboratory coats, gloves, eye protection, etc.,) and engineering control equipment (e.g., chemical fume hood) are made available, in good working order, and being used properly;
- Conduct periodic lab inspections and immediately take steps to abate hazards that may pose a risk to life or safety upon discovery of such hazards; and
- Actively enforce all applicable safety procedures and ensure that the CHP is followed by lab staff and all visitors, including having a progressive disciplinary process for lab staff members that do not comply with safety rules.

Laboratory Supervisors must ensure that employees receive CHP training and information before any work with hazardous materials occurs. Laboratory Supervisors must also ensure that all employees receive annual CHP refresher training. The Laboratory Supervisor can provide the training or delegate this task to a qualified individual (e.g., Laboratory Safety Officer, senior lab employee). The CHP training must be documented. See Appendix A for the CHP Lab-Specific Training Certification form, which can be used to document reading the CHP. Failure to follow the requirements of the CHP could possibly result in injuries, fines from regulatory agencies such as OSHA, and/or disciplinary action.

1.4.2 Laboratory Employee Responsibilities

All employees (e.g., graduate research assistants, graduate students, undergraduate students, lab technicians, post-doctoral researchers, and visiting scientists) in laboratories that use, handle, or store hazardous chemicals must:

1. Review and follow the requirements of the CHP;
2. Follow all verbal and written laboratory safety rules, regulations, and SOPs required for the tasks assigned;
3. Develop and practice good personal chemical hygiene habits such keeping work areas clean and uncluttered;
4. Plan, review, and understand the hazards of materials and processes in the laboratory prior to conducting work;
5. Utilize appropriate measures to control hazards, including consistent and proper use of engineering controls, administrative controls, and PPE;
6. Understand the capabilities and limitations of PPE;
7. Immediately report all accidents, near misses, and unsafe conditions to the Laboratory Supervisor;
8. Complete all required EHS and/or other mandatory safety training and provide written documentation to the Laboratory Supervisor;
9. Participate in the EHS managed medical surveillance program when required; and
10. Inform the Laboratory Supervisor of any work modifications ordered by a physician as a result of medical surveillance, occupational injury, or chemical exposure.

1.4.3 Laboratory Safety Officer Responsibilities

Very often it is not practical for the Laboratory Supervisor to be present in the lab on a daily basis to ensure that safe and compliant practices are being carried out by all lab staff. For this reason, it is highly recommended that each Laboratory Supervisor establish a Laboratory Safety Officer to manage the daily operations of the lab's safety program. The Laboratory Supervisor should empower the Laboratory Safety Officer to make decisions on daily operations involving safety and compliance, including the authority to instruct other lab personnel to follow all safety procedures (e.g., PPE use, hazardous waste procedures, etc.). This person should be familiar with how the lab operates and have demonstrated lab safety experience (e.g., senior graduate student, post-doc, lab manager). Having a Laboratory Safety Officer in the lab provides many benefits such as:

- Other lab personnel know who to contact with questions about daily operations involving safety and compliance;
- Empowers someone other than the Laboratory Supervisor to enforce lab safety rules;
- Provides consistency within the respective academic department; idea is that each Laboratory Safety Officer attends departmental safety committee meetings and reports issues back to the lab; and
- Provides good, marketable experience for the Laboratory Safety Officer to be involved in a safety leadership role.

The role of the Laboratory Safety Officer should include:

1. Provide appropriate training to new lab personnel and ensure that the training is properly documented;
2. Enforce lab safety rules;
3. Attend departmental/college level safety committee meetings and report significant information back to the lab; and
4. Report safety issues back to the Laboratory Supervisor when necessary.

1.4.4 Non-Laboratory Personnel / Support Staff Responsibilities

Custodians and maintenance staff (support staff) often must enter laboratories to perform routine tasks such as cleaning and equipment maintenance. Support staff members are expected to follow the posted safety rules of each laboratory. Minimum PPE requirements for support staff working in a laboratory are safety glasses, as well as a garment and fully enclosed shoes covering all skin beneath the waist. If additional PPE is required or if other unique safety requirements must be followed, it is the lab personnel's responsibility to notify support staff. These additional requirements should be clearly communicated to support staff; posting the requirements on the lab door or somewhere else highly visible is recommended.

1.4.5 Chemical Hygiene Officer Responsibilities

The Chemical Hygiene Officer, who is the Director of EHS, or designated individual(s), has the primary responsibility for ensuring the implementation of all components of the CHP. The Chemical Hygiene Officer must:

- Inform Laboratory Supervisors of all health and safety requirements and assist with the selection of appropriate safety controls (engineering controls, administrative controls, and PPE);
- Ensure that Laboratory Supervisors have the necessary resources to maintain compliance with the CHP and that all lab staff receive appropriate training;
- Act as the liaison between the Laboratory Supervisors and the Purdue Chemical Laboratory Safety Committee;

- Conduct periodic lab inspections and immediately take steps to abate hazards that may pose a risk to life or safety upon discovery of such hazards;
- Ensure that SOPs and hazard assessments are being prepared;
- Maintain employee exposure-monitoring records, when applicable;
- Help to develop and implement appropriate environmental health and safety policies and procedures;
- Review and evaluate the effectiveness of the CHP program at least annually and update it as appropriate; and
- Actively enforce all applicable safety procedures and ensure the contents of the CHP are followed; take appropriate actions when safety procedures are not followed.

1.5 Environmental Health and Safety Department

Environmental Health and Safety (EHS) serves as the environmental health and safety department for Purdue University. EHS's primary role is to manage regulatory compliance with all federal, state, and Purdue regulations involving environmental health and safety issues. EHS facilitates a number of programs that apply to laboratory safety, a few of which include biological safety, laser safety, personal protective equipment, radiation safety, development of standard operating procedures, as well as the CHP. EHS also performs numerous safety inspections of facilities throughout the year to monitor compliance with regulatory requirements. EHS also provides a variety of services such as chemical, biological, and radioactive waste pickups, and safety training and consultation. More information regarding all of EHS's resources and services can be found on the EHS website.

1.6 Integrated Safety Plan

It is the policy of Purdue University to integrate environmental health and safety into all operations. The Integrated Safety Plan (ISP), which is facilitated by EHS, was developed to provide a framework for laboratories to comply with environmental health and safety (EHS) regulations. The ISP assists in communication of EHS issues across the organization and calls for departmental level safety committees and individual self-audits. The ISP provides indemnification from regulatory fines for units with a certified safety program. An ISP certified safety program must have the following elements:

- Regular safety committee meetings;
- Means of communicating safety issues to the department in a timely manner;
- Upper administrative support for safety;
- Self-audits checklists, which is a self-inspection program, must be completed for all areas;
- Abatement of deficiencies found during the self-audits;
- An annual safety program audit and walk-through by EHS; and
- Recommendation for ISP certification renewal from EHS

More information about the ISP program can be found on the EHS Integrated Safety Plan webpage.

1.7 Chemical and Laboratory Safety Committee

Purdue University has established the Chemical and Laboratory Safety Committee (CLSC) with the responsibility to promote safe and proper chemical management at all Purdue University Campuses and related facilities. Chemical management includes, but is not limited to, the procurement and the safe handling, use, storage, and disposal of chemicals. The CLSC reviews lab safety programs and makes recommendations to the provost as appropriate. The CLSC consists of members appointed from the faculty and staff of the major research, teaching, and service areas where chemicals are handled or used. Although EHS facilitates the content of the CHP, it is ultimately the responsibility of the CLSC to approve changes and updates to the CHP.

Chapter 2: Hazardous Chemical Classification Systems

Chemical classification systems are designed to communicate hazards. The three most widely used classification systems are the OSHA Globally Harmonized System for Classifying and Labeling Chemicals (implemented under the OSHA Hazard Communication Standard), the National Fire Protection Association (NFPA) system of classifying the severity of hazards, and the Department of Transportation (DOT) hazard classes. These classification systems are used by chemical manufacturers when creating safety data sheets and chemical labels, therefore it is important that Purdue lab employees understand the basic elements of each classification system.

2.1 Globally Harmonized System for Classifying Chemicals

The Globally Harmonized System (GHS) is a world-wide system adopted by OSHA for standardizing and harmonizing the classification and labeling of chemicals. The objectives of the GHS are to:

- Define health, physical, and environmental hazards of chemicals;
- Create classification processes that use available data on chemicals for comparison with the defined hazard criteria (numerical hazard classification is based on a 1 – 5 scale, 1 being the most hazardous and 5 being the least hazardous); and
- Communicate hazard information, as well as protective measures, on labels and Safety Data Sheet (SDS), formerly known as Material Safety Data Sheets (MSDS).

2.1.1 Safety Data Sheets

The SDS provides comprehensive information that is imperative for the safe handling of hazardous chemicals. Laboratory personnel should use the SDS as a resource to obtain information about hazards and safety precautions. SDSs cannot provide information for hazards in all circumstances. However, the SDS information enables the employer to develop an active program of worker protection measures such as training on hazard mitigation. Chemical manufacturers are required to use a standard format when developing SDSs. The SDS will contain 16 headings which are illustrated in Figure 2.1.

1.	Identification of the substance or mixture and of supplier	**9.**	Physical and chemical properties
2.	Hazards Identification	**10.**	Stability and reactivity
3.	Composition/information on ingredients	**11.**	Toxicological information
4.	First aid measures	**12.**	Ecological information
5.	Firefighting measures	**13.**	Disposal considerations
6.	Accidental release measures	**14.**	Transport considerations
7.	Handling and storage	**15.**	Regulatory information
8.	Exposure controls/personal protection	**16.**	Other information

Figure 2.1 – GHS Required Sections of a Safety Data Sheet

2.1.2 Chemical Labeling

The GHS standardized label elements, which are not subject to variation and must appear on the chemical label, contain the following elements:

- Symbols (hazard pictograms) are used to convey health, physical and environmental hazard information, assigned to a GHS hazard class and category;
- Signal Words such as “Danger" (for more severe hazards) or "Warning" (for less severe hazards), are used to emphasize hazards and indicate the relative level of severity of the hazard assigned to a GHS hazard class and category;
- Hazard statements (e.g., “Danger! Extremely Flammable Liquid and Vapor”) are standard phrases assigned to a hazard class and category that describe the nature of the hazard; and
- Precautionary statements are recommended measures that should be taken to minimize or prevent adverse effects resulting from exposure to the hazardous chemical.

The GHS also standardizes the hazard pictograms that are to be used on all hazard labels and SDSs. There are 9 pictograms that represent several defined hazards, and include the harmonized hazard symbols which are intended to convey specific information about each hazard. Figure 2.2 illustrates these GHS hazard pictograms.

		
Carcinogen, Respiratory Sensitizer, Reproductive Toxicity, Target Organ Toxicity, Mutagenicity	**Flammable, Pyrophoric, Self-Heating, Emits Flammable Gas, Organic Peroxide**	**Irritant, Dermal Sensitizer, Acute Toxicity (harmful), Narcotic Effects**
		
Gas Under Pressure	**Corrosive**	**Explosive, Organic Peroxide, Self-Reactive**
		
Oxidizer	**Environmental Toxicity**	**Acute Toxicity (Severe)**

Figure 2.2 – GHS Hazard Pictograms

GHS labeling requirements are only applicable to chemical manufacturers, distributors, and shippers of chemicals. GHS labeling requirements are not required for chemicals being stored in a laboratory. However, since most chemicals stored in the laboratory have been purchased from a chemical manufacturer, the GHS labeling and pictogram requirements are very relevant and must be understood by laboratory employees. Figure 2.3 illustrates the GHS label format showing the required elements.

ACETONE

PRODUCT IDENTIFIER
Code:
Product Name:

SUPPLIER IDENTIFICATION
Company Name:
Address:
Phone Number:

PRECAUTIONARY STATEMENTS
Keep away from heat, sparks, open flames, hot surfaces – No smoking.
Avoid breathing dust, fumes, gas, mist, vapors, and spray.
IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing.
Repeated exposure may cause skin dryness and cracking.
In Case of Fire: Use water spray, alcohol-resistant foam, dry chemical, or carbon dioxide.
First Aid: Move out of dangerous area. Consult a physician. If inhaled, move person to fresh air. If not breathing, give artificial respiration. In case of skin contact, wash with soap and plenty of water. In case of eye contact, rinse thoroughly with plenty of water for at least 15 minutes. If swallowed, do not induce vomiting. Never give anything by mouth to an unconscious person. Rinse mouth with water, consult a physician.

HAZARD PICTOGRAMS

SIGNAL WORD
Danger

HAZARD STATEMENT
Highly flammable liquid and vapor.
Causes mild skin irritation.
Causes serious eye irritation.
May cause drowsiness or dizziness.

Figure 2.3 – GHS Label Format

As mentioned earlier, one of the objectives of GHS was to create a quantitative hazard classification system (numerical hazard classification is based on a 1 – 5 scale, 1 being the most hazardous and 5 being the least hazardous) based on physical characteristics such as flash point, boiling point, lethal dose of 50% of a population, reactivity, etc. Table 2.1 illustrates how the numerical hazard classification works for flammable liquids. More information on GHS can be found on the OSHA website.

Table 2.1 – GHS Hazard Classification System for Flammable Liquids

Category	Criteria	Pictogram	Signal Word	Hazard Statement
1	Flash point < 23 °C Boiling point ≤ 35 °C		Danger	Extremely flammable liquid and vapor
2	Flash point < 23 °C Boiling point > 35 °C		Danger	Highly flammable liquid and vapor
3	Flash point ≥ 23 °C and < 60 °C		Warning	Flammable liquid and vapor
4	Flash point ≥ 60 °C and ≤ 93 °C		Warning	Combustible liquid
5	There is no Category 5 for flammable liquids			

2.2 National Fire Protection Association Rating System

The NFPA system uses a diamond-shaped diagram of symbols and numbers to indicate the degree of hazard associated with a particular chemical. This system was created to easily and quickly communicate hazards to first responders in the event of an emergency situation. These diamond-shaped symbols are placed on chemical containers to identify the degree of hazard associated with the specific chemical or chemical mixture. The NFPA system is a common way to identify chemical hazards and should be understood by laboratory employees. The NFPA 704 numerical rating system is based on a 0 – 4 system; 0 meaning no hazard and 4 meaning the most hazardous (note: this in contrast to the GHS system of 1 –5 where 1 is the most hazardous and 5 is the least hazardous). Figure 2.4 illustrates the NFPA hazard rating system and identifies both the hazard categories and hazard rating system.

Health Hazard	Fire Hazard	Reactivity Hazard	Specific Hazard
4 - Deadly **3** - Extreme Danger **2** - Hazardous **1** - Slightly Hazardous **0** – Normal Material	**4** - FP* < 73° F **3** - FP < 100° F **2** - 100° F < FP < 200° F **1** - FP > 200° F **0** - Will Not Burn * FP = Flash Point	**4** - May Detonate **3** - Shock/Heat May Detonate **2** - Violent Chemical Change **1** - Unstable if Heated **0** - Stable	**ACID** Acid **ALK** Alkali **COR** Corrosive **~~W~~** No Water Radioactive

Figure 2.4 – NFPA Hazard Rating System

2.3 Department of Transportation Hazard Classes

The DOT regulates the transportation of all hazardous materials in the United States, and defines a hazardous material as any substance that has been determined to be capable of posing an unreasonable risk to health, safety, or property when transported in commerce. There are several methods that can be employed to determine whether a chemical is hazardous for transport, a few of which included:

- Reviewing the DOT Hazardous Materials Table (49 CFR 172.101);
- Reviewing the SDS, specifically Section 2: Hazardous Identification and Section 14: Transport Considerations, for the chemical being shipped, as detailed above in Section 2.1.1 of the CHP;
- Reviewing the chemical label and looking for hazard information detailed above in Section 2.1.2 of the CHP; and
- Understanding the chemical and physical properties of the chemical.

All hazardous chemicals must be properly labeled by the chemical manufacturer or distributor before transportation occurs. Chemical containers stored in laboratories are not required to be labeled per DOT standards; however the DOT 9 hazard classes are often seen on chemical containers and are discussed in Section 14 of GHS-formatted SDSs. The DOT 9 hazard classes are illustrated below in Figure 2.5. It should be noted that Figure 2.5 only lists the primary hazard classes, the sub classes (e.g., Organic Peroxides, DOT Class 5.2) were omitted for stylistic purposes.

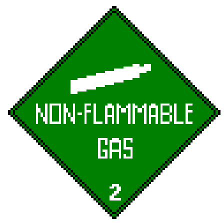
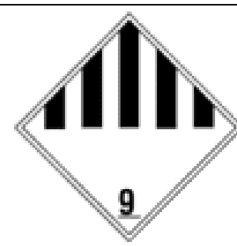
		
DOT Class 1 Explosives	**DOT Class 2 Compressed Gases**	**DOT Class 3 Flammable Liquids**
		
DOT Class 4 Flammable Solids	**DOT Class 5 Oxidizers**	**DOT Class 6 Poisons**
		
DOT Class 7 Radioactive Materials	**DOT Class 8 Corrosives**	**DOT Class 9 Miscellaneous**

Figure 2.5 – NFPA Hazard Rating System

Chapter 3: Classes of Hazardous Chemicals

Chemicals can be divided into several different hazard classes. The hazard class provides information to help determine how a chemical can be safely stored and handled. Each chemical container, whether supplied by a chemical manufacturer or produced in the laboratory, must have a label that clearly identifies the chemical constituents. In addition to a specific chemical label, more comprehensive hazard information can be found by referencing the SDS for that chemical. The OSHA 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. This definition of a hazardous chemical and the GHS primary classes of chemicals are briefly discussed below.

3.1 Physical Hazards

A chemical is a physical hazard if there is scientifically valid evidence that it is flammable, combustible, water reactive, explosive, organic peroxide, oxidizer, pyrophoric, self-heating, self-reactive, or a compressed gas. Each physical hazard is briefly defined below. Refer to Appendix B (section B.1) for detailed information on each physical hazard.

- **Explosives:** A liquid or solid which is in itself capable by chemical reaction of producing gas at such a temperature and pressure and at such a speed as to cause damage to the surroundings.
- **Flammable Liquids:** Materials which under standard conditions can generate sufficient vapor to cause a fire in the presence of an ignition source and have a flash point no greater than 93 °C (200 °F).
- **Flammable Solid:** A solid which is readily combustible, or may cause or contribute to a fire through friction.
- **Gases under Pressure:** Gases which are contained in a receptacle at a pressure not less than 280 kPA at 20 °C or as a refrigerated liquid.
- **Organic Peroxide:** A liquid or solid which contains the bivalent -0-0- structure and may be considered a derivative of hydrogen peroxide, where one or both of the hydrogen atoms have been replaced by organic radicals.
- **Oxidizer:** A liquid or solid, while in itself is not necessarily combustible, may generally by yielding oxygen, cause or contribute to the combustion of other material.
- **Pyrophoric Substance (also called Spontaneously Combustible):** A liquid or solid that even in small quantities and without an external ignition source can ignite after coming in contact with the air.
- **Self-Heating Substance:** A liquid or solid, other than a pyrophoric substance, which, by reaction with air and without energy supply, is liable to self-heat.
- **Self-Reactive Substance:** A liquid or solid that is liable to undergo strong exothermic thermal decomposition even without participation of oxygen (air).
- **Water-Reactive Substance:** A liquid or solid that reacts violently with water to produce a flammable or toxic gas, or other hazardous conditions.

3.2 Health Hazards

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. Each health hazard is briefly defined below. Refer to Appendix B (section B.2) for detailed information on each health hazard.

- **Carcinogens:** Substances that cause cancer. Generally, they are chronically toxic substances; that is, they cause damage after repeated or long-duration exposure, and their effects may only become evident after a long latency period. Carcinogens are separated into two classes: select carcinogens and regulated carcinogens.
- **Corrosives:** Substances that cause destruction of living tissue by chemical corrosion at the site of contact and can be either acidic or caustic (basic).
- **Hazardous Substances with Toxic Effects on Specific Organs:** Substances that pose adverse health effects to specific organs such as the liver, kidneys, lungs, etc.
- **High Acute Toxicity Substances:** Substances that may be fatal or cause damage to target organs as the result of a single exposure or exposures of short duration. Acute toxins are quantified by a substance's lethal dose-50 (LD50) or lethal concentration-50 (LC50), which is the lethal dose of a compound to 50% of a laboratory tested animal population (e.g., rats, rabbits) over a specified time period.
- **Irritant:** Substances that cause reversible inflammatory effects on living tissue by chemical action at the site of contact.
- **Reproductive Toxins:** Substances that may affect the reproductive capabilities, including chromosomal damage (mutations) and effects on fetuses (teratogens).
- **Sensitizer (also called allergen):** A substance that causes exposed individuals to develop an allergic reaction in normal tissue after repeated exposure to the substance.

3.3 Biological Hazards

The Purdue University Institutional Biosafety Committee (IBC) is the campus-based committee that has the responsibility for reviewing and approving all proposals, activities, and experiments involving an organism or product of an organism that presents a risk to humans, plants, animals, or the environment. The Laboratory Supervisor must submit to the IBC an application to use rDNA, synthetic nucleic acids, potential pathogens, human tissue, fluids, and/or cell lines in their research. The IBC review is conducted in accordance with the guidance and requirements of National Institutes of Health, the Centers for Disease Control, and Purdue University policies, and the Biosafety Manual. All Laboratory Supervisors have an obligation to be closely familiar with EHS guidelines applicable to their work and to adhere to them. More detail regarding the IBC process can be found on the Purdue Office of the Vice President for Research website.

3.4 Radioactive Material Hazards

The Purdue University Radiation Safety Committee (RSC) is the campus-based committee that has the responsibility for reviewing and approving all proposals, activities, and experiments involving radioactive material and radiation producing devices. The Laboratory Supervisor must submit to the RSC through EHS, an application to use radioactive material or radiation-producing devices. Use of radioactive materials at Purdue University is authorized under a license issued by the US Nuclear Regulatory Commission or a registration with the Indiana State Department of Health and all work must comply with applicable regulations. The policies and procedures for handling radioactive materials are contained in the *Purdue University Radiation Safety Manual*.

3.5 Laser Hazards

The Purdue University Laser Safety Committee (LSC) is the campus-based committee that has the responsibility for reviewing and approving all proposals, activities, and experiments involving laser radiation devices. Laboratory Supervisors must submit to the LSC through EHS, an application to use Class 3B and Class 4 lasers or laser devices. The use of lasers is subject to OSHA regulations and utilizes current ANSI standards to develop guidance. The policies and procedures for handling lasers are contained in the *Purdue University Laser Safety Guidelines*.

Chapter 4: Laboratory Safety Controls

Laboratory safety controls include engineering controls, administrative controls, and PPE. Elements of these three categories should be used in a layered approach to minimize employee exposure to hazardous chemicals. The hierarchy of controls prioritizes hazard mitigation strategies on the premise that the best way to control a hazard is to systematically eliminate it from the workplace or substitute a less hazardous technique, process, or material. If elimination or substitution are not feasible options, administrative controls, engineering controls, and PPE must be used to provide the necessary protection. The laboratory employee's responsibility is to follow administrative controls, use engineering controls, and wear PPE correctly and effectively.

4.1 Routes of Exposure

There are four primary routes of exposure in which hazardous substances can enter the body: inhalation, absorption, ingestion, and injection. Of these, the most likely routes of exposure in the laboratory are by inhalation or skin absorption. Many hazardous chemicals may affect people through more than one of these exposure modes, so it is critical that protective measures are in place for each of these exposure routes.

4.2 Engineering Controls and Safety Equipment

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

- Substitution with less hazardous equipment, chemicals, or processes (e.g., safety cans for glass bottles);
- Isolation of the operator or the process (e.g., use of a glove box when handling air- or water-sensitive chemicals); and
- Use of forced ventilation systems (e.g., chemical fume hood, biological safety cabinet).

4.2.1 Chemical Fume Hoods

A chemical fume hood is a type of local ventilation installation that is designed to limit exposure to hazardous or toxic fumes, vapors, or dusts. To determine if a chemical is required to be used inside of a chemical fume hood, first check the SDS for that chemical. Statements found in Section 2 on a SDS such as "do not breathe dust, fumes, or vapors" or "toxic by inhalation" indicate the need for ventilation. As a best practice, always use a chemical fume hood for all work involving the handling of open chemicals (e.g., preparing solutions, transferring chemicals) whenever possible. If a chemical fume hood is required or recommended to be used, the following guidelines must be followed at all times:

- Chemical fume hoods must be marked to indicate the proper sash position for optimum hood performance as illustrated in Figure 4.1. The chemical fume hood sash should be positioned at this height whenever working with hazardous chemicals that could generate toxic aerosols, gases, or vapors. In general, the sash height should be set at a level where the operator is shielded to some degree from any splashes, explosions, or other violent reactions which could occur and where optimum air flow dynamics are achieved. Most chemical fume hoods are not intended to be used with the sash fully open. The sash should only be fully opened to add or remove equipment from the chemical fume hood.

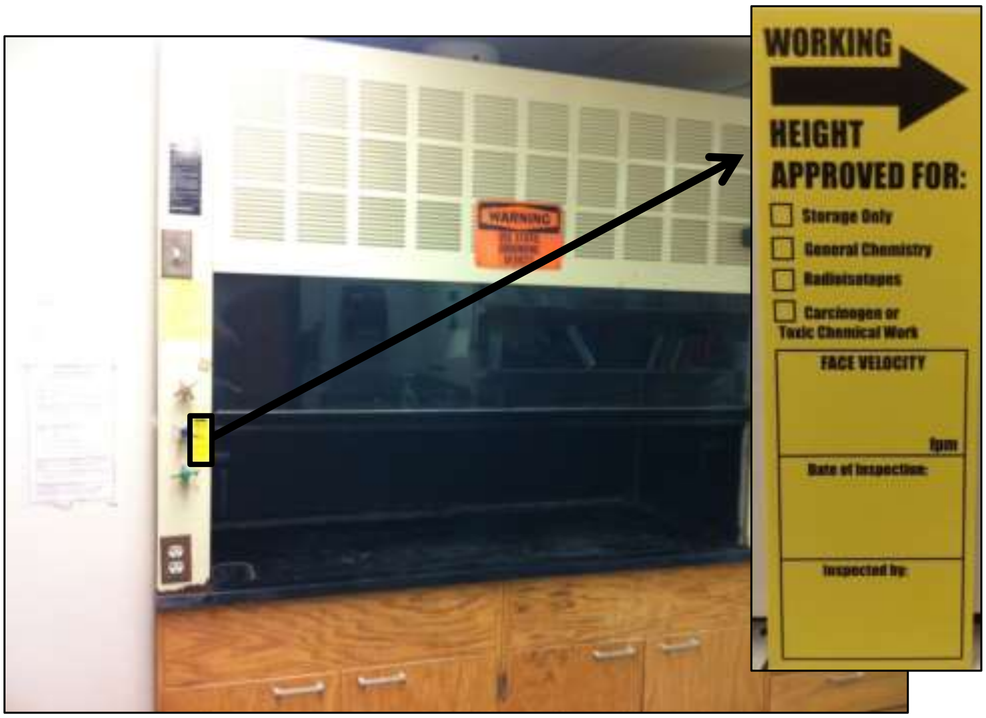


Figure 4.1 – Chemical Fume Hood Sash Approved Working Height

- Chemical fume hoods must be equipped with a continuous reading monitoring device to indicate the adequacy of flow. All lab employees must know how to read and interpret this gauge and check that the fume hood is operating properly before using hazardous chemicals in the fume hood. There are many different types of chemical fume hoods on campus, so it is important that the lab employee understands the specific functions of each chemical fume hood used in the lab.
- Only apparatus and chemicals essential to the specific procedure or process should be placed in the chemical fume hood. Extraneous materials from previous experiments should be removed and stored in a safe location outside the chemical fume hood.
- Chemical fume hoods used for experimental work should not be used for chemical or equipment storage. Fume hoods used for chemical storage

should only be used for storage; experimental work should not be conducted in these hoods.

- All chemical containers used in fume hoods, including secondary containers (e.g., beakers, flasks, reaction vessels, vials, etc.) must be labeled. If is not practical to label a secondary container that is in process (e.g., reaction vessel, flask), a temporary label can be used as shown in Section 5.7 of the CHP. Reaction vessels in chemical fume hoods must also be labeled. If labeling the vessel itself is not practical, the hood sash or wall may be labeled as illustrated in Figure 4.2.

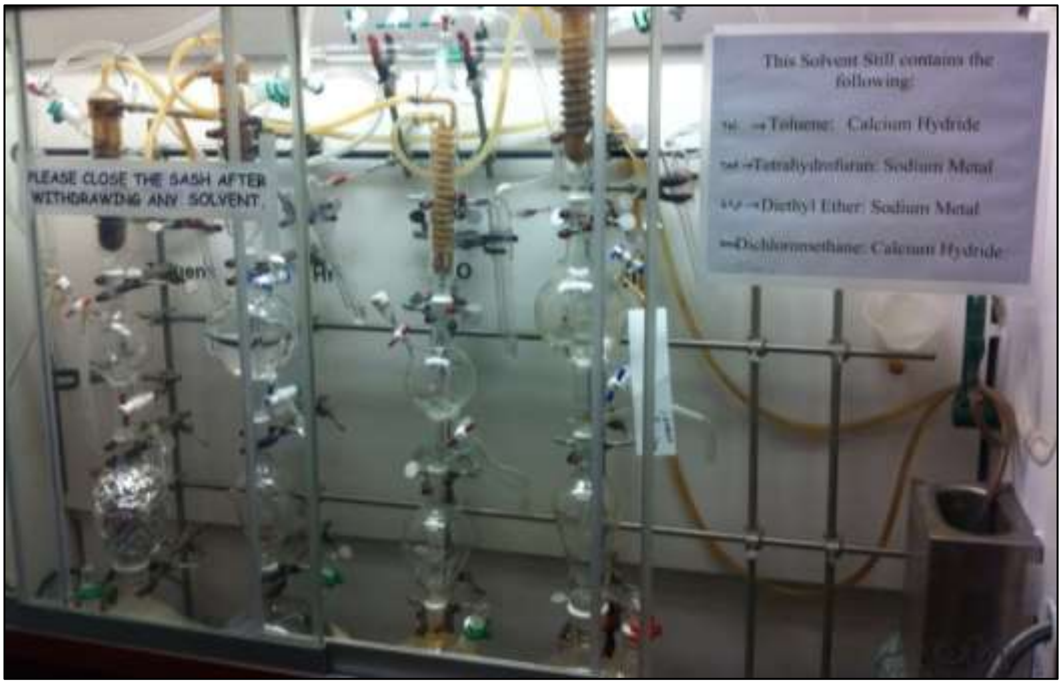


Figure 4.2 – Alternative Labeling of Chemical Fume Hood Reaction Vessels

- Do not allow the vents or air flow baffles to be blocked, as this can interfere with the designed and optimal air flow of the chemical fume hood.
- Never put your head inside of an operating chemical fume hood.
- All chemical fume hoods should be routinely checked for airflow by measuring the face velocity, which should be between 70-125 feet per minute. EHS conducts face velocity readings on a routine basis and records this information on the hood label. Contact EHS with questions regarding chemical fume hoods 765-494-6371.

4.2.2 Glove Boxes

A glove box, as illustrated in Figure 4.3, is a sealed container that is designed to allow material to be handled in a specific atmosphere (typically inert). Glove boxes can be used to protect sensitive items inside the glove box or the user on the outside of the glove box, or both. The following recommendations should be followed by all personnel using a glove box:

Figure 4.3 – Glove Box

- All personnel must receive documented training from the Laboratory Supervisor or delegate before any work in a glove box occurs. All trained personnel must understand the design features and limitations of the glove box before use. The training must include detailed instruction on elements such as the ventilation and vacuum controls that maintain a pressure differential between the glove box and outside atmosphere, atmospheric controls (e.g., controlling oxygen concentrations and moisture), etc.
- Prior to use, a visual glove inspection must be performed. Changing of a glove must be documented (date, manufacturer, model of glove, and person performing change). Gloves should not be used until they fail; they should be changed according to the glove box manufacturer's recommendations or whenever necessary.
- Plugging ports that are never or infrequently used is recommended. A properly plugged port should have a stub glove and a glove port cap installed.
- Chemical resistant gloves (e.g., disposable nitrile gloves) should be used under the glove box gloves to protect from contamination.
- The gloves box gloves should be cleaned on a routine basis (before each use is recommended) as a good hygiene practice.
- The glove box pressure must be checked before use and immediately after gloves are changed. The pressure check should be documented.
- Keep sharps in an approved container while in the glove box.
- Do not work in the glove box unless the lighting is working.

- Follow all safe work practices for using and handling compressed gas that may be associated with working in the glove box. Follow the manufacturer's recommendations.
- All equipment and chemicals in the glove box must be organized and all chemicals must be labeled. Do not allow items, particularly chemicals to accumulate in the glove box.

4.2.3 Laminar Flow Clean Benches

A laminar flow clean bench, as shown in Figure 4.4, is an enclosed bench designed to prevent contamination of semiconductor wafers, samples, or any particle sensitive device. Air is drawn through a filter and blown in a very smooth, laminar flow towards the user. Therefore it is critical that absolutely no hazardous chemicals, infectious and/or radioactive materials ever be used in a laminar flow clean bench, as the vapors are blown directly towards the user. Applications that involve the use of chemicals should be conducted in chemical fume hoods.

Figure 4.4 – Laminar Flow Clean Bench

4.2.4 Biological Safety Cabinets

A biological (or biosafety) safety cabinet, as shown in Figure 4.5, is an enclosed, ventilated laboratory workspace used for safely working with materials contaminated with (or potentially contaminated with) infectious materials. The primary purpose of a biosafety cabinet is to serve as a means to protect the laboratory worker and the surrounding environment from pathogens. All exhaust air is filtered as it exits the biosafety cabinet, removing harmful particles. Biological safety cabinets are not designed to be used with chemical applications so the use of chemicals should be kept to a minimum. Applications that involve the use of chemicals should be conducted in chemical fume hoods.

Figure 4.5 – Biological Safety Cabinet

4.2.5 Safety Showers and Eyewash Stations

All laboratories using hazardous chemicals must have immediate access to safety showers and eye wash stations. Safety showers must have a minimum clearance of 24 inches from the centerline of the spray pattern in all directions at all times. Identify the safety station with a highly visible sign and maintain an unobstructed path to it. All lab personnel must be aware of the location and know how to properly use the safety shower and eyewash stations.

If lab personnel are exposed to a hazardous chemical, they should dial 911 (or someone else in the lab that is not exposed should dial 911) and use the safety shower and/or eye wash unit for 15 minutes or until emergency response have personnel arrive and begin treatment. If an uninjured individual is present, this person should assist with the decontamination of the affected individual.

All eyewash stations must be flushed by laboratory personnel on a weekly basis to ensure proper working order. This will keep the system free of sediment and prevent bacterial growth from reducing performance. EHS performs annual inspections of all campus safety shower and eyewash stations. This inspection evaluates the basic mechanical functionality of each station. Any deficiencies are repaired either by EHS staff or by Purdue Physical Facilities maintenance staff. If the safety shower or eye wash unit becomes inoperable, notify your building deputy immediately.

4.2.6 Fire Extinguishers

All fire extinguishers should be mounted on a wall in an area free of clutter. Each fire extinguisher on campus is inspected on an annual basis by the Purdue Fire Department. All laboratory personnel should be familiar with the location, use, and classification of the extinguishers in their laboratory. Ensure that the fire extinguisher being used is appropriate for the type of material on fire before attempting to extinguish any fire. Table 4.1 illustrates the fire classification system, which should be used to determine the most suitable fire extinguisher for a particular area. Laboratory personnel are not required to extinguish fires that occur in their work areas and should not attempt to do so unless:

- It is a small, contained fire that can be quickly and safely extinguished (e.g., small trashcan sized fire);
- Appropriate training has been received and the individual feels the fire can be safely extinguished; and
- It is necessary to extinguish a fire in order to safely exit an area (e.g., fire is blocking an exit).

If a fire occurs in the laboratory and is extinguished by lab personnel, the Purdue University Fire Department must still be contacted immediately by dialing 911. It is common for fires to reignite so it is critical that the Purdue Fire Department still be contacted.

Table 4.1 – Fire Classifications System

Classification	Fire Type
Class A	Ordinary fire (wood and paper)
Class B	Flammable liquids and gases
Class C	Electric fire
Class D	Combustible metal fire
Class K	Kitchen fire

4.2.7 Laboratory Doors

Chemical Hygiene Plan laboratory doors that open to public corridors or spaces must be kept closed at all times to:

- Aid in maintaining proper building airflow and balance as well as
- Provide a level of containment for fire, smoke, odors, and other potential contaminants that may make their way into public access corridors and spaces

Most laboratories at Purdue University have fire doors equipped with a self-closing assembly that exerts enough force to close and latch the door from any partially open position. Fire doors must remain closed at all times unless equipped with a hold-open device and automatic door closer that ensures it closes in a fire or upon smoke/fire alarm system activation. Do not block, obstruct, prop open, disable or modify a closing assembly, or otherwise make a fire door inoperable. Using chocks or installing manually operated hold-opens on fire doors is never acceptable. If a fire door that does not have a hold-open device and automatic door closer must be held open, it must be done by a person.

4.3 Administrative Controls

Administrative controls are procedural measures which can be taken to reduce or eliminate hazards associated with the use of hazardous materials. Administrative controls include, but are not limited to, the following:

- Ensuring that employees are provided adequate documented training for safe work with hazardous materials
- Careful planning of experiments and procedures with safety in mind; planning includes the development of written SOPs and hazard assessments (discussed in detail in Chapter 6) for safe performance of the work
- Discussing safety on a regular basis (e.g., during lab meetings) and creating an atmosphere where people feel comfortable talking about safety
- Restricting access to areas where hazardous materials are used
- Using safety signs or placards to identify hazardous areas (designated areas)
- Labeling all chemicals
- Substitution of toxic materials with less toxic materials, when possible
- Good housekeeping and good personal hygiene such as routine hand washing and regular decontamination of areas that are possibly chemically contaminated such as bench-tops and fume hoods
- Prohibiting eating and drinking where chemicals are used or stored

4.3.1 Standard Operating Procedures

SOPs are written instructions that detail the steps that will be performed during a given procedure and include information about potential hazards and how these hazards will be mitigated. SOPs must be prepared by laboratory personnel who are the most knowledgeable and involved with the experimental process. However, the Laboratory Supervisor is ultimately responsible for approving SOPs regardless of who prepares them.

The OSHA Lab Standard requires SOPs to be developed for all hazardous tasks that are performed in the lab. This would include work with hazardous chemicals (e.g., flammable liquids, compressed gases, etc.) and also work with hazardous equipment/operations (e.g., solvent distillation, hydrogenation, centrifuge, etc.). An individual SOP is not required for every hazardous task performed or chemical used in the lab; SOPs can be written in a comprehensive manner that encompasses many similar hazards. For example, if a procedure in the lab requires the use of acetone and ethyl acetate, both of which are flammable liquids, one SOP on flammable liquids can be created rather than a separate SOP for both acetone and ethyl acetate. To assist researchers in complying with the OSHA Lab Standard, EHS has developed SOP templates that can be used by laboratories. These SOPs are not complete as is; they are templates that must be customized by each laboratory before they are considered complete. Instructions for completion are included in each SOP template. Laboratories are encouraged to use these templates to develop their own SOPs. Contact EHS at 765-494-0121 if assistance is needed with developing lab-specific SOPs. For the up-to-date list of SOP templates, visit the EHS Standard Operating Procedures webpage.

4.3.2 Required Laboratory Postings

The following forms and labels are required to be posted by most campus laboratories:

- The *Laboratory Information* door posting is required for all laboratories.
- The Certification of Hazard Assessment Form is required for all laboratories. Detailed information regarding the hazard assessment process is presented in Section 6.3 of the CHP.
- The Carcinogens, Reproductive Toxins, or Extremely Toxic Chemicals label (Toxic Chemicals Label), which is illustrated in Figure 4.6 is required if a lab uses or stores any chemicals on the *Chemicals Requiring Designated Areas* list. Contact EHS 765-494-6371 to request Toxic Chemicals Labels.

Figure 4.6 – Toxic Chemicals Label

- The *Abbreviations and Chemical Formulas* list is required for all labs that use abbreviations and/or chemical formulas as a means to label chemical containers, including secondary containers such as beakers, flasks, and vials. This list is not all inclusive and any abbreviations not listed must be added by laboratory personnel.

There are several other lab postings that may also be required that are not discussed in the CHP, particularly if radioisotopes and/or biological agents are used in the lab. This information should be obtained by reviewing the *Radiation Safety Manual* and/or *Biological Safety Manual*. Additional information regarding lab postings and labels can be found on the EHS Labels, Signs, Stickers and Door Postings webpage.

4.4 Personal Protective Equipment (PPE)

Personal protective equipment (PPE) should be used to supplement engineering controls. However, PPE should never be used as a substitute for engineering controls when engineering controls are required. PPE must be worn at all time in the laboratory when handling hazardous chemicals. Proper PPE selection can be determined in the following ways:

- Ask the Laboratory Supervisor about proper PPE selection.
- Review the SOP and associated hazard assessment for the task to be performed.
- Review Section 8, “Exposure Controls/Personal Protection” of the SDS for the chemical(s) being used. This will provide basic information on the PPE recommended for use with the particular chemical. The SDS addresses "worst case" conditions; therefore, all the equipment described may not always be necessary for a specific task. In addition, the SDS may not provide sufficient information concerning a specific respirator or type of glove appropriate for the chemical.

Additional PPE requirements are detailed in Chapter 6 and Chapter 9 of the CHP.

Chapter 5: Laboratory Management Plan

An effective laboratory management plan is essential to operating a safe lab environment. Requirements on topics such as lab housekeeping, equipment safety, chemical inventories, proper handling, storage, segregation, and labeling of chemicals must be established and known by all laboratory personnel. This chapter details how laboratories should be safely managed at Purdue.

5.1 Laboratory Safety Guidelines

All laboratory employees must have a good understanding of the hazards associated with the chemicals being used and stored in the lab. Basic factors such as the physical state (gas, liquid, or solid) of the chemical and the type of facilities and equipment involved with the procedure should be considered before any work with hazardous materials occurs.

5.1.1 Laboratory Safety Considerations

Many factors are involved in an effective laboratory safety program. Considering the following questions will help address many of the factors that should be considered before work in the lab begins:

- Is the material flammable, explosive, corrosive, or reactive?
- Is the material toxic, and if so, how can I be exposed to the material (e.g., inhalation, skin or eye contact, accidental ingestion, accidental puncture)?
- What kind of ventilation do I need to protect myself?
- What kind of PPE (e.g., chemical-resistant gloves, respirator, and goggles) do I need to protect myself?
- Will the process generate other toxic compounds, or could it result in a fire, explosion, or other violent chemical reaction?
- What are the proper procedures for disposal of the chemicals?
- Do I have the proper training to handle the chemicals and carry out the process?
- Are my storage facilities appropriate for the type of materials I will be using?
- Can I properly segregate incompatible chemicals?
- What possible accidents can occur and what steps can I take to minimize the likelihood and impact of an accident? What is the worst incident that could result from my work?

5.1.2 General Laboratory Safety Rules

It is extremely important that all laboratory safety rules are known and followed by lab personnel. Not only is it important that the rules are understood and followed, it is also important that the Laboratory Supervisor enforce all lab safety rules. A culture of safety must be adopted by all employees before a lab safety program can be successful. The following general laboratory safety rules should be followed at all times:

- Prior to beginning work in the lab, be prepared for hazardous materials emergencies and know what actions to take in the event of an emergency. Plan for the worst-case scenario. Be sure that necessary supplies and equipment are available for handling small spills of hazardous chemicals. Know the location of safety equipment such as the nearest safety shower and eyewash station, fire extinguisher, spill kit, and fire alarm pull station.
- Do not work alone in the lab if you are working with high hazard materials (e.g., acutely toxics, reactives, or processes that involve handling a large volume of flammable materials, > 1 liter).
- If working with a high-hazard chemical, ensure that others around you know what you are working with and understand the potential hazards.
- Limit access to areas where chemicals are used or stored by posting signs and/or locking doors when areas are unattended.
- Purchase the minimum amount of hazardous materials necessary to efficiently operate the laboratory.
- Ensure that adequate storage facilities (e.g., chemical storage rooms, flammable safety cabinets) and containers are provided for hazardous materials. Ensure that hazardous materials are properly segregated by chemical compatibility.
- Ensure that ventilation is adequate for the chemicals being used. Understand how chemical fume hoods function and be able to determine if the hood is not functioning properly.
- Use good personal hygiene practices. Keep your hands and face clean; wash thoroughly with soap and water after handling any chemical. Do not handle your cell phone while wearing protective gloves.
- Smoking, drinking, eating, and the application of cosmetics are forbidden in areas where hazardous chemicals are in use. Confine long hair and loose clothing.
- Never smell or taste a hazardous chemical. Never use mouth suction to fill a pipette.
- When using equipment that creates potential hazards (e.g., centrifuge), ensure that the equipment is being used following the manufacturer’s guidelines and instructions. If equipment requires routine maintenance (e.g., HEPA filters need to be changed), ensure the maintenance is performed by a qualified individual.
- Use required PPE as instructed by the *PPE Policy* detailed in Chapter 6.

5.2 Housekeeping

Housekeeping is an important element to a laboratory safety program. A clean, well-maintained lab improves safety by preventing accidents and can enhance the overall efficiency of the work being performed. The following laboratory housekeeping guidelines should be followed:

- All doorways and hallways must be free of obstructions to allow clear visibility and exit. The laboratory should be uncluttered without excessive storage of materials that could cause or support a fire (e.g., paper, cardboard, flammable liquids, etc.).
- Fire protection sprinklers must be unobstructed; a minimum of 18 inches of clearance is required below the sprinkler head. If the laboratory does not have fire protection sprinklers, there must be a minimum of 24 inches of clearance below the ceiling.
- Do not store items that block fire extinguishers or eyewash and safety shower stations.
- Do not store items in front of electrical boxes/panels in the lab.
- A routine cleaning schedule should be established. All work surfaces should be kept as clean as possible. All potentially chemically contaminated work area surfaces (e.g., chemical fume hood deck, countertops) should be cleaned routinely (e.g. daily, weekly).
- For operations where spills and contamination are likely (e.g., agarose gel electrophoresis/ethidium bromide applications), cover work spaces with a bench paper or liner. The soiled bench paper should be changed on a routine basis or as needed.
- All chemical spills must be cleaned up immediately. Refer to Chapter 8 of the CHP for detailed chemical spill cleanup procedures.
- Do not allow materials to accumulate in lab fume hoods and remove used tissues, foil, gloves, razor blades, or other unnecessary objects immediately after use. The safety of the workspace and the hood ventilation may be compromised when excessive chemicals and equipment are kept in hoods.
- Ensure that all waste (e.g., trash, chemically contaminated debris waste, etc.) is placed in the appropriate containers. Do not overfill waste containers.
- All equipment should be cleaned and returned to storage after each use.
- Equipment should be stored in a safe and orderly manner that prevents it from falling.
- Chemical containers must be clean, properly labeled, and returned to storage upon completion or usage. Avoid storing liquids above eye level.
- Do not store heavy or frequently used items on top shelves. Locate items used daily close to the work area.

5.3 Chemical Inventories

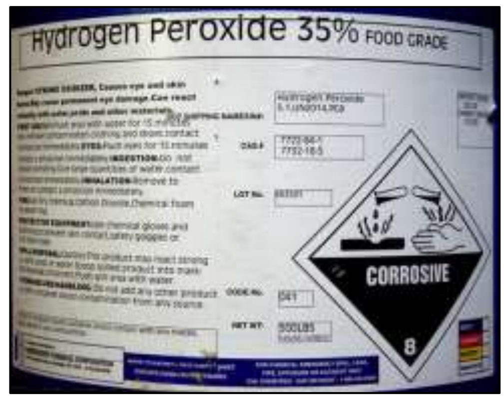
It is a prudent practice to develop and maintain a chemical inventory. Taking a routine chemical inventory can reduce the number of unknown chemicals and the tendency to stockpile chemicals. EHS recommends that all laboratories take a chemical inventory at least annually. Depending on the type of chemicals being used and stored in a laboratory, EHS may require that a chemical inventory be prepared for a room, work unit, or department (e.g., Department of Homeland Security Chemical Facility Anti-Terrorism Standards Inventory) on a routine basis.

5.4 Safety Data Sheets

The SDS provides comprehensive information that is imperative for the safe handling of hazardous chemicals. Carefully read the label and SDS and make sure that you understand the information provided in this document before using a chemical. In some cases, it may be necessary to do additional research. The Laboratory Supervisor should be consulted if necessary. EHS is also a good resource if additional information is needed.

It is important that all lab employees have access to SDS for all hazardous chemicals that are stored in the lab. Access can mean storing hard copies of SDS in the lab or some other easily accessible location (e.g., departmental main office), or can mean storing electronically by a means that is also accessible to all lab personnel (e.g., shared network drive). To obtain a copy of a SDS, contact the chemical manufacturer or EHS at 765-494-6371. Many manufacturers' SDS can be found online.

5.5 Chemical Labeling Requirements



Every chemical container present in the laboratory, whether hazardous or not, must be properly labeled. All secondary chemical containers (e.g., wash bottles, beakers, flasks, sample vials, etc.) must also be properly labeled. Avoid using abbreviations, chemical formulae, or structure unless there is a complete and up-to-date legend (e.g., MeOH = Methanol) prominently posted in the lab. Most chemicals come with a manufacturer label that contains all of the necessary information, so care should be taken to not damage or remove these labels. It is recommended that each bottle also be dated when received and when opened to assist in determining which chemicals are expired and require proper disposal. Detailed information and strategies for the labeling of research samples is discussed in Section 5.13 of the CHP. These same strategies can be used when labeling secondary chemical containers as well.

5.6 Chemical Segregation

All chemicals must be stored according to chemical compatibility. Once segregated by chemical compatibility, they can then be stored alphabetically. Information regarding chemical compatibility can be found in the SDS, primarily in Section 7, "Handling and Storage" and Section 10, "Stability and Reactivity". If unsure of proper segregation procedures, contact the Laboratory Supervisor or EHS for assistance. Chemical segregation can be achieved by either isolation (e.g., organic solvents stored in a flammable cabinet), physical distance (e.g., acids and bases are stored on opposite sides of a chemical storage room), or secondary containment (e.g., placing oxidizing acids such as nitric acid into a secondary containment to segregate from organic acids such as formic acid as shown in Figure 5.7). In the most general terms, proper segregation can be achieved by:

- Storing acids away from bases and toxics;
- Storing oxidizers away from organic chemicals; and
- Storing reactive and acutely toxic materials away from all other chemicals.

Table 5.1 illustrates a more detailed chemical compatibility logic that can be used for chemical storage. Hazard classes marked by an X need to be segregated from each other (e.g., Acid, inorganic must be segregated from Base, inorganic). Contact EHS at 765-494-0121 with questions regarding chemical segregation.

Table 5.1 – Chemical Compatibility Chart

	Acid, inorganic	**Acid, organic**	**Acid, oxidizer**	**Base, inorganic**	**Base, organic**	**Oxidizer**	**Toxic, inorganic**	**Toxic, organic**	**Reactive**	**Organic solvent**
Acid, inorganic				**X**	**X**		**X**	**X**	**X**	
Acid, organic			**X**	**X**	**X**	**X**	**X**	**X**	**X**	
Acid, oxidizer		**X**		**X**	**X**		**X**	**X**	**X**	**X**
Base, inorganic	**X**	**X**	**X**						**X**	
Base, organic	**X**	**X**	**X**			**X**			**X**	
Oxidizer		**X**			**X**			**X**	**X**	**X**
Toxic, inorganic	**X**	**X**	**X**						**X**	
Toxic, organic	**X**	**X**	**X**			**X**			**X**	
Reactive	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**		**X**
Organic solvent			**X**			**X**			**X**	

5.7 Chemical Storage Requirements

Proper storage of chemicals is an essential component to a laboratory safety program. Improper chemical storage practices can cause undesired chemical reactions, which may form hazardous products that can lead to employee exposure or possibly fires and property damage. All lab employees should carefully read each chemical's SDS and container label before deciding how to store a chemical, as these will often indicate any special storage requirements that may be necessary. The following subsections describe chemical storage requirements in more detail.

5.7.1 General Chemical Storage

The following general chemical storage guidelines must be followed in all laboratories:

- Each chemical in the laboratory must be stored in a specific location and returned there after each use. Acceptable chemical storage locations may include flammable cabinets, corrosive cabinets, fume hood cabinets, secure laboratory shelves, or appropriate laboratory refrigerators or freezers.
- Chemical containers must be in good condition and appropriate for the chemical that they contain and be free from exterior contamination.
- Chemical fume hoods should not be used as permanent chemical storage areas, unless designated as such. Not only does this create potentially unsafe conditions by

having extraneous chemicals stored near chemical reactions and processes, excess chemical bottles in the hood may also seriously impair the ventilating capacity of the fume hood. Only chemicals being used in the process or experiment being conducted in the fume hood are allowed to be stored in the fume hood and should be removed when the process or experiment is complete.

- Chemicals should not be permanently stored on bench tops. Avoid storing any chemical containers on the floor. Under no circumstance should chemical containers, or anything else, be stored in aisle ways, corridors, or in front of doors.
- Hazardous liquids should not be stored on shelves above eye-level unless there is a SOP detailing safe handling procedures.
- Chemicals should be stored at an appropriate temperature and humidity level and never be stored in direct sunlight.
- Periodic cleanouts of expired or unneeded chemicals should be conducted to minimize the volume of hazardous chemicals stored in the laboratory.
- Always follow the chemical manufacturer's storage instructions, if provided.

5.7.2 Flammable Liquids Storage

Flammable liquids include any liquid with a flash point no greater than 93 °C (200 °F). The following guidelines for storing flammable liquids must be followed in all laboratories:

- Flammable and combustible liquids should be stored in flammable storage cabinets, as shown in Figure 5.1, whenever possible. No more than 10 gallons of flammable liquid is permitted to be stored outside of a flammable storage cabinet unless it is stored in a flammable safety can equipped with a spring-loaded lid and an internal screen as shown in Figure 5.2.
- Domestic refrigerators or freezers must never be used to store flammable liquids. Flammable liquids can only be stored in refrigerators or freezers that are designed for flammable materials (Note: most refrigerators and freezers are not intended for flammable storage).
- Flammable liquids must be stored in well-ventilated areas free from ignition sources.
- Some organic solvents (e.g., diethyl ether, tetrahydrofuran) have a shelf-life and can form organic peroxides over time while in storage. These "peroxide formers" must be dated when received from the chemical manufacturer and disposed of once expired. If any time-sensitive chemicals are found to be past the manufacturer's expiration date, they must be submitted to EHS for hazardous waste disposal immediately. See Appendix C for a list of commonly found organic solvents that potentially form organic peroxides.

Figure 5.1 – Flammable Storage Cabinet

Figure 5.2 – Flammable Safety Can

5.7.3 Compressed Gases Storage

Compressed gases are defined as gases that are contained in a receptacle at a pressure not less than 280 kPA at 20 °C or as a refrigerated liquid. The following guidelines for storing compressed gases must be followed in all laboratories:

- Compressed gas cylinders (cylinders) must be stored in a secure, well-ventilated location, and in an upright position at all times. Small cylinders such as lecture bottles are not required to be stored in the upright position; they can be safely laid down in a chemical cabinet. However, when lecture bottles are in use they should be secured and stored in an upright position if at all possible.
- All cylinders should be handled as if full and should never be completely emptied.
- Cylinders that are not in use (meaning that the cap is on) must be secured and have the safety cap. Multiple cylinders may be secured together, only if they are capped (not in use). Only capped cylinders can be secured with a single restraining device as shown in Figure 5.3.
- Cylinders that are in use, meaning there is a regulator attached, must be individually secured by a chain or strap as shown in Figure 5.4. Cylinder valves and regulators should be protected from impact or damage.

Figure 5.3 – Not In-Use Cylinders

Figure 5.4 – In-Use Cylinders

5.7.4 Reactive Materials Storage

Reactive materials include explosives, pyrophorics, self-heating and self-reacting compounds, and water-reactives. Many reactive materials are also toxic and are dissolved or immersed in a flammable solvent (e.g., lithium alkyl compounds dissolved in diethyl ether, sodium metal immersed in mineral oil). Other common hazards often associated with reactive chemicals include corrosivity, teratogenicity, or organic peroxide formation. The following guidelines for storing reactive materials must be followed in all laboratories:

- The amount of reactive materials stored in the lab must be kept to a minimum. Any expired or unnecessary reactive materials must be properly disposed of as hazardous waste.
- All reactive materials must be clearly labeled with the original manufacturer's label, which should have the chemical name, hazard labels, and pictograms. The label should not be defaced in any way.
- All reactive materials should be placed into secondary containment as a best management practice.
- Suitable storage locations for reactive materials include inert gas-filled desiccators or glove boxes, flammable storage cabinets that do not contain aqueous or other incompatible chemicals, or intrinsically safe refrigerators or freezers that also do not contain aqueous or other incompatible chemicals. If possible, store all reactive chemicals in a small flammable cabinet (such as a cabinet underneath a fume hood) dedicated only for reactives. Signs should be posted to indicate their presence and unique hazards as shown in Figure 5.5.

Figure 5.5 – Reactive Chemicals Storage

- Many reactive materials are water and/or air reactive and can spontaneously ignite on contact with air and/or water. Therefore, reactives must be handled under an inert atmosphere and in such a way that rigorously excludes air and moisture.
- If reactive materials are received in a specially designed shipping, storage, or dispensing container (such as the Aldrich Sure-Seal packaging system), ensure that the integrity of that container is maintained. Ensure that sufficient protective solvent, oil, kerosene, or inert gas remains in the container while reactive materials are stored.

5.7.5 Acutely Toxic Materials Storage

Acutely toxic materials are defined as substances that may be fatal or cause damage to target organs as the result of a single exposure or exposures of short duration. The following guidelines for storing acutely toxic materials must be followed in all laboratories:

- Suitable storage locations for acutely toxic materials include desiccators, glove boxes, flammable storage cabinets that do not contain incompatible chemicals (primarily strong acids), or non-domestic refrigerators or freezers. These locations should be clearly posted.
- Acutely toxic materials should be stored in secondary containment at all times as a best management practice.
- If possible, store all acutely toxic materials in a cabinet dedicated only for acutely toxic materials. Signs should be posted to indicate their presence and unique hazards.
- The amount of acutely toxic material stored in the lab should be kept at a minimum. Any expired or unnecessary materials must be properly disposed of as hazardous waste.

- All acutely toxic materials should be clearly labeled with the original manufacturer's label, which should have the chemical name, hazard labels, and pictograms. The label should not be defaced in any way.

5.7.6 Corrosive Materials Storage

Corrosive materials are defined as substances that cause destruction of living tissue by chemical corrosion at the site of contact and can be either acidic or basic (caustic). The best storage method for corrosive materials is inside of a corrosive storage cabinet or lab cabinet where acids and bases are segregated at all times. Acids must also be segregated from chemicals where a toxic gas would be generated upon contact with an acid (e.g., cyanide or sulfide compounds). Organic acids (e.g., acetic acid, formic acid) must be stored away from oxidizing acids (e.g., nitric acid, perchloric acid), as these types of acids are incompatible with each other. Segregation can be achieved either by physical distance (preferred method) or by secondary containment as shown in Figure 5.6.

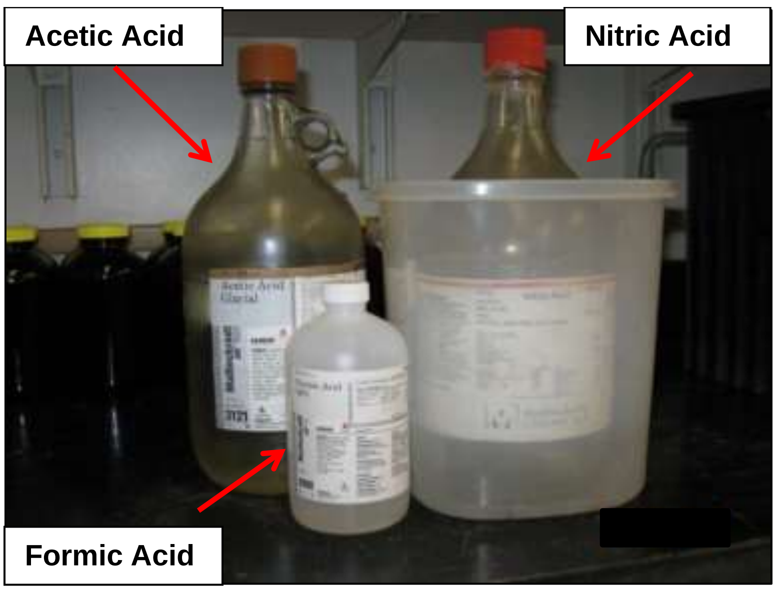


Figure 5.6 – Segregation Using Secondary Containment

5.7.7 Oxidizers and Organic Peroxide Storage

Oxidizing materials are defined as substances which, while not necessarily combustible, by yielding oxygen can cause or contribute to the combustion of other material. An organic peroxide is an organic substance which contains the bivalent -O-O- structure and may be considered a derivative of hydrogen peroxide, where one or both of the hydrogen atoms have been replaced by organic radicals. The following guidelines for storing oxidizers and organic peroxides must be followed in all laboratories:

- Oxidizers (e.g., hydrogen peroxide, sodium nitrate) and organic peroxides (e.g., methyl ethyl ketone peroxide, benzoyl peroxide) must be stored in a cool, dry location and kept away from combustible materials such as wood, pressboard, paper, and organic chemicals (e.g., organic solvents and organic acids).

- If possible, store all strong oxidizing agents in a chemical cabinet dedicated only for oxidizers.
- The amount of oxidizers and organic peroxides stored in the lab should be kept at a minimum.
- All material must be clearly labeled; the original manufacturer's label with the chemical name, hazard labels, and pictograms should not be defaced or covered.

5.7.8 Refrigerators and Freezers Chemical Storage

A number of general precautions need to be taken when storing chemicals in refrigerators and/or freezers in the laboratory. When working with freezers or refrigerators, the following procedures must be followed:

- Domestic refrigerators or freezers must never be used to store flammable liquids. Flammable liquids are only allowed to be stored in refrigerators or freezers that are designed for flammable materials (most refrigerators are not intended for flammable storage).
- Lab refrigerators or freezers must never be used to store food or beverages for consumption. Lab refrigerators/freezers should be posted with a sign that states "No Food or Drink".
- All chemicals stored in a refrigerator or freezer must be labeled.
- Ensure that the chemicals stored in a refrigerator or freezer is compatible with each other. For example, do not store an oxidizer such as hydrogen peroxide in a refrigerator with organic chemicals.
- There must not be any open chemicals in a refrigerator or freezer. All containers must be completely sealed or capped and safely stored.
- Chemicals should be allowed to warm to room temperature before sealing to prevent pressure buildup.
- Shelves in refrigerators or freezers should all have suitable plastic trays for secondary containment in the refrigerator and freezer compartments. If plastic trays are not available, liquid chemicals should be placed in secondary containers to contain spills.
- Remember that power outages and technology failures can cause internal temperatures to rise, which can impact chemical contents. Be aware of unusual odors, vapors, etc., when opening the refrigerator or freezer.
- An inventory should be posted on the refrigerator door.
- Chemical refrigerator or freezers should be located away from laboratory exits.
- Refrigerators and freezers should be cleaned-out and manually defrosted as necessary.

- When defrosting a freezer, consideration should be taken regarding potential chemical contamination of the water. If the water draining from a defrosted refrigerator may be chemically contaminated, contact EHS at 765-494-0121 for further assistance.

5.8 Compressed Gas Cylinder Safety

Compressed gas storage requirements are discussed above in Section 5.7.3. However, there are some additional important safety requirements for use of compressed gases in laboratories detailed below:

- Gas cylinder connections and fittings must be inspected frequently for deterioration.
- Never use a leaking, corroded, or damaged cylinder and never refill a compressed gas cylinder.
- When stopping a leak between the cylinder and regulator, always close the valve before tightening the union nut.
- The regulator must be replaced with a safety cap when the cylinder is not in use.
- The safety cap must be in place when a gas cylinder is moved. For large gas cylinders (>27 inches), an approved gas cylinder cart should be used to move it.
- The cylinder must be strapped to the cart and the protective cap must be in place before moving the cylinder. A cylinder should never be moved or transported without the protective cap. The proper way to move a large gas cylinder is illustrated in Figure 5.7.
- Never dispense from a cylinder if it is on a gas cylinder cart.

Figure 5.7 – Gas Cylinder Cart

A few compressed gas cylinders have a shelf-life and can become more hazardous as time goes on. It is extremely important that these cylinders are identified and managed properly. If any time-sensitive gases are found to be past the manufacturer's expiration date, they must be submitted to EHS for hazardous waste disposal immediately. The following is a list of time-sensitive compressed gases:

- Hydrogen Fluoride, anhydrous
- Hydrogen Bromide, anhydrous
- Hydrogen Sulfide, anhydrous
- Hydrogen Cyanide, anhydrous
- Hydrogen Chloride, anhydrous

The compressed gases listed above have a shelf-life provided by the manufacturer that must be strictly followed. There have been numerous incidents involving these compounds related to storage past the expiration date. For example, hydrogen fluoride (HF) and hydrogen bromide (HBr) cylinders have a shelf-life of one to two years, depending on the manufacturer. Over time, moisture can slowly enter the cylinder, which initiates corrosion. As the corrosion continues, HF and/or HBr slowly react with the internal metal walls of the cylinder to produce hydrogen. The walls of the cylinder slowly weaken due to the corrosion, while at the same time the internal pressure increases due to the hydrogen generation. Ultimately, these cylinders fail and create extremely dangerous projectiles and a toxic gas release which can be deadly. Figure 5.8 shows a 30-year-old HF lecture bottle cylinder that exploded in a Purdue University laboratory in 2011.

Figure 5.8 – HF Cylinder Incident at Purdue University in 2011

5.9 Cryogenic Liquids Safety

A cryogenic liquid is defined as a liquid with a normal boiling point below -150 °C (-240 °F). The most common cryogenic liquid used in a laboratory setting is liquid nitrogen. By definition, all cryogenic liquids are extremely cold. Cryogenic liquids and their vapors can rapidly freeze human tissue and can also pose an asphyxiation hazard if handled without proper ventilation. The following precautions should be taken when handling cryogenic liquids:

- Use and store cryogenic liquids in well-ventilated areas only.

- Guard against skin damage by wearing appropriate PPE while handling cryogenic liquids. Proper PPE for handling cryogenic liquids includes chemical splash goggles, a face shield, cryogenic-safe gloves, long sleeves, as well as a garment and fully enclosed shoes covering all skin beneath the waist.
- Cryogenic liquids will vent (boil off) from their storage containers as part of normal operation. Containers are typically of a vacuum jacketed design to minimize heat loss. Excessive venting and/or an isolated ice build-up on the vessel walls may indicate a fault in the vessel's integrity or a problem in the process line. A leaky container should be removed from service and taken to a safe, well-ventilated area immediately.
- All systems components piping, valves, etc., must be designed to withstand extreme temperatures.
- Pressure relief valves must be in place in systems and piping to prevent pressure build up. Any system section that could be valved off while containing cryogenic liquid must have a pressure relief valve. The pressure relief valve relief ports must be positioned to face toward a safe location.
- Transfer operations involving open cryogenic containers, such as Dewars must be done slowly, while wearing all required PPE. Care must be taken not to contact non-insulated pipes and system components.
- Open transfers will be allowed only in well-ventilated areas.
- Do not use a funnel while transferring cryogenic liquids.
- Use tongs or other similar devices to immerse and remove objects from cryogenic liquids; never immerse any part of your body into a cryogenic liquid.

5.10 Nanoparticle Safety

The American Society of Testing and Materials (ASTM) Committee on Nanotechnology has defined a nanoparticle as a particle with lengths in two or three dimensions between 1 and 100 nanometers (nm). Nanoparticles can be composed of many different base materials and may be of different shapes including: nanotubes, nanowires, and crystalline structures such as fullerenes and quantum dots. Nanoparticles present a unique challenge from an occupational health perspective as there is a limited amount of toxicological data currently available for review. However, some studies have shown that existing exposure control technologies have been effective in reducing exposure to nanoparticles. Refer to the *Nanoparticle Safety and Health Guidelines* for detailed procedures and guidance regarding the safe handling of nanoparticles.

5.11 Sharps Handling Safety

Sharps are defined as items capable of puncturing, cutting, or abrading the skin such as glass or plastic pipettes, broken glass, test tubes, petri dishes, razor blades, needles, and syringes with needles. Sharps are often contaminated with hazardous chemicals and/or infectious agents, so multiple hazards are often encountered. Employees that routinely work with sharps must be aware of the risk of being punctured or lacerated. It is important for these employees to take precautions and properly handle sharps in order to prevent injury and potential disease transmission. These employees should use appropriate PPE (e.g., puncture-resistant gloves), tools, barrier protection, sharps waste containers, and engineering controls to protect themselves. Refer to the *Sharps and Infectious Waste: Handling and Disposal Guidelines* for detailed procedures regarding sharps handling and disposal procedures.

5.12 Equipment, Apparatus, and Instrument Safety

5.12.1 Centrifuges

The following safety guidelines should be followed when operating centrifuges:

Before centrifugation:

- Centrifuges must be properly installed and operated only by trained personnel. Centrifuges cannot be placed in the hallway of a building; they must remain inside of the laboratory.
- Train each operator on proper operating procedures, review the user manual.
- Use only rotors compatible with the centrifuge. Check the expiration date for ultracentrifuge rotors.
- Check tubes, bottles, and rotors for cracks and deformities before each use.
- Make sure that the rotor, tubes, and spindle are dry and clean.
- Examine O-rings and replace if worn, cracked, or missing.
- Never overfill centrifuge tubes (don not exceed ¾ full).
- Always cap tubes before centrifugation.
- Always balance buckets, tubes, and rotors properly.
- Check that the rotor is seated on the drive correctly, close the lid on the centrifuge, and secure it.
- When using swinging bucket rotors, make sure that all buckets are hooked correctly and move freely.

During centrifugation:

- Close lids at all times during operation. Never open a centrifuge until the rotor has stopped.
- Do not exceed safe rotor speed.
- The operator should not leave the centrifuge until full operating speed is attained and the machine appears to be running safely without vibration.
- Stop the centrifuge immediately if an unusual condition (noise or vibration) begins and check load balances.

After centrifugation:

- Allow the centrifuge to come to a complete stop before opening.
- Wear new pair of outer gloves to remove rotor and samples.
- Check inside of centrifuge for possible spills and leaks, clean centrifuge and rotor thoroughly if necessary.
- Wash hands after removing gloves.

5.12.2 Stirring and Mixing Equipment

Stirring and mixing devices commonly found in laboratories include stirring motors, magnetic stirrers, and shakers. These devices are typically used in lab operations that are performed in a chemical fume hood, and it is important that they be operated in a way that prevents the generation of electrical sparks. Only spark-free induction motors should be used in power stirring and mixing devices or any other rotating equipment used for laboratory operations. Because stirring and mixing devices, especially stirring motors and magnetic stirrers, are often operated for fairly long periods without constant attention, the consequences of stirrer failure, electrical overload or blockage of the motion of the stirring impeller should be considered.

5.12.3 Heating Devices

Laboratories commonly use heating devices such as ovens, hot plates, heating mantles, oil baths, salt baths, sand baths, air baths, hot-tube furnaces, hot-air guns, and microwave ovens. Steam heated devices are generally preferred whenever temperatures of 100 °C or less are required because they do not present shock or spark risks and can be left unattended with assurance that their temperature will never exceed 100 °C. Ensure the supply of water for steam generation is sufficient prior to leaving the reaction for any extended period of time.

A number of general precautions need to be taken when working with heating devices in the laboratory. When working with heating devices, consider the following:

- The actual heating element in any laboratory heating device should be enclosed in such a fashion as to prevent a laboratory worker or any metallic conductor from accidentally touching the wire carrying the electric current.
- If a heating device becomes so worn or damaged that its heating element is exposed, the device should be either discarded or repaired before it is used again.
- The external cases of all variable autotransformers have perforations for cooling by ventilation and, therefore, should be located where water and other chemicals cannot be spilled onto them and where they will not be exposed to flammable liquids or vapors.

- Fail-safe devices can prevent fires or explosions that may arise if the temperature of a reaction increases significantly because of a change in line voltage, the accidental loss of reaction solvent, or loss of cooling. Some devices will turn off the electric power if the temperature of the heating device exceeds some preset limit or if the flow of cooling water through a condenser is stopped owing to the loss of water pressure or loosening of the water supply hose to a condenser.

5.12.4 Distillation and Solvent Purification Systems

The process of thermal solvent distillation is inherently dangerous. If not handled properly, fire, explosion, and/or personnel exposure can result. A few common chemicals distilled in laboratories include tetrahydrofuran, methylene chloride, diethyl ether, toluene, dimethylformamide, benzene, and hexanes. The guidelines below should be followed while thermal distillation of organic solvents is conducted in the lab:

- The thermal solvent distillation system should be installed inside of a chemical fume hood if possible.
- Ensure that all heat generating equipment has a shut-off device installed.
- Ensure that all water connections on the condenser are clamped securely.
- Inspect all glassware for defects before setting them up in the experiment.
- Keep all air and water-sensitive drying agents under inert atmosphere. Make consistent efforts to not store or use other flammable or hazardous chemicals inside the fume hood where distillation is taking place.

5.12.5 Laboratory Glassware

Broken laboratory glassware is dangerous. Glassware-related injuries ranging from small cuts to multiple stitches and eye damage are common to lab workers. In order to reduce the risk of accidents, the following guidelines should be followed:

- Temperature changes can shatter any laboratory glassware. Never flash-cool glassware with cold water, especially after autoclaving or exposure to any high temperatures.
- Only round-bottomed or thick-walled (e.g., Pyrex) evacuated reaction vessels specifically designed for operations at reduced pressure should be used.

- Inspect glassware for any small imperfections before using. Sometimes a hairline crack may be present. Tap the glassware with a pen and listen to the tone to tell if there is a defect. A ringing tone indicates the glassware is fine, while a dull “thud” indicates there is a flaw present.
- Don not keep cracked glassware. If the bottom of a graduated cylinder is chipped or broken, properly dispose of it.
- Always wear appropriate PPE when working with glassware and varying temperatures. Always wear safety glasses.

5.12.6 High Pressure Systems

Working with high pressure systems in a laboratory can result in over-pressurization, explosion, and the possible hazards of flying glass, chemical exposure, and fire. All high-pressure systems must be set up and operated with careful consideration of potential risks. The following procedures should be followed when working with high pressure systems in the laboratory:

- High-pressure operations should be performed only in pressure vessels appropriately selected for the operation, properly labeled and installed, and protected by pressure-relief control devices.
- Vessels, connecting hoses, and any apparatus must be strong enough to withstand the stresses encountered at the intended operating temperatures and pressures and must not corrode or otherwise react when in contact with the materials it contains.
- All pressure equipment should be visually inspected before each use.

5.12.7 Vacuum Systems

Vacuum work can result in an implosion and the possible hazards of flying glass, splattering chemicals, and fire. All vacuum operations must be set up and operated with careful consideration of the potential risks. The following guidelines should be followed when using vacuum apparatus in the laboratory:

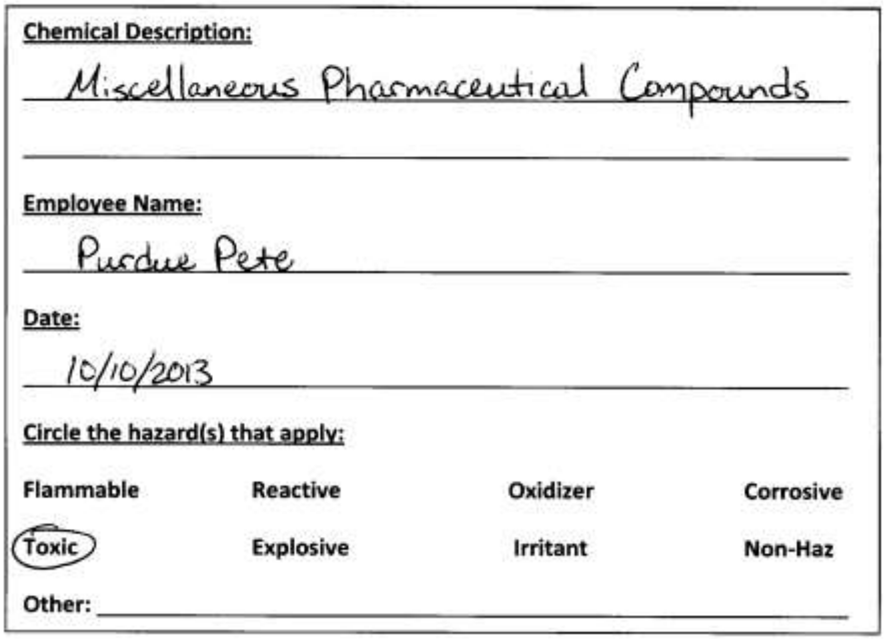
- Do not allow water, solvents, or corrosive gases to be drawn into vacuum systems. Protect pumps with cold traps and vent their exhaust into an exhaust hood.
- Assemble vacuum apparatus in a manner that avoids strain, particularly to the neck of the flask.
- Avoid putting pressure on a vacuum line to prevent stopcocks from popping out or glass apparatus from exploding.

- Place vacuum apparatus in such a way that the possibility of being accidentally hit is minimized. If necessary, place transparent plastic around it to prevent injury from flying glass in case of an explosion.
- When using a rotary evaporator, the glass components of the rotary evaporator should be made of Pyrex or similar glass. Glass vessels should be completely enclosed in a shield to guard against flying glass should the components implode. Increase in rotation speed and application of vacuum to the flask whose solvent is to be evaporated should be gradual.
- When using a vacuum source, it is important to place a trap between the experimental apparatus and the vacuum source. The vacuum trap protects the pump and the piping from the potentially damaging effects of the material, protects people who must work on the vacuum lines or system, and prevents vapors and related odors from being emitted back into the laboratory or system exhaust. The following vacuum trapping guidelines should be followed:
    - Make sure the flask is properly clamped and secured.
    - Make sure the vacuum hose is connected to the vacuum line, not the gas line.
    - To prevent contamination, all lines leading from experimental apparatus to the vacuum source should be equipped with filtration or other trapping device as appropriate.
    - For particulates, use filtration capable of efficiently trapping the particles in the size range being generated.
    - For most aqueous or non-volatile liquids, a filter flask at room temperature is adequate to prevent liquids from getting to the vacuum source.
    - For solvents and other volatile liquids, use a cold trap of sufficient size and cold enough to condense vapors generated, followed by a filter flask capable of collecting fluid that could be aspirated out of the cold trap.
    - For highly reactive, corrosive, or toxic gases, use a sorbent canister or scrubbing device capable of trapping the gas.

5.13 Research Samples and Chemicals Developed in the Lab

Research samples and chemicals developed in the lab (samples) must be managed responsibly. Samples often accumulate in labs for years and are difficult to identify and dispose of and can create unsafe and non-compliant conditions if not managed properly. The following requirements apply to samples developed in the laboratory:

- All samples must be kept closed except when in use. Storage in beakers or flasks should be temporary. If temporarily storing samples in beakers or flasks, a cork, Parafilm®, or some other closure device must be used.
- All samples must be labeled with the chemical name, date the sample was developed/received, and the name of generator. Chemical structure or a labeling system that is only known to lab personnel is not acceptable as the only means of labeling samples. Abbreviations can be used as a labeling system as long as an up-to-date legend is posted in the lab.
- Samples should be disposed of within 6 months unless actively being used for analysis. Stockpiling unusable samples in not an acceptable practice. All samples that are no longer necessary must be properly disposed of in a timely manner using EHS's hazardous waste program.
- Samples must be stored according to the primary hazard class; this should be done to the best of your ability by considering the properties that are known or assumed.
- If the hazard(s) of a sample are unknown, the Laboratory Supervisor must attempt to determine whether it is hazardous or not. Assume all samples are toxic unless otherwise demonstrated. This can be accomplished by literature review or reviewing the hazards of other similar compounds. At a minimum, the Laboratory Supervisor should be able to determine if a chemical is flammable, corrosive, oxidant, or reactive. Call EHS at 765-765-494-0121 for assistance with identifying the hazards of samples.
- If samples are consolidated for storage (e.g., vial boxes), it is not always necessary to label every sample container. For example, a box containing sample vials which are all in the same hazard class (e.g., miscellaneous pharmaceutical compounds considered to be toxic) can have one label on the outside of the box stating "Miscellaneous Toxic Pharmaceutical Compounds" or a similar description. A label such as the one shown in Figure 5.9 can be used to identify consolidated samples, and should only be used on a temporary basis. This type of information communicates the hazards to emergency responders, as well as gives EHS the information necessary for proper disposal.
- If the chemical substance is produced for another user outside of the lab, the Laboratory Supervisor must comply with the OSHA Hazard Communication Standard including the requirements for preparing a SDS and properly labeling the sample.


Chemical Description:
Miscellaneous Pharmaceutical Compounds

Employee Name:
Purdue Pete

Date:
10/10/2013

Circle the hazard(s) that apply:

Flammable	Reactive	Oxidizer	Corrosive
Toxic	Explosive	Irritant	Non-Haz

Other: ______

Figure 5.9 – Example Temporary Sample Container Label

5.14 Transporting Hazardous Chemicals

Transporting chemicals is a potentially hazardous process that must be done properly to avoid accidents and potential injuries. The following subsections discuss how to properly ship chemical off campus using a shipping company, how to transport chemicals on campus using a Purdue-owned vehicle, and how to safely move chemicals by foot across campus.

5.14.1 Shipping Hazardous Chemicals off Campus

Shipping chemicals, research samples, or other similar materials off campus is potentially regulated by the Department of Transportation (DOT) and/or other regulatory agencies. Chemicals regulated for shipping require very specific types of packaging, labeling, and documentation and must be prepared by trained personnel. EHS makes the determination on whether a chemical is classified as hazardous for transportation purposes. Unless the researcher is DOT trained, they are not authorized to make this determination. Shipments that are not prepared by trained personnel can result in delays, loss of research samples, and potential regulatory fines. EHS can provide assistance by either providing shipment services, or if necessary, training personnel on the proper shipping procedures. More information about shipping chemicals can be found on the EHS *S*hipping Hazardous Materials webpage.

As previously stated, EHS prepares all regulated chemicals for shipment according to DOT requirements. However, laboratory personnel prepare the inner container (e.g., vial, jar) and provide it to EHS for shipment. When selecting an inner container to be given to EHS for an off-campus hazardous materials shipment, the following guidelines must be followed:

- The chemical must be compatible with the container. For example, corrosive chemicals must not be placed in metal containers; hydrofluoric acid in any concentration must not be placed in glass containers.
- Chemical permeability should be considered when selecting a plastic container, especially for organic solvents. The container must be able to effectively contain the chemical during transportation under normal conditions.
- The container must have an appropriate lid that is able to close and seal, meaning the container will not leak during transportation under normal conditions. Any containers that do not properly seal (e.g., beaker, flask, test tube) will not be shipped off campus by EHS.

5.14.2 Transporting Chemicals on Campus via Purdue Vehicle

Purdue University is a state agency and therefore is exempt from Department of Transportation (DOT) hazardous materials regulations. However, the "intent" of the DOT regulations is still required when transporting chemicals on campus using a motor vehicle. This essentially means that all chemical containers must be properly packaged, labeled, and segregated according to hazard class. Do not attempt to move large volumes (e.g., greater than 5 gallons in total volume) of chemicals across campus. If a large volume of chemicals needs to be moved across campus, such as an entire lab move, contact EHS 765-494-0121 for further assistance. The following procedures must be followed in order to properly and legally transport chemicals across campus:

- Only Purdue-owned vehicles are permitted to be used to transport chemicals. For liability and insurance purposes, no personal vehicles should ever be used to transport hazardous chemicals.
- The hazardous materials cannot be stored/transported in the same compartment that the passengers are in; must be placed either in the trunk of a car or bed of truck depending on the specific hazards and quantity, contact EHS for further instruction.
- Ensure that each container has an appropriate, tight-fitting lid. The lid should have the ability to contain the contents of the container even if it becomes inverted during transport. Examples of inappropriate lids include cracked caps, loosely fitting rubber stoppers, or Parafilm®.
- Chemicals should be segregated according to the primary hazard class. For example, do not place an oxidizer such as ammonium nitrate in the same container as an organic solvent such as acetone.
- All containers should be packaged upright.
- Chemical containers should be placed in some type of outer packing such as a box, bin or bucket. Containers should remain securely packaged during loading, transport, and unloading. Glass to glass contact should be avoided. Bubble wrap, newspaper, and vermiculite are good examples of packaging material that will prevent glass to glass contact.

- The outer containers should remain tightly secured during transport. Measures should be taken to avoid movement of the outer containers. For example, the containers should be secured using a strap or an empty box can be used to fill the gap between the last box and the sidewall of the vehicle.
- The outer container must be labeled in a manner that identifies the contents (e.g. corrosives, flammables).
- Transport with two or more people if possible.
- Be prepared for unseen accidents. At least one person should be knowledgeable of the materials being transported. An inventory with an estimated volume or weight per hazard should be recorded and available during transport (e.g., 5 gallons of flammable liquid and 10 pounds of toxic solids).
- Prepare a spill kit prior to transport. Material such as appropriate PPE, absorbent material, and an empty bucket is sufficient for most small spills.
- Carry a cell phone and know who to call in the event of an emergency. The Purdue Fire Department will respond to on-campus emergencies. Dial 911 from a Purdue phone or 765-494-8221 from a cell phone to contact Purdue Police dispatch.

5.14.3 Transporting Chemicals on Campus via Foot

Transporting small volumes of chemicals across campus via foot (e.g., from two neighboring campus buildings) is acceptable as long as it is done properly. Do not attempt to move large volumes (e.g., greater than 5 gallons in total volume) of chemicals across campus via foot. If a large volume of chemicals needs to be moved, such as an entire lab move, contact EHS 765-494-0121 for further assistance. The following procedures must be followed when moving chemicals on campus by way of foot:

- PPE must be worn when handling potentially contaminated surfaces. During the time which the chemicals are moved on campus via foot, PPE may not be necessary or even appropriate (e.g., employees should not wear chemical-resistant gloves in public areas). However, appropriate PPE and spill containment equipment should be brought along in the event of a spill or incident.

- Chemical stock room personnel shall not dispense or sell chemicals in breakable containers of any size unless the customer has an approved transport container in which to place the chemical for transporting before leaving the stock room. Chemical requisitioners may purchase a transport container from a lab supply company. 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/alkalis; and metal, rubber, or plastic for organic solvents. An example of a bottle carrier is illustrated in Figure 5.10.

Figure 5.10 – Chemical Bottle Carrier

- 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.
- 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.

5.15 Laboratory Security

All laboratory personnel have a responsibility to protect university property from misuse and theft of hazardous materials, particularly those that could threaten human health. At a minimum, the following security measures should be employed in all campus laboratories:

- The laboratory door should remain locked when not occupied.
- Always feel free to question anyone that enters the lab that you do not know and ask to see identification if necessary.
- If you see anything suspicious or someone displays suspicious behavior, immediately report it to the Purdue Police Department by dialing 911 (emergency) or 765-494-8221 (non-emergency).
- Any sensitive information or particularly hazardous chemicals should not be stored out in the open where anyone can readily have access to them. These types of materials should be stored in a secure location and lab personnel should always be present when these materials are in use.

5.16 Laboratory Self-Inspections

EHS performs laboratory inspections for various purposes (e.g., routine building safety and compliance inspections). However, the Laboratory Supervisor or a qualified designee should also inspect the laboratory for compliance with the requirements of the CHP at a minimum on an annual basis. Lab personnel have a much greater understanding of the unique hazards and issues that are encountered in their individual lab than EHS does. The goal of these self-inspections is to identify and correct unsafe and non-compliant conditions that could potentially result in an injury to lab personnel or a fine from a regulatory agency (e.g., open hazardous waste container). All deficiencies found during the inspection should be reviewed and corrected. The following elements should be performed during these inspections:

- Housekeeping practices should be reviewed. Chemicals should be stored appropriately and labeled. Evidence of spills and/or chemical contamination should be cleaned. All glassware and equipment should be stored appropriately, etc.
- Hazard assessments should be updated if process changes have occurred. For example, the lab is now performing organic synthesis and working with organometallic compounds.
- Training records should be updated and documented if new lab personnel have not yet been trained or if any processes have changed.
- Excess or outdated chemicals should be properly disposed of by EHS.
- Safety supplies such as PPE and spill containment equipment should be replenished if necessary.

A recommended template to use during laboratory self-inspections is the Integrated Safety Plan Self-Audit Checklist.

5.17 Laboratory Ergonomics

Many tasks in laboratories require repetitive motions which may lead to cumulative trauma injuries of the body, these effects can be long term. Tasks like pipetting, weighing multiple samples, standing at the bench or hood and using microscopes for long periods of time can cause physical stress. Even time compiling data at a computer poses potential physical problems. Ergonomics is the study of interaction of the human body with the work environment. Ergonomics strives to fit the job to the body through proper body positioning, posture, movement, tools, workplace layout and design. Parts of the body commonly affected by poor ergonomics include: neck, shoulders, back, hands, wrists, elbows, legs, and feet.

EHS has resources available to improve ergonomic conditions and help reduce cumulative trauma injuries to laboratory workers. Often simple adjustments are all that is required to improve conditions. Refer to the EHS Ergonomics webpage for information regarding EHS's ergonomics program.

5.18 Laboratory Electrical Safety

5.18.1 Training

Laboratory employees shall be trained to understand the specific hazards associated with electrical energy. See the written *Electrical Safety Program* for more information.

Employees who need access to operate circuit breakers and fused switches in electrical panels may require additional training to be designated by their supervisor as qualified for the task.

5.18.2 Portable Electrical Equipment and Extension Cords

The following requirements apply to the use of cord-and-plug-connected equipment and flexible cord sets (extension cords):

- Extension cords may only be used to provide temporary power and must be used with Ground Fault Circuit Interrupter (GFCI) protection during maintenance and construction activities and in damp or wet locations.
- Portable cord and plug connected equipment and extension cords must be visually inspected before use for external defects such as loose parts, deformed and missing pins, or damage to outer jacket or insulation, and for possible internal damage such as pinched or crushed outer jacket. Any defective cord or cord-and-plug-connected equipment must be removed from service and no person may use it until it is repaired and tested to ensure it is safe for use.
- Extension cords must be of the three-wire type. Extension cords and flexible cords must be designed for hard or extra hard usage. The rating or approval must be visible.
- Portable equipment must be handled in a manner that will not cause damage. Flexible electric cords connected to equipment may not be used for raising or lowering the equipment.
- Extension cords must be protected from damage. Sharp corners and projections must be avoided. Flexible cords may not be run through windows or doors unless protected from damage, and then only on a temporary basis. Flexible cords may not be run above ceilings or inside or through walls, ceilings or floors, and may not be fastened with staples or otherwise hung in such a fashion as to damage the outer jacket or insulation.
- Extension cords used with grounding type equipment must contain an equipment-grounding conductor; the cord must accept a three-prong, or grounded, plug. Operating equipment with extension cords without a grounding plug is prohibited.
- Attachment plugs and receptacles may not be connected or altered in any way that would interrupt the continuity of the equipment grounding conductor. Additionally, these devices may not be altered to allow the grounding pole to be

inserted into current connector slots. Clipping the grounding prong from an electrical plug is prohibited.
- Flexible cords may only be plugged into grounded receptacles. Adapters that interrupt the continuity of the equipment grounding connection may not be used.
- All portable electric equipment and flexible cords used in highly conductive work locations, such as those with water or other conductive liquids, or in places where employees are likely to contact water or conductive liquids, must be approved for those locations.
- Employee's hands must be dry when plugging and unplugging flexible cords and cord and plug connected equipment if energized equipment is involved.
- If the connection could provide a conducting path to the employee's hands (e.g. if a cord connector is wet from being immersed in water), the energized plug and receptacle connections must be handled only with insulating protective equipment.
- Lamps for general illumination must be protected from breakage, and metal shell sockets must be grounded.
- Temporary lights must not be suspended by their cords unless they have been designed for this purpose.
- Extension cords are considered to be temporary wiring, and must also comply with the section on "Requirements for Temporary Wiring" in this program.

5.18.3 Temporary Wiring Requirements

Temporary electrical power and lighting installations 600 volts or less, including flexible cords, cables and extension cords, may only be used during and for renovation, maintenance, repair, or experimental work. The following additional requirements apply:

- Ground-fault protection (e.g. GFCI) must be provided on all temporary-wiring circuits, including extension cords, used for construction or maintenance activities.
- In general, all equipment and tools connected by cord and plug must be grounded. Listed or labeled double insulated tools and appliances need not be grounded.
- Receptacles must be of the grounding type.
- Flexible cords and cables must be of an approved type and suitable for the location and intended use. They may not be used as a substitute for the fixed wiring, where run through holes in walls, ceilings or floors, where run through doorways, windows or similar openings, where attached to building surfaces, or where concealed behind building walls, ceilings, floors, rugs or carpeting.
- Suitable disconnecting switches or plug connects must be installed to permit the disconnection of all ungrounded conductors of each temporary circuit.
- Lamps for general illumination must be protected from accidental contact or damage, either by elevating the fixture above 8 feet above the floor or other working surface or by providing a suitable guard. Hand lamps supplied by flexible

cord must be equipped with a handle of molded composition or other approved material and must be equipped with a substantial bulb guard.
- Flexible cords and cables must be protected from accidental damage. Sharp corners and projections are to be avoided. Flexible cords and cables must be protected from damage when they pass through doorways or other pinch points.

5.18.4 Wet or Damp Locations

Work in wet or damp work locations (i.e., areas surrounded or near water or other liquids) should not be performed unless it is absolutely critical. Electrical work should be postponed until the liquid can be cleaned up. The following special precautions must be incorporated while performing work in damp locations:

- Only use electrical cords that have GFCIs;
- Place a dry barrier over any wet or damp work surface;
- Remove standing water before beginning work. Work is prohibited in areas where there is standing water;
- Do not use electrical extension cords in wet or damp locations; and
- Keep electrical cords away from standing water.

Chapter 6: Personal Protective Equipment (PPE) Policy

6.1 Purpose

The purpose of the *Personal Protective Equipment (PPE) Policy* is to ensure that all employees are aware of the PPE requirements and procedures to adequately protect themselves against chemical, radiological, biological, or mechanical hazards. This policy has been prepared in accordance with the requirements of the OSHA PPE regulations (29 CFR 1910.132 - 29 CFR 1910.140, 29 CFR 1910.95). As briefly discussed in Chapter 4 of the CHP, PPE should never be used in place of engineering or administrative controls.

6.2 Scope

The *PPE Policy* applies to all personnel that work with or around hazardous chemicals or other safety and health hazards in laboratory setting. The *PPE Policy* applies to all areas (not just laboratories) of the West Lafayette Campus, regional campuses, research farms, agricultural centers and related facilities and operations. The *PPE Policy* does not cover all potential hazards (e.g., confined space entry, welding operations, high voltage, etc.) in all operations or settings. If a laboratory encounters hazards not covered in the *PPE Policy* contact EHS at 765-494-6731 for assistance.

6.3 Hazard Assessment

The hazard assessment is a process of identifying the hazards associated with a defined task, and prescribing PPE along with other relevant protection measures that must be employed to minimize the risk from the identified hazards. Hazard assessments are performed by completing a certification of hazard assessment, which is a written document detailing the hazard assessment process for defined tasks. The Laboratory Supervisor is responsible for ensuring that hazard assessments are performed and the certification(s) is written, signed, dated, and readily available or posted in the lab. The Laboratory Supervisor is also responsible for ensuring that all lab personnel receive documented training on applicable hazard assessments. The certification of hazard assessment should be reviewed at least annually and updated any time a process is modified or when a new task which presents a hazard is introduced into the lab.

Hazard assessments can be organized using three formats: by individual task (e.g., pipetting hazardous liquids), by location (e.g., Chemistry Laboratory Room 1250), or by job title (e.g., Chemistry Lab Technician). Any of these formats is acceptable and often will be used in conjunction with each other to provide the safest laboratory work environment possible for employees. The following subsections describe each hazard assessment format in more detail.

See the EHS Forms webpage for hazard assessment certification templates.

6.3.1 Task Evaluation Hazard Assessment

Task evaluation hazard assessments should be conducted for specific tasks such as preparing dilute hydrochloric acid solutions or an ozonolysis reaction and workup. These types of hazard assessments should be written in a very detailed manner. The following steps that should be taken to perform a task evaluation hazard assessment:

- Describe the task.
- List the potential hazards associated with each body part (e.g., Eyes: Chemical Splash).
- Determine the appropriate PPE requirements for each hazard (e.g., Eyes: Safety Goggles).
- List other control measures required such as engineering and administrative controls (e.g., always prepare solutions in the chemical fume hood).

6.3.2 Location Evaluation Hazard Assessment

Location evaluation hazard assessments should be conducted for specific laboratories. These types of hazard assessments should be written in a comprehensive manner that includes the majority of hazards present in a specific location (e.g., flammable and corrosive liquids). This type of hazard assessment is most commonly used in laboratories and should be posted in a location within the lab where it is easily accessed by personnel (e.g., posted near the front door of the lab). If employees perform specific tasks not covered by the laboratory hazard assessment, then it will be necessary to perform a task evaluation assessment that does address the specific hazards of that task. The following describes the steps that should be taken to perform a task evaluation hazard assessment:

- Identify the hazards of the lab (e.g., flammable/corrosive/oxidant/toxic liquids).
- List each task where the hazard is present.
- Determine PPE requirements for each task.
- List other control measures required such as engineering and administrative controls (e.g., all work with hazardous chemicals should be conducted in a chemical fume hood).

6.3.3 Job Title Evaluation Hazard Assessment

Job title evaluation hazard assessments should be conducted for specific positions. These types of hazard assessments should be written in a comprehensive manner that includes the majority of hazards that a specific job position (e.g., Animal Care Technician) routinely encounters during the normal course of work. This type of hazard assessment is commonly used for positions where the hazards encountered do not frequently change. If the employee encounters a hazard that is not covered by the job title evaluation hazard assessment, then it will be necessary to perform another type of hazard assessment such as the task evaluation hazard assessment that does address the specific hazards of that task. The following describes the steps that should be taken to perform a task evaluation hazard assessment:

- Identify hazards that the position title may encounter while performing normal duties (e.g., animal bites while working with mice).
- List each task where the hazard is present.
- Determine the PPE requirements for each task.
- List other control measures required such as engineering and administrative controls.

6.4 Minimum PPE Requirements for Laboratory Employees

This section details the minimum PPE requirements for all laboratories using hazardous chemicals. These requirements do not apply to labs that involve solely mechanical, computer, laser or other non-ionizing radiation, or electrical operations. The requirements listed do not cover all operations in all laboratories. Some operations and procedures may warrant further PPE, as indicated by the SDS, the SOP for the chemical(s) being used, facility policies, or regulatory requirements.

While working in a CHP laboratory it is likely that at some point during the workday one will work with, be in the vicinity of, or directly adjacent to hazardous chemicals. Figure 6.1 illustrates the minimum PPE required when working with hazardous chemicals. When not working with hazardous chemicals, the minimum PPE required includes safety glasses, lab coat, as well as a garment and fully enclosed shoes covering all skin beneath the waist.

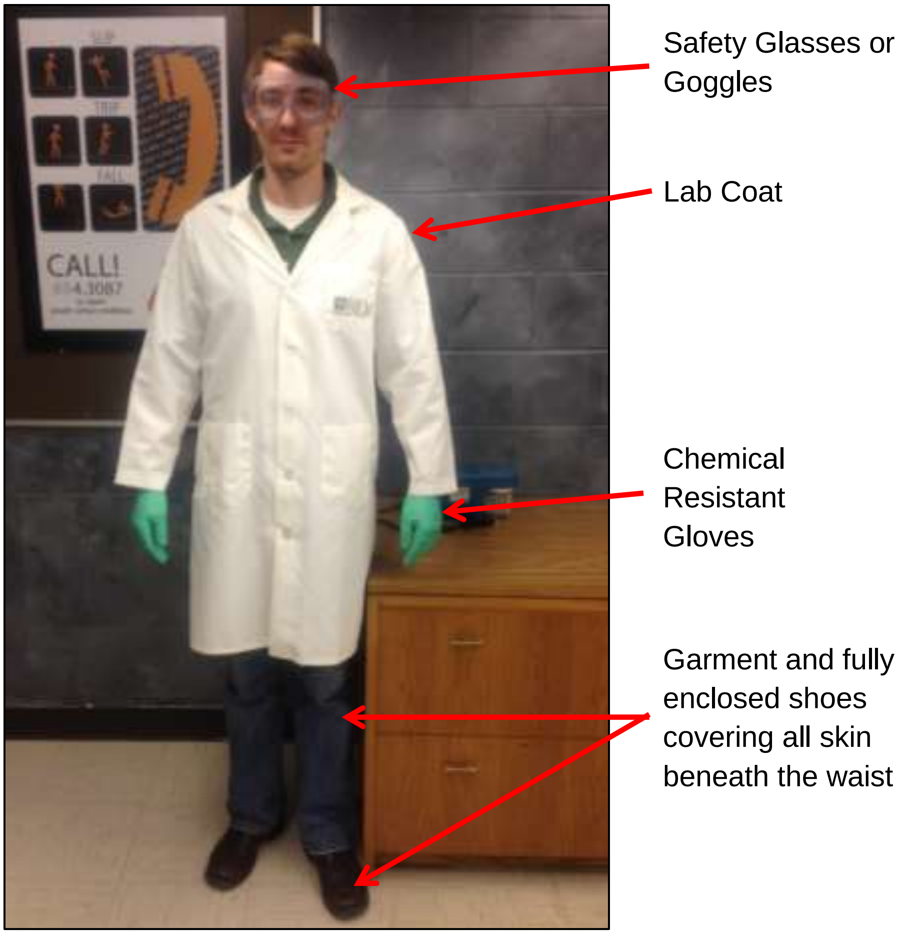


Figure 6.1 – Appropriate PPE for the Laboratory

6.4.1 Head Protection

If there is a serious risk of chemical splash to the head, a chemical-resistant hoodie must be worn. Each affected employee must wear protective helmets when working in areas where there is a potential for injury to the head from falling objects or "bump" hazards.

6.4.2 Hearing Protection

Hearing protection is not typically required in laboratory settings. However, if the lab seems excessively noisy (e.g., operating equipment that is loud, air handling unit is loud) and it is difficult to communicate with co-workers while in the lab, contact EHS 765-494-6371 for a noise level evaluation.

6.4.3 Respiratory Protection

The use of respirators in the laboratory setting is not typically necessary since all work involving hazardous materials must be conducted in a chemical fume hood whenever possible. When ventilation is not adequate to provide protection against an inhalation hazard, respiratory protective equipment may be necessary. There is a variety of respiratory protective equipment available for use, but no one device will provide protection against all possible hazards. Respirator selection is based on the chemical and process hazard, and the protection factors required. Respirators are not to be used except in conjunction EHS's *Respiratory Protection Program*. This 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. Visit the Respiratory Protection webpage or contact EHS at 765-494-6371 with questions about the *Respiratory Protection Program*.

6.4.4 Eye and Face Protection

Each affected employee must use appropriate eye and face protection equipment when exposed to hazards from chemical splash, flying debris, or other exposures that may occur in the laboratory. Safety glasses must be worn at all times by all individuals that are occupying the laboratory area. Splash-proof safety goggles and/or a face shield may be more appropriate depending on the type of work being performed (e.g., transferring liquids outside of a chemical fume hood). All eye protection equipment must be American National Standards Institute (ANSI) approved and appropriate for the work being done. Eye and face protection may not be required in the lab if the employee is sitting at a workstation or desk that is away from chemical processes (e.g., working at a desktop computer, having a lab meeting at a table not adjacent to hazardous operations).

6.4.5 Hand Protection

Each affected employee must wear appropriate hand protection when the hands may be exposed to skin contact of hazardous chemicals, cuts, abrasions, punctures, or harmful temperature extremes. Chemical-resistant gloves must be worn while handling any hazardous chemical container; regardless of whether the container is open or closed (it should be assumed that all chemical containers are contaminated). When selecting appropriate gloves, it is important to evaluate the effectiveness of the glove type to the specific hazardous chemical being handled. Some gloves are more suitable for certain chemicals than others. The SDS for the specific chemical being handled and the glove manufacturer's glove chart should be consulted to select the most appropriate glove. Do not purchase gloves from a manufacturer that does not provide an adequate glove chart. It is recommended that each lab purchase a general-purpose disposable nitrile glove (nitrile gloves are typically more versatile and provide resistance to a wider range of chemicals than latex gloves do) with a minimum of a 4 mil thickness that is suitable for general chemical handling. When handling chemicals or equipment with harmful

temperature extremes such as liquid nitrogen or autoclaves, appropriate protection such as cryogenic gloves or heat-resistant gloves must be worn.

The volume of hazardous chemical being handled should be considered as well. For example, if working with a small volume of a sodium hydroxide solution, disposable chemical-resistant gloves provide adequate protection. But if working with a large volume of sodium hydroxide as with a base bath for instance, a more durable and thick glove such as a butyl rubber should be selected to provide adequate protection.

Chemical-resistant gloves must not be worn outside of the laboratory (e.g., hallways, elevators, offices) to avoid contamination of public areas. Gloves should also be removed prior to handling any equipment that could likely result in cross-contamination (e.g., water fountains, phones, computer work stations). Disposable gloves must never be reused.

6.4.6 Body Protection

Each affected employee must wear protective clothing to protect the body from recognized hazards. All unprotected skin surfaces that are at risk of injury should be covered. A garment and fully enclosed shoes covering all skin beneath the waist must be worn at all times by all individuals that are occupying the laboratory area; shorts are not permitted. Lab coats, coveralls, aprons, or protective suits are required to be worn while working on, in the vicinity of, or adjacent to, all procedures using hazardous chemicals (using means that the chemical bottle is open and the chemical is being poured, transferred, pipetted, etc.). Lab coats must be appropriately sized for the individual and be fastened (snap buttons are recommended) to their full length. Lab coat sleeves must be of a sufficient length to prevent skin exposure while wearing gloves. Flame resistant lab coats must be worn when using any quantity of pyrophoric materials or more than 1 liter of flammable liquids. It is also recommended that 100% cotton (or other non-synthetic material) clothing be worn underneath the flame-resistant lab coat to minimize injury in the case of a fire emergency.

Lab coats should not be worn outside of the lab unless the individual is traveling directly to an adjacent lab work area. Lab coats should not be worn in common areas such as break rooms, offices, or restrooms. Each department is responsible for providing laundry services as needed to maintain the hygiene of laboratory coats. They may not be cleaned by staff members at private residences or public laundry facilities. Alternatives to laundering lab coats include routinely purchasing new lab coats for employees to replace contaminated lab coats, hiring a professional garment laundering service, or using disposable lab coats. Departments can also choose to purchase a washer and dryer and launder their own lab coats.

6.4.7 Foot Protection

To protect against spills or dropped chemicals, fully enclosed shoes must be worn at all times when in the laboratory; open toe (toe, top, or heel) shoes and/or sandals are not permitted in any circumstance. Each affected employee must wear protective footwear when working in areas where there is a high-risk of objects falling on or rolling across the foot, piercing the sole, and where the feet are exposed to electrical or chemical hazards. If there is a high risk of chemical contamination to the foot (e.g., cleaning up a chemical spill on the floor), then chemical-resistant booties may need to worn as well.

6.5 Minimum PPE Requirements for Support Staff and Visitors

Support staff (e.g., custodians, maintenance workers) and visitors often must enter laboratories to perform routine tasks such as maintenance or take a tour of the lab. These individuals are present in the laboratory, but are not performing work with or directly adjacent to any work with hazardous chemicals. To be present in the laboratory, the minimum PPE requirements include safety glasses as well as a garment and fully enclosed shoes covering all skin beneath the waist. If additional PPE is required or if other unique safety requirements must be followed, it is the lab personnel's responsibility to notify support staff and/or visitors of the additional requirements.

6.6 PPE Training Requirements

Laboratory Supervisors must ensure that all employees receive PPE training before any work with hazardous materials occurs. This training must be documented using the Certification of Training Form (Appendix B of the Purdue University *Personal Protective Equipment (PPE) Policy*. Each lab employee must be trained to know at least the following:

- When PPE is necessary;
- What PPE is necessary;
- How to properly don, doff, adjust, and wear PPE;
- The limitations of the PPE; and
- The proper care, maintenance, and useful life of PPE.

Each affected employee must demonstrate an understanding of the training provided and the ability to use the PPE properly before performing any work requiring the use of PPE. When the Laboratory Supervisor has reason to believe that an affected employee who has already been trained does not have the understanding and skill required (e.g., employee is seen handling hazardous materials without wearing proper PPE), then the Laboratory Supervisor must ensure the employee is retrained.

6.7 Injuries, Illnesses, and Medical Examinations

Employees must notify their Laboratory Supervisor of all injuries and illnesses regardless of the magnitude. The Laboratory Supervisor must ensure that a First Report of Injury Form is completed. Employees should report to a Purdue approved occupational medical provider if medical attention is required (Note: The Purdue University Student Hospital is not an approved occupational medical provider). If the injury is serious and presents an emergency situation, dial 911 and emergency responders (Purdue Fire Department if located on the West Lafayette Campus) will respond and transport the patient to a local hospital emergency room. For more information regarding the First Report of Injury reporting process, contact Environmental Health and Safety.

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:

- Whenever an employee develops signs or symptoms associated with a hazardous chemical to which the employee may have been exposed in the laboratory;
- Where exposure monitoring reveals an exposure level routinely above the action level (or in the absence of an action level, the permissible exposure limit) 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; and
- 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 examination. All medical examinations must be performed by or under the direct supervision of a licensed medical care provider and must be provided without cost to the employee.

Chapter 7: Hazardous Waste Management

7.1 Introduction

Hazardous waste is generally defined as waste that is dangerous or potentially harmful to human health or the environment. Hazardous waste regulations are strictly enforced by both the Environmental Protection Agency (EPA) and the Indiana Department of Environmental Management. The Laboratory Supervisor is responsible for managing the hazardous waste program in a safe and compliant manner. No chemical waste should be poured down the drain or discarded in the trash unless it is certain that doing so does not violate hazardous waste regulations or the West Lafayette wastewater treatment plant's requirements (see section 7.7 of this chapter for information and guidance for acceptable sink disposal practices).

Hazardous wastes can be liquid, solid, gas, or sludge. They can be discarded chemicals or mixtures generated from research and teaching operations, commercial products (e.g., cleaning fluids or pesticides), or by-products of manufacturing processes. All hazardous waste falls into one of the following categories:

- Characteristic Wastes: includes wastes that are ignitable, corrosive, reactive, or toxic (D-listed).
- Listed Wastes: includes wastes from common manufacturing and industrial processes (F-listed), wastes from specific industries (K-listed), and wastes from commercial chemical products (U- and P-listed).
- Universal Waste: includes certain batteries (primarily rechargeable batteries such lithium, nickel-cadmium, nickel metal hydride, and mercury oxide), mercury-containing equipment (e.g., thermometers, thermostats), and certain lamps (e.g., fluorescent bulbs). Note: alkaline batteries and incandescent bulbs are not considered Universal Wastes and can be legally disposed of as trash.
- Mixed Waste: hazardous waste mixed with radioactive waste.

EPA-regulated hazardous waste should not be mistaken for biological or radiological wastes.

7.2 Waste Identification and Labeling

All chemical constituents in a hazardous waste container must be identified by knowledgeable laboratory personnel. Not only is this required by the EPA, it also ensures that waste can be properly characterized and disposed of by EHS. If there is uncertainty about the composition of a waste stream resulting from an experimental process, laboratory employees must consult the Laboratory Supervisor for assistance. In most cases, careful documentation and review of all chemical products used in the experimental protocol will result in accurate waste stream characterization. Additionally, review SDSs (specifically Section 2, "Hazard Identification" and Section 13, "Disposal Considerations") to obtain information about hazardous constituents and characteristics.

All waste should be properly labeled as soon the first drop of waste enters a waste container. Containers must be labeled and clearly marked with words that describe the contents of the waste and the words "Hazardous Waste". Hazardous waste should be listed completely on the label provided by EHS in a percentage format as shown in Figure 7.1. Listing accurate percentages is not as important (+ 5% is acceptable and constituents less than 1% can be listed as “trace”) as listing all of the chemicals that makeup the waste. If a chemical is found in the laboratory and the composition is unknown, it should be assumed to be hazardous and labeled as “Hazardous Waste – awaiting proper characterization”.


PURDUE UNIVERSITY HAZARDOUS WASTE DISPOSAL TAG

PI:

1. %
2. %
3. %
4. %
5. %
6. %
7. %
8. %
9. %
10. %

HAZARD (check all that apply)

- ❑ Water-reactive
- ❑ Reactive
- ❑ Flammable
- ❑ Oxidizer
- ❑ Carcinogen
- ❑ Corrosive
- ❑ Toxic
- ❑ Other

Figure 7.1 – Purdue University Hazardous Waste Label

7.3 Waste Storage Requirements

Hazardous waste containers in Purdue laboratories are stored in satellite accumulation area (SAA). SAAs are used to manage hazardous waste in laboratories and shops because doing so provides safe and effective means to accumulate hazardous waste before removal by EHS. Additionally, SAAs provide the least restrictive regulatory option for the accumulation and storage of hazardous waste containers. The following SAA rules must be followed at all times when managing hazardous waste in a laboratory:

CAUTION

Hazardous Waste Satellite Accumulation Area

- All waste must be stored in containers.
- Containers must be in good condition and compatible with the waste they contain (no corrosive waste in metal containers).
- Containers must be kept closed at all times except when adding or removing waste.
- Containers must be labeled or clearly marked with words that describe the contents of the waste (e.g., liquid chromatography waste) and the words "Hazardous Waste".
- Containers must be stored at or near the point of generation and under the control of the generator of the waste (wastes should remain in the same room they were generated in). A central waste collection room should not be established.
- The waste storage volume should never exceed 55 gallons per SAA.

- Containers should be segregated by chemical compatibility during storage (e.g., acids away from bases, secondary containment can be used as a means of segregation).
- Avoid halogenated and non-halogenated wastes in the same waste container.
- Avoid mixing incompatible waste streams in the same container (e.g., acids with bases, oxidizers with organic solvents) that will potentially create an exothermic reaction in the waste container. If mixing waste streams does create heat, allow the container to vent and cool in a chemical fume hood before sealing to avoid over pressurization of the container as illustrated in Figure 7.2.
- Collect all highly toxic, reactive, mercury and any exotic wastes (e.g., dioxin compounds, PCBs, controlled substances) separately even if they are chemically compatible with other waste streams. Failing to do so can result in costly disposal fees (e.g., mixing mercury with an organic solvent waste means that the entire waste stream must be treated as mercury waste).
- All spills and leaks should be cleaned up immediately.
- Identification of SAAs is not required by the EPA, but it is recommended as a good practice.

Figure 7.2 – Container Failure Due to Mixing Incompatible Waste Streams

7.4 Waste Containers

EHS does not provide containers to campus. It is the responsibility of the generator of the waste to provide containers. Usually, the original container of the main component of the waste can be used (e.g., 4-liter glass jar, 5-gallon green metal solvent can). Lab supply companies also offer waste containers such as 20-liter carboys as shown in Figure 7.3 for purchase.

If requested, reusable hazardous waste storage containers of 5 gallons or larger may be returned to the generator's area. Mark the container clearly with "Return to", the building, and room number as illustrated in Figure 7.4. Containers unsuitable for reuse will be properly disposed of and not returned.

Figure 7.3 – 20 Liter Carboy

Figure 7.4 – Reusable Waste Container

Containers unsuitable for reuse will be properly disposed of and not returned. If a container is deemed unsuitable for reuse, the lab will be notified by EHS staff. Purdue's policy for the disposal of empty containers is implemented to protect Purdue facilities and the Physical Facilities Buildings and Grounds staff when removing trash. Please remember that some chemical residues have the potential to mix with other incompatible residues in the dumpster or compactor causing a reaction or fire. In addition, sealed containers may become pressurized during compaction, which may result in residues spraying onto workers. Please keep the following procedures and information in mind when disposing of empty containers:

- Triple rinse empty containers with a solvent capable of removing the original material.
- Collect the rinsate for disposal through EHS.
- Identify triple-rinsed, dry, odorless, and empty containers by placing a "Safe for Disposal" label on the container (Figure 5.3). Contact EHS at 765-494-0121 or by a supply request through EHSA to request a supply of these labels.
- Remove any cap that may cause the container to become pressurized when compacting.
- Arrange removal of these containers with the Building Services staff in your area or take these containers to the designated area beside the dumpster outside your building.
- If unable to remove residual hazardous materials from containers, submit these to EHS for pickup using EHSA.

Figure 7.5 – Safe for Disposal Label

7.5 Waste Disposal Procedures

EHS provides pickup services for all chemical and biological waste generated on the West Lafayette campus. A hazardous materials pickup request must be completed and submitted using the Environmental Health and Safety Assistant (EHSA) software by the generator of the waste to initiate pickup services. Once the pickup request has been processed, EHS HMM staff will come to the area to pick up the waste.

The following procedures must be followed to have hazardous waste removed from campus locations:

1. Prior to pick up, all waste must be placed in the SAA within the same room where the waste was generated.
2. All waste must be placed in an appropriate container(s).
3. All containers must be capped and properly labeled.
4. All containers must be taken out of their storage refrigerators and allowed to warm to room temperature.
5. Visit the EHS homepage and click the “EHSA Waste Pickup Request” button to request a chemical waste pickup through EHSA.

Waste pickups may be placed on hold by EHS for the following reasons:

- Room is locked and EHS personnel do not have a key or a way to gain access
- Improper container or container is leaking or has been overfilled
- Improper caps/lids, and/or
- Mislabeled containers:
  - No label
  - Use of chemical formula or abbreviations
  - Label description does not match the contents of containers, and/or

- Containers are heavily contaminated and not in good condition

7.6 Unknown Chemical Waste

Unknown chemicals are a serious problem in laboratories. Mysterious chemicals are often stored in labs for years before lab personnel notice the unidentified items. However, steps can be taken to assist with proper management of unknowns. Unknown chemicals must be properly identified according to hazard class before proper disposal. The hazards that should be noted include: corrosive, flammable, oxidizer, reactive, toxic, and radioactive. The following subsections describe in detail how to properly manage unknown chemicals.

7.6.1 Labeling Unknown Chemicals

Until the unknown chemical can be properly identified by either lab staff or EHS, the container should be labeled with a Hazardous Waste Disposal Tag. The following information should be written on the label: "Unknown hazardous chemical, awaiting proper characterization by EHS" as illustrated in Figure 7.6.

Figure 7.6 – Properly Labeled Unknown Waste

7.6.2 Identifying Unknown Chemicals

Every effort should be made by laboratory personnel to identify unknown chemicals. Here are a few steps that can be taken to help this effort:

1. Ask other laboratory personnel if they are responsible for, or can help identify the unknown chemical.
2. The type of research conducted in the laboratory can be useful information for making this determination. Eliminating certain chemicals as a possibility helps narrow the problem as well. This is especially important for mercury, PCB, or

dioxin compounds because they must be managed separately from other hazardous waste.

3. For trade products, contact the manufacturer or search online to obtain an SDS. EHS staff can assist you in finding an SDS.

7.6.3 Removing Unknown Chemicals from the Work Area

If it is not possible to identify the material, a "Hazardous Waste" label should be placed on the container as described above in Section 7.6.1 and a Hazardous Materials Pickup Request Form should be submitted which describes all of the available information (e.g., 4-liter container of clear liquid). Call EHS at 765-494-0121 if you have a question about an unknown.

7.6.4 Preventing Unknown Chemicals

Here are a few tips that will help prevent the generation of unknown chemicals:

- Label all chemical containers, including beakers, flasks, vials, and test tubes. The label should be placed on the container, not the cap to avoid accidental mislabeling.
- Immediately replace labels that have fallen off or that are deteriorated.
- Label containers using chemical names. Do not use abbreviations, structure, or formulae.
- Archived research samples are often stored in boxes containing hundreds of small vials. Label the outside of the box with the chemical constituents paying special attention to regulated materials such as radioactive material, organic solvents, heavy metals and other toxics. If the samples are nonhazardous, label them as such.
- Submit frequent Hazardous Materials Pickup Request Forms to reduce the amount of chemicals in your laboratory.
- Employees should dispose of all of their waste before leaving/graduating from Purdue. The lab and/or department should come up with a system to ensure that all faculty, staff, and students properly dispose of hazardous waste, including unwanted research samples, before employees leave.

7.7 Sink and Trash Disposal

No chemical waste should be poured down the drain or discarded in the trash. Submit all weigh boats, pipet tips, and gloves that have had direct contact with chemicals. If gloves have not been in direct contact with chemicals, then they can be disposed of in the regular trash or recycled. Please contact EHS at 765-494-0121 for further information regarding laboratory debris disposal.

7.8 Sharps Waste

Sharps are items capable of puncturing, cutting, or abrading the skin such as glass or plastic pipettes, broken glass, test tubes, petri dishes, razor blades, needles, and syringes with needles. Sharps waste contaminated with hazardous chemicals must be placed into puncture resistant containers (e.g., sharps container, plastic or metal container with lid) and properly labeled as detailed in Chapter 4 of the *Purdue University Hazardous Waste Guidelines*. All chemically contaminated waste should be inventoried on a Hazardous Materials Pickup Request Form and sent to EHS for proper disposal.

Clean uncontaminated broken glassware and plastic sharps should be placed in a corrugated cardboard box or other strong disposable container. Do not exceed 20 pounds. When ready for disposal, the box should be taped shut and prominently labeled as “Sharp Objects/Glass – Discard” or similar wording. The “Safe for Disposal” label (Figure 7.5) should also be affixed to the outside of the container. Contact your Physical Facilities Building Services department for specific non-hazardous waste disposal instructions. More detail regarding sharps, including biologically contaminated sharps, can be found at the found in the EHS *Sharps and Infectious Waste Handling and Disposal Guidelines*.

7.9 Liquid Chromatography Waste

Liquid chromatography (LC) is an analytical technique used to separate, identify, quantify, and purify individual components of a mixture. This technique is very common in biological and chemical research. The most common type of LC at Purdue is High Performance Liquid Chromatography (HPLC). Purdue has numerous LC instruments located in laboratories all over campus. Because organic solvents (e.g., methanol, acetonitrile) are commonly used in the process, most LC waste is regulated by the EPA as hazardous waste. Consequently, all containers collecting LC waste must remain closed while the LC unit is in operation. It is neither acceptable to place a waste line running from the LC unit into an open waste container nor is it acceptable to use foil or Parafilm® as a means of closure as shown in Figure 7.7.

Open Waste		**Foil**	**Parafilm®**
			

Figure 7.7 – Improper LC Waste Collection Practices

One of the following practices must be employed in order to comply with hazardous waste regulations for LC waste collection systems:

1. Purchase an engineered container and/or cap designed for LC waste collection. Figure 7.8 shows several examples of acceptable solutions for proper LC waste collection that can be purchased.

Ported (No Threads) **Cap**	**4 Port Cap** (threaded)	**Solvent Bottle Cap**
		

Figure 7.8 – Proper LC Waste Collection Options for Purchase

2. An existing cap can be modified by the research lab for LC waste collection. To modify an existing cap, a hole can be drilled into a cap. The diameter of the hole should be similar to the diameter of the waste line; there should be a tight fit between the container opening and waste line. In addition, a hole should be drilled to accommodate any exhaust filter or air valve tube that may be required. It is recommended that either a 4-liter container or 5-gallon carboy be used for waste collection. The modified cap should be replaced with a regular, unmodified cap once the container is full and ready for EHS pickup.

Chapter 8: Chemical Spills

Chemical spills in the laboratory can pose a significant risk to human health and the environment. All lab personnel must be trained on how to properly respond to chemical spills in order to minimize risk. In general, chemical spills can be placed into one of two categories: non-emergency chemical spills, or emergency chemical spills.

8.1 Non-Emergency Chemical Spill Procedures

Non-emergency chemical spills are generally defined as less than 1 liter, do not involve a highly toxic or reactive material, do not present a significant fire or environmental hazard, and are not in a public area such as a hallway. These spills can be cleaned up by properly trained lab personnel using conventional lab PPE (e.g., safety glasses/goggles, lab coat, gloves) and the lab spill kit. In general, when a non-emergency spill occurs in the lab the area around the spill should be isolated, everyone in the lab should be made aware of the spill, and the spilled material should be absorbed and collected using either pads or some other absorbent material such as oil dry or kitty litter. Decontamination of the spill area should be conducted using an appropriate solvent (soap and water is often the most effective). Proper PPE should be worn at all times and only trained personnel should conduct the cleanup. Additionally, review the SDS(s) (specifically Section 6, “Accidental Release Measures”) to obtain chemical-specific cleanup information.

8.2 Emergency Chemical Spill Procedures

Emergency chemical spills are generally defined as greater than 1 liter, involve a highly toxic or reactive compound, present an immediate fire or environmental hazard, or require additional PPE (e.g., respirator) and specialized training to properly cleanup. The following procedures should be followed in the event of an emergency chemical spill:

- Cease all activities and immediately evacuate the affected area (make sure that all personnel in the area are aware of the spill and also evacuate).
- If chemical exposure has occurred to the skin or eyes, the affected personnel should be taken to the nearest safety shower and eyewash station.
- Dial 911, which will initiate both the Purdue Police and Purdue Fire Department response, if the situation is, or could become an emergency (e.g., chemical exposure has occurred, a fire or explosion has occurred).
- The fire alarm should be pulled, which will initiate building evacuation, if any of the following occurs:

- A fire and/or explosion has occurred (or there is a threat of fire and/or explosion);
- The large spill (which is either highly toxic or presents an immediate fire or environmental hazard) is in a public area such as a hallway;
- Toxic vapors are leaving the area where the spill has occurred, such as seeping from the laboratory into the hallway or neighboring rooms;
- You are unsure of the hazards and feel that the spill could be harmful to building occupants.
- Ensure that no one else is allowed to enter the area until the spill has been properly cleaned up by the Purdue Fire Department.

8.3 Chemical Spill Kits

Each laboratory should have a spill response kit available for use. Lab spill kits can either be purchased from a vendor or created by lab personnel, but each spill kit should be equipped to handle small spills of the most common hazards in the laboratory. The kit should be equipped with response and cleanup materials such as:

- Absorbent materials such as pads, booms, oil dry or kitty litter, booms, or pillows
- Neutralizing agents (e.g., Neutrasorb®) for acids and/or bases if high volume of acids and/or bases are stored in the laboratory
- Containers such as drums, buckets, and/or bags to containerize spilled material and contaminate debris generated during the cleanup process
- PPE such as gloves, safety glasses and/or goggles, lab coat or apron, chemical-resistant booties
- Caution tape or some other means to warn people of the spill

Chapter 9: Training

Effective training is crucial to a successful laboratory safety program. Laboratory Supervisors must actively participate in the training process to ensure that all lab employees are effectively trained before any work with hazardous materials occurs. This chapter details the minimum training requirements for all Purdue laboratories. It should be noted that depending on the type of research being conducted and associated hazards, there may be additional training requirements that are not detailed in this chapter. For more information, contact EHS at 765-494-6371 or visit the EHS Training webpage.

9.1 CHP Training

As discussed in Chapter 1 of the CHP, all laboratory employees (graduate students, lab technicians/managers, post-docs, visiting scientists, etc.) must receive documented CHP training before any work with hazardous materials occurs. The Laboratory Supervisor is responsible for providing CHP training. Initial CHP training should include the following:

- Review the lab-specific CHP in its entirety
- Review lab-specific hazard assessments
- Review lab-specific SOPs
- Review any other lab-specific protocol or requirements

Refer to Appendix A for the CHP Lab-Specific Training Certification form, which can be used to document having read the CHP.

9.1.1 Lab Safety Fundamentals Online Training

The Lab Safety Fundamentals (LSF) online training was developed to provide basic laboratory safety training for individuals working with recognized hazards in the laboratory. This training is ideal for first year graduate students. LSF online training is a course offered through Purdue University's Learning Management System created by Vivid Learning Systems. The training covers mainly chemical hazards but is appropriate for all individuals that work in research laboratories. It should be completed prior to starting work in the laboratory. Each trainee must take the exam to receive training credit. For access to the LSF online training, visit the EHS Training webpage.

9.1.2 Annual CHP Refresher Requirements

After receiving the initial documented CHP training, all lab employees must receive annual CHP refresher training as well. This annual refresher training can be a condensed version of the initial CHP training, but should include at least the following elements:

- Review of the lab-specific hazard assessments (review of PPE requirements)
- Review of the lab-specific SOPs

- Review of any additional lab-specific rules and requirements
- Review of chemical spill and lab emergency procedures

9.2 PPE Training

As discussed in Chapter 6 of the CHP, Laboratory Supervisors must ensure that all lab employees receive documented PPE training before any work with hazardous materials occurs. Document PPE training using the Certification of Training Form (Appendix B of the Purdue University *Personal Protective Equipment (PPE) Policy*. Each lab employee must be trained to know at least the following:

- When PPE is necessary
- What PPE is necessary
- How to properly don, doff, adjust, and wear PPE
- The limitations of the PPE
- The proper care, maintenance, and useful life of PPE

Each affected employee must demonstrate an understanding of the training provided, and the ability to use the PPE properly, before performing any work requiring the use of PPE.

9.3 SOP Training

As discussed in Chapter 4 of the CHP, SOPs are written instructions that detail the steps that will be performed during a given procedure and include information about potential hazards and how these hazards will be mitigated. SOPs must be developed for all hazardous tasks that are performed in the lab. Laboratory Supervisors must ensure that all applicable personnel receive documented training on lab-specific SOPs. More information regarding SOPs can be found on the EHS *Standard Operating Procedures*.

9.4 Laboratory Chemical Safety Course (CHM 605)

The Purdue Department of Chemistry offers a graduate level, zero credit fall-semester course (CHM 605) that covers the fundamentals of laboratory chemical safety practices. CHM 605 includes a strong focus on learning how to find, read, interpret and use the information in safety data sheets, chemical labels, and other printed chemical safety information. Other topics covered include fire protection/prevention, electrical safety, laser and ionizing radiation safety, machine safety (pumps, autoclaves, centrifuges), and non-PPE safety equipment (hoods, extinguishers, fire protection systems and building elements, general ventilation, showers, eyewashes), and an understanding of administrative controls, engineering controls, and how to select, use, maintain and decide to retire/replace PPE necessary for laboratory work with chemicals. Regulatory agency familiarity and compliance topics including OSHA, EPA, DOT, and NRC are also included. CHM 605 is open to all departments and is a required course for some departments. All graduate students working in a laboratory environment are strongly encouraged to take CHM 605.

9.5 EHS Researcher’s Guide

The CHP focuses on work with hazardous chemicals in the laboratory. However, other common types of hazards are present in many research labs as well (e.g., biological hazards, lasers, etc.). EHS has developed the Researcher’s Guide as a tool to assist researchers with compliance and training requirements for a broad range of common hazards and regulatory programs found in the laboratory. Visit the EHS Researcher’s Guide webpage for more information.

Appendix A:

Lab-Specific
Training Certification Form

PURDUE UNIVERSITY
Chemical Hygiene Plan

Lab-Specific Training Certification

(Please Type or Print Legibly)

For: ____

Laboratory Supervisor, Building, and Room(s)

After reading your lab-specific Purdue Chemical Hygiene Plan, complete and return a copy of this form to your Laboratory Supervisor. By signing below, you acknowledge that you understand your lab-specific Chemical Hygiene Plan and the policies and procedures applicable to the OSHA Occupational Exposure to Hazardous Chemicals in Laboratories Standard (29 CFR 1910.1450). Your Laboratory Supervisor will provide additional information and training as appropriate.

Name: ______________________________ Work Telephone: ______________

Email Address: ____

Department: ____

Job Title: ____

Employee Signature: ______________________________ Date: ______________

Filing:

File each employee's completed Chemical Hygiene Plan Lab-Specific Training Certification Form in a central administrative location. These and all other safety training records should be organized in a way that allows original records for a single staff member or for an entire work group (as identified by the Laboratory Supervisor) to be retrieved quickly and efficiently on request by an OSHA inspector or a EHS staff member.

Appendix B:

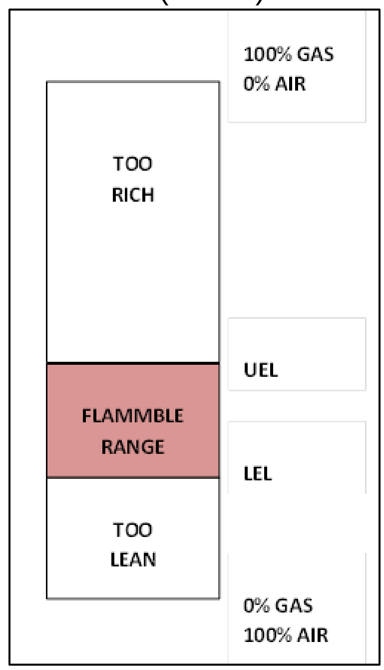
OSHA Hazard Class Definitions

B.1 Physical Hazards

B.1.1 Flammable Liquids

Flammable hazards are materials which under standard conditions can generate sufficient vapor to cause a fire in the presence of an ignition source. Flammable liquids (e.g., hexane, ethyl acetate, and xylene) are more hazardous at elevated temperatures due to more rapid vaporization. The following definitions are important to understand when evaluating the hazards of flammable liquids:

- **Flammable liquid** is a liquid having a flash point no greater than 93 °C (200 °F).
- **Flash point** is the minimum temperature at which the application of an ignition source causes the vapors of a liquid to ignite under specified test conditions.
- **Boiling point** is the temperature at which the vapor pressure of a liquid equals the atmospheric pressure and the liquid changes into a vapor.
- **Auto ignition temperature** is the minimum temperature at which self-sustained combustion will occur in the absence of an ignition source.
- **Lower explosive limit (LEL)** is the lowest concentration (percentage) of a gas or a vapor in air capable of producing a flash of fire in presence of an ignition source (arc, flame, heat).
- **Upper explosive limit (UEL)** is the highest concentration (percentage) of a gas or a vapor in air capable of producing a flash of fire in presence of an ignition source (arc, flame, heat).



Some organic solvents (e.g., diethyl ether) have the potential to form potentially shock-sensitive organic peroxides. See Appendix 3 for additional information regarding peroxide forming chemicals.

Chapter 5.7.2 of the CHP details flammable liquids storage requirements.

B.1.2 Flammable Solids

A flammable solid is a solid which is readily combustible, or may cause or contribute to a fire through friction. Readily combustible solids are powdered, granular, or pasty substances which are dangerous if they can be easily ignited by brief contact with an ignition source. Flammable solids are more hazardous when widely dispersed in a confined space (e.g., finely divided metal powders).

B.1.3 Gases under Pressure

Gases under pressure are gases which are contained in a receptacle at a pressure not less than 280 kPA at 20 °C or as a refrigerated liquid. Gases under pressure include the following:

- **Compressed gas** is a gas which when packaged under pressure is entirely gaseous at -50 °C; including all gases with a critical temperature ≤ -50 °C.
- **Liquefied gas** is a gas which when packaged under pressure is partially liquid at temperatures above -50 °C.
- **Refrigerated liquefied gas** is a gas which when packaged is made partially liquid because of its low temperature.
- **Dissolved gas** is a gas which when packaged under pressure is dissolved in a liquid phase solvent.

All compressed gases are hazardous due to the fact they are stored in compressed cylinders, which can explode and act as a projectile if ruptured. Compressed gases also carry the hazards of the chemicals they contain such as asphyxiation (carbon dioxide), toxicity (nitric oxide), flammable (propane), and corrosive (hydrogen chloride).

Chapter 5.7.3 of the CHP details compressed gases storage requirements.

B.1.4 Pyrophoric, Self-Heating, and Self-Reactive Materials

Pyrophoric material (also called "spontaneously combustible") is a liquid or solid that even in small quantities and without an external ignition source can ignite after coming in contact with the air.

Self-heating material is a solid or liquid, other than a pyrophoric substance, which, by reaction with air and without energy supply, is liable to self-heat. This endpoint differs from a pyrophoric substance in that it will ignite only when in large amounts (kilograms) and after long periods of time (hours or days).

Self-reactive material is a thermally unstable liquid or solid liable to undergo a strongly exothermic thermal decomposition even without participation of oxygen (air).

Chapter 5.7.4 of the CHP details the storage requirements for reactive chemicals.

B.1.5 Water-Reactive Materials

A water-reactive material is a liquid or solid that reacts violently with water to produce a flammable or toxic gas, or other hazardous conditions. Alkali metals (e.g., sodium, potassium) and metal hydrides (e.g., calcium hydride) are common water-reactive materials found in laboratories.

Chapter 5.7.4 of the CHP details the storage requirements for reactive chemicals.

B.1.6 Oxidizers

An oxidizing solid/liquid is a solid/liquid which, while in itself is not necessarily combustible, may generally by yielding oxygen, cause or contribute to the combustion of other material. Hydrogen peroxide, nitric acid, and nitrate solutions are examples of oxidizing liquids commonly found in a laboratory. Sodium nitrate, Sodium perchlorate, and Potassium permanganate are examples of oxidizing solids commonly found in a laboratory.

Chapter 5.7.7 of the CHP details oxidizer storage requirements.

B.1.7 Organic Peroxides

An organic peroxide is an organic liquid or solid which contains the bivalent -0-0- structure and may be considered a derivative of hydrogen peroxide, where one or both of the hydrogen atoms have been replaced by organic radicals. The term also includes organic peroxide formulations (mixtures). Such substances and mixtures may:

- Be liable to explosive decomposition;
- Burn rapidly;
- Be sensitive to impact or friction; or
- React dangerously with other substances

Chapter 5.7.7 of the CHP details organic peroxide storage requirements.

B.1.8 Explosives

An explosive substance (or mixture) is a solid or liquid substance (or mixture of substances) which is in itself capable by chemical reaction of producing gas at such a temperature and pressure and at such a speed that can cause damage to the surroundings. Pyrotechnic substances are included even when they do not evolve gases. A pyrotechnic substance (or mixture) is designed to produce an effect by heat, light, sound, gas or smoke or a combination of these as the result of non-detonative, self-sustaining, exothermic chemical reactions. An explosive compound that is sometimes found in a laboratory setting is picric acid (2,4,6-trinitrophenol).

If a laboratory plans to work with explosive compounds, contact EHS for further instructions before any work occurs.

B.2 Health Hazards

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. Each health hazard is defined and briefly discussed below.

B.2.1 Irritants

Irritants are defined as chemicals that cause reversible inflammatory effects on living tissue by chemical action at the site of contact. A wide variety of organic and inorganic compounds, including many chemicals that are in a powder or crystalline form, are irritants. Symptoms of exposure can include reddening or discomfort of the skin and irritation to respiratory systems.

B.2.2 Sensitizers

A sensitizer (allergen) is a substance that causes exposed individuals to develop an allergic reaction in normal tissue after repeated exposure to the substance. Examples of sensitizers include diazomethane, chromium, nickel, formaldehyde, isocyanates, arylhydrazines, benzylic and allylic halides, and many phenol derivatives. Sensitizer exposure can lead to all of the symptoms associated with allergic reactions, or can increase an individual's existing allergies.

B.2.3 Corrosives

Corrosive substances cause destruction of living tissue by chemical corrosion at the site of contact and can be either acidic or caustic (basic). Major classes of corrosive substances include:

- Strong acids such as sulfuric, nitric, hydrochloric and hydrofluoric acids
- Strong bases such as sodium hydroxide, potassium hydroxide, and ammonium hydroxide
- Dehydrating agents such sulfuric acid, sodium hydroxide, phosphorus pentoxide and calcium oxide
- Oxidizing agents such as hydrogen peroxide, chlorine, and bromine

Chapter 5.7.6 of the CHP details corrosives storage requirements.

B.2.4 Hazardous Substances with Toxic Effects on Specific Organs

Substances with toxic effects on specific organs include:

- Hepatotoxins, which are substances that produce liver damage, such as nitrosamines and carbon tetrachloride.
- Nephrotoxins, which are substances that cause damage to the kidneys, such as certain halogenated hydrocarbons.
- Neurotoxins, which are substances that produce toxic effects on the nervous system, such as mercury, acrylamide, and carbon disulfide.
- Substances that act on the hematopoietic system (e.g., carbon monoxide and cyanides), which decrease hemoglobin function and deprive the body tissues of oxygen.
- Substances that damage lung tissue such as asbestos and silica.

B.2.5 Particularly Hazardous Substances

Substances that pose such significant threats to human health are classified as "particularly hazardous substances" (PHSs). The OSHA Laboratory Standard requires that special provisions be established to prevent the harmful exposure of researchers to PHSs, including the establishment of designated areas for their use. Particularly hazardous substances are divided into three primary types:

1. Carcinogens
2. Reproductive Toxins
3. Substances with a High Acute Toxicity

B.2.5.1 Carcinogens

Carcinogens are chemical or physical agents that cause cancer. Generally, they are chronically toxic substances; that is, they cause damage after repeated or long-duration exposure, and their effects may only become evident after a long latency period. Chronic toxins are particularly insidious because they may have no immediately apparent harmful effects. These materials are separated into two classes:

1. **Select Carcinogens:** Select carcinogens are materials which have met certain criteria established by the National Toxicology Program or the International Agency for Research on Cancer regarding the risk of cancer via certain exposure routes. It is important to recognize that some substances involved in research laboratories are new compounds and have not been subjected to testing for carcinogenicity.
2. **Regulated Carcinogens:** Regulated carcinogens are more hazardous and have extensive additional requirements associated with them. The use of these agents may require personal exposure sampling based on usage. When working with Regulated Carcinogens, it is particularly important to review and effectively apply engineering and administrative safety controls as the regulatory requirements for

laboratories that may exceed long term (8 hour) or short term (15 minutes) threshold values for these chemicals are very extensive.

B.2.5.2 Reproductive Toxins

Reproductive toxins include any chemical that may affect the reproductive capabilities, including chromosomal damage (mutations) and effects on fetuses (teratogens). Reproductive toxins can affect the reproductive health of both men and women if proper procedures and controls are not used. For women, exposure to reproductive toxins during pregnancy can cause adverse effects on the fetus; these effects include embryolethality (death of the fertilized egg, embryo or fetus), malformations (teratogenic effects), and postnatal functional defects. For men, exposure can lead to sterility. Examples of embryotoxins include thalidomide and certain antibiotics such as tetracycline. Women of childbearing potential should note that embryotoxins have the greatest impact during the first trimester of pregnancy. Because a woman often does not know that she is pregnant during this period of high susceptibility, special caution is advised when working with all chemicals, especially those rapidly absorbed through the skin (e.g., formamide).

B.2.5.3 Substances with a High Acute Toxicity

Substances that have a high degree of acute toxicity are materials that may be fatal or cause damage to target organs as the result of a single exposure or exposures of short duration. Acute toxins are quantified by a substance's lethal dose-50 (LD_{50}) or lethal concentration-50 (LC_{50}), which is the lethal dose of a compound to 50% of a laboratory tested animal population (e.g., rats, rabbits) over a specified time period. High acute toxicity includes any chemical that falls within any of the following OSHA-defined categories:

- A chemical with a median lethal dose (LD50) of 50 mg or less per kg of body weight when administered orally to certain test populations.
- A chemical with an LD50 of 200 mg less per kg of body weight when administered by continuous contact for 24 hours to certain test populations.
- A chemical with a median lethal concentration (LC50) in air of 200 parts per million (ppm) by volume or less of gas or vapor, or 2 mg per liter or less of mist, fume, or dust, when administered to certain test populations by continuous inhalation for one hour, provided such concentration and/or condition are likely to be encountered by humans when the chemical is used in any reasonably foreseeable manner.

Chapter 5.7.5 of the CHP details acutely toxic compounds storage requirements.

Appendix C:

Peroxide Forming Chemicals

Peroxide Forming Chemicals

Autoxidation in common laboratory solvents can lead to unstable and potentially explosive peroxide formation. The reaction can be initiated by exposure to air, heat, light, or contaminants. Most of these solvents are available with inhibitors to slow the peroxide formation. Examples of inhibitors include BHT (2,6-di-tert-butyl-4-methyl phenol) and Hydroquinone. There are three categories of peroxide formers:

Group A chemicals are those which form explosive levels of peroxides after prolonged storage, especially after exposure to air without concentration. Test these for peroxide formation before using and discard 3 months after opening.

Table C.1 – Group A Chemicals	
Butadiene	Isopropyl ether
Chloroprene	Tetrafluoroethylene
Divinylacetylene	Vinylidine chloride

Group B chemicals form peroxides that are hazardous only on concentration by distillation or evaporation. Test these before distillation and discard after 12 months.

Table C.2 – Group B Chemicals		
Acetal	Dicyclopentadiene	Methyl isobutyl ketone
Acetaldehyde	Diethyl ether	4-Methyl-2-pentanol
Benzyl alcohol	Diethylene glycol dimethyl ether	2-Pentanol
2-Butanol	Dioxane	4-Penten-1-ol
Cumene	Ethylene glycol dimethyl ether	1-Phenylethanol
Cyclohexanol	4-Heptanol	2-Phenylethanol
2-cyclohexen-1-ol	2-Hexanol	2-Propanol
Cyclohexene	Methylacetylene	Tetrahydrofuran
Decahydronaphthalene	3-Methyl-1-butanol	Tetrahydronaphthalene
Diacetylene	Methylcyclopentane	Vinyl ether

Group C chemicals consist of monomers which form peroxides that can initiate explosive polymerization. Inhibited monomers should be tested before use and discarded after 12 months. Uninhibited monomers should be discarded 24 hours after opening.

Table C.3 – Group C Chemicals	
Acrylic acid	Styrene
Acrylonitrile	Tetrafluoroethylene
Butadiene	Vinyl acetate
Chloroprene	Vinyl acetylene
Chlorotrifluoroethylene	Vinyl chloride
Methyl methacrylate	Vinyl pyridine

General Guidelines

- Solvents containing inhibitors should be used whenever possible.
- All peroxide forming solvents should be tested prior to distillation.
- Peroxide forming solvents should be purchased in limited quantities.
- Peroxide forming solvents should be marked with the purchase date and the date opened.
- Peroxide forming solvents should be sealed tightly and stored away from light and heat.
- Periodic testing should be done on opened containers and the results marked on the containers.

Testing

- Obtain test strips for the range of 0-100 ppm peroxide.
- Record the test results on the bottle.
- If the test results are 100 ppm or greater, contact EHS at 765-494-0121 for proper disposal.

Appendix D:

Summary of Changes

June 14, 2024

- Changed *“Radiological and Environmental Management”* and *“REM”* references to *“Environmental Health and Safety”* and *“EHS”* respectively
- Corrected formatting, punctuation, and spelling
- Updated telephone numbers to XXX-XXX-XXXX format
- Removed URLs
- Section 7.1: last sentence removed “A more detailed definition of hazardous waste, including the D, F, P, and U lists, is provided in Appendices 1 and 2 of the *Hazardous Waste Disposal Guidelines*.”
- Section 7.2
  - Figure 7.1 updated
- Section 7.4
  - Updated to match new *Hazardous Waste Disposal Guidelines* document requirements
  - Figure 7.3: updated
  - Figure 7.4: updated
- Section 7.5
  - Updated to reflect the *Environmental Health and Safety Assistant (EHSA)* software used to initiate chemical waste pickup services.
- Section 7.6
  - Figure 7.7 updated
- Section 7.7
  - Updated to match new *Hazardous Waste Disposal Guidelines* document requirements
- Section 7.9
  - Figure 7.9 deleted reference to and picture of “Safety Cans”

February 15, 2022

- Removed *“complete the 3 modules and”* from next to last sentence in section 9.1.1

Tab 1:

Lab-Specific

Standard Operating Procedures

Tab 2:

Lab-Specific

Protocols, Requirements, Rules

Tab 3:

Lab-Specific

Hazard Assessments