Oakland University

Chemical Hygiene Plan

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MIOSHA – PART 431. HAZARDOUS WORK IN LABORATORIES

Laboratory Safety and Compliance

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Rochester, Michigan 48309-4452

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PART I. IMPLEMENTING THE CHEMICAL HYGIENE PLAN

1. INTRODUCTION

1.1. Purpose and Scope

Purpose

Oakland University is committed to providing a safe and healthy workplace in compliance with MIOSHA regulations. MIOSHA recognizes the unique characteristics of the laboratory environment, and has tailored a standard for occupational exposure to hazardous chemicals in laboratories. This standard is often referred to as the "Laboratory Standard". Under this standard and as amended January 10, 2014, Oakland University is required to produce a Chemical Hygiene Plan which addresses the specific hazards, and its approach to minimize or prevent these hazards.

The purpose of the Plan is to provide guidelines for management of chemical, and other associated hazards in the lab. Although work practices to promote safety in the laboratory are established by the plan, it is ultimately the responsibility of the individual to ensure that health and safety practices are properly implemented in the laboratory.

Scope

This Plan is designed to protect laboratory workers from potential hazards in their work environment. It applies to all laboratories, and all personnel who supervise or work in these labs.

1.2. Hierarchy of Controls

MIOSHA has adopted a policy which establishes the order in which hazard control options must be utilized. The preferred control method is the use of *engineering controls* to eliminate or isolate the hazard (e.g., fume hoods, glove boxes, process isolation, process substitution); if engineering controls are not feasible then *administrative controls* (work practice changes) may be utilized. As a last resort personal protective equipment (respirators, clothing, goggles, etc.) should be used. Labs are encouraged to first consider if a hazardous substance or procedure can be eliminated or substituted for, in addition to MIOSHA policy steps above.

1.3. CHP Organization

Part I. Implementing the CHP
Includes regulatory requirements of the Standard, and addresses the following:

- Designated responsibilities for implementing compliance with the Laboratory Standard
- Key definitions
- Requirements for employee training
- Ways in which "hazard communication" documents are managed and/or accessed
- Procedure for assessing employee exposure
- Procedure for "designating" work/storage areas (for chemicals of high toxicity)
- Policy regarding medical consultation/examination
- Process for evaluating safety equipment
- Policy regarding "high hazard" operations
- Record keeping requirements

Part II. Standard Laboratory Practices
Describes Standard Laboratory Practices (SLPs) for working safely in laboratories.

Part III. Health and Safety Information for Hazard Classes
Provides information on how to identify, classify, handle, and store chemicals.

Part IV. Chemical Toxicology
Provides an overview of general toxicology principles.

Part V. Glossary and Common Acronyms
Terms

Part VI. Fact Sheets
Supplemental guidance on specific laboratory hazards.

2. ROLES AND RESPONSIBILITIES

Oakland University's Chemical Hygiene Plan defines the roles, responsibilities and accountability of all individuals who work, visit, or manage areas where chemicals and lab hazards are present. It is each individual's responsibility to follow these guidelines.

The following section clarifies the roles and responsibilities of the Office of Environmental Health and Safety, Chemical Hygiene Officer, Laboratory Safety Committee, Director/Department Heads, Supervisors/Principal Investigators, laboratory managers and lab workers.

2.1. Oakland University's Office of Environmental Health and Safety

OU's Office of Environmental Health and Safety (EH&S) is charged with interpreting federal, state and local regulations relating to chemical, biological, and radiological materials used in laboratory teaching and research, constructing practical recommendations for complying with these regulations, and communicating these strategies to laboratory managers/supervisors.

Therefore, the primary function of Environmental Health and Safety is to act in an advisory capacity to the individual department supervisors/administrators, and help them provide a safe and healthful workplace. The CHP requires EH&S to:

A. Staff a Chemical Hygiene Officer
B. Conduct laboratory audits annually, and recommending remedial measures.
C. Provide disposal services for chemical, infectious and radioactive wastes.
D. Consult with employees regarding laboratory safety and chemical exposures.

2.2. Oakland University Chemical Hygiene Officer (CHO)

The OU Chemical Hygiene Officer oversees and manages chemical hygiene program. He/she can be reached in the Office of EH&S, ext. 4196. Responsibilities are the following:

A. Knows the contents of the relevant regulation (MIOSHA-STD-1212, PART 431-Hazardous Work in Laboratories) and updates the Chemical Hygiene Plan as required.

B. Develops and implements University-wide components of the Chemical Hygiene Plan to ensure consistent and well documented program procedures.

C. Works with Department representatives and laboratory supervisors to develop specific components of the Chemical Hygiene Plan. Special attention is given to safe use, storage and disposal of chemicals. The CHO will monitor procurement of chemicals through the Laboratory Chemical Inventory process.

D. Conducts and documents chemical hygiene training sessions for all laboratory supervisors/Principal Investigators, and assist these individuals with training (both general and "site-specific") their teaching assistants, laboratory students, visiting scholars, etc.

E. Advises laboratory supervisors regarding implementation of this Chemical Hygiene Plan.

F. Performs and records laboratory safety audits.

G. Reviews and evaluates effectiveness of the Chemical Hygiene Plan annually.

2.3. Oakland University Department Personnel

Each of the following departments is known to conduct "laboratory work", as defined in the MIOSHA Laboratory Standard and is thereby required to implement those requirements identified in this Chemical Hygiene Plan:

- Department of Biological Sciences
- Department of Chemistry
- Biomedical Research Support (BRS)
- Eye Research Institute (ERI)
- Department of Physics
- School of Health Sciences (SHS)
- School of Engineering and Computer Science (SECS)
- School of Education and Human Services (SEHS)
- School of Medicine (SOM)
- School of Nursing (SON)

2.4. Committees

The university's Laboratory Safety Committee (Chaired by the Laboratory Compliance Manager, ext. 4196) is in place to assist departments to implement safe work practices in the laboratory and assure concurrent compliance with the MIOSHA Laboratory Standard. This committee has representatives from each of the departments listed in Part I., Section 2.3 of the CHP. Employees are welcome to bring chemical hygiene concerns/questions to the Committee or attend committee meetings.

Although setting up *departmental* "laboratory safety" committees for purposes of implementing safe work practices is optional, department managers/supervisors may benefit by working together on efforts to implement consistent policies and procedures that are in accordance with this Chemical Hygiene Plan.

2.5. Department Heads

Department Chairs (in Biology, Chemistry, Physics, SECS and SEHS, SON, SOM are responsible to ensure implementation of the Chemical Hygiene Plan in their departments. This assertion is derived in part from Article XXVI of the 2006 -2009 AAUP Agreement (Item 190 b.) which states:

"Chairpersons are responsible for implementing university regulations within their departments....

Likewise, Directors/Department Heads (in BRS ERI and SHS), as "heads" of their respective departments/programs, are also responsible to ensure implementation of the Chemical Hygiene Plan in their units.

2.6. Laboratory "Supervisor"/ Principal Investigator

The MIOSHA Laboratory Standard (in fact all MIOSHA Standards) explicitly places the primary responsibility to implement all regulatory safety requirements on the "front-line supervisor" of the associated operations. University laboratory operations, materials, equipment, and funding are unique to each laboratory. Therefore, by consensus, universities have interpreted the "front-line supervisors" to be the Principal Investigators of research laboratories and the laboratory instructors of academic laboratories. For "shared" laboratories, this responsibility should be delegated by department Chairs to one or more persons within their departments and identified on the department's Laboratory Chemical Inventory (LCI).
In the event of a Lab Supervisor and/or PI is not available for an extended period of time, a lab proctor or alternate contact must be designated for all high hazard operations.

The **laboratory supervisor** has the following responsibilities with regard to laboratory safety:

A. General Knowledge and Preparedness

1) Responsible for the information needed to recognize and control chemical hazards in the laboratory.
2) Knows the current legal requirements concerning regulated substances at use in their laboratory.
3) Selects and employs laboratory practices and containment procedures (engineering controls) that reduce the potential for exposure to hazardous chemicals to the appropriate level.
4) Defines hazardous operations, designates safe practices and selects protective equipment.
5) Ensures appropriate controls (engineering and personal protective equipment) are used and are in good working order.
6) Assures that copies of the CHP are available to the laboratory employees, students and support staff.
7) Works with EH&S to properly handle and store all hazardous wastes.
8) Notify Lab Safety when switching, vacating or remodeling a lab.
9) Limits access to only authorized personnel.

B. Employee Training, Supervision and Surveillance

1) Ensures that program and support staff receives general Laboratory Right To Know Training and Site Specific Training as described in Part I. Section 4.
2) Ensures that employees understand the training received (i.e., verifies that every employee has passed the applicable competency exam(s) administered by EH&S and/or that supervisor).
3) Monitors the injury and illness records to assist improvement of safety procedures.
4) Becomes familiar with the regulatory components of MIOSHA's Laboratory Standard (outlined in this CHP) and ensures laboratory compliance.
5) Supervises the performance of laboratory staff to ensure safe practices in the laboratory, and enforces policies/procedures as necessary.
6) Conducts routine lab inspections to ensure compliance with laboratory Standard Operating Procedures (SOP).
7) Ensures that lab personnel obtain medical surveillance (where required by MIOSHA). See Part I Section 7.1 for more information.

C. LCI Checklist

1) Ensures that the Laboratory Chemicals Inventory (LCI) is accurate, complete, and submitted on a timely basis to EH&S by the requested deadline. A copy must be readily available to all employees in Appendix A of the CHP binder.

D. High Hazard Chemicals

1) Notifies EH&S prior to acquiring highly hazardous substances (see **Part I. Section 9.** for more information). Upon receipt of this information, EH&S shall advise the OU Police Department and OU's Fire Safety Inspector.
2) Works with EH&S to develop detailed Standard Operating Procedures, (<u>not</u> covered in the Standard Laboratory Practices, **Part II.** of this Manual) for high hazard operations (see **Part I. Section 9.)**.
3) Develops and posts SOPs for working with high hazard chemicals.
4) Defines and posts the location of work areas where highly toxic, potentially carcinogenic, mutagenic and/or **teratogenic substan**ces will be used and stored (see **Part I. Section 7.** for more information).

E. Incident Follow-up and Corrective Action

1) Investigates spills, accidents and injuries, and provides associated documentation (including corrective actions that will potentially minimize the repetition of the incident) to that department's Laboratory Safety Committee representative (and/or the EH&S Laboratory Safety Staff).
2) Works with EH&S following significant spills to arrange for workplace air samples, swipes or other tests to determine presence of airborne and/or surface

contamination.

3) Ensures that all employees are trained in the use and accessibility of laboratory and departmental spill kits.
4) Prepares and communicates procedures for responding to accidents, injuries or illnesses, including (but not limited to) those associated with chemical spills.
5) Ensures that action is taken to correct work practices and conditions that may result, or have resulted, in the unplanned release of chemicals.
6) Ensures proper clean-up and disposal of spilled and/or contaminated materials.

2.7. Laboratory Manager

The **laboratory manager** assists the principal investigators and the Office of Environmental Health and Safety as follows:

A. Assists with procurement and stocking of personal protective equipment**.**

B. Assists with communications between EH&S and the principal investigators.

C. Assists with distribution of CHP copies to laboratory employees.

D. Maintains his/her department's **"**Reference Copy**"** of this Chemical Hygiene Plan in an accessible location to all laboratory employees.

E. Notifies EH&S of staff changes and room assignments.

2.8. Laboratory Worker

The **laboratory worker** is also expected to take responsibility for his/her own actions in the laboratory. He/she has the following responsibilities:

A. Obtains information about the hazards of the materials with which he/she works, as well as those in the immediate vicinity.

B. Plans and conducts each operation in accordance with established Standard Laboratory Practices, SLPs (provided in Part II. of this CHP).

C. Develops and demonstrates safe "chemical hygiene" habits (i.e., chemical safety practices and procedures).

D. Reports unsafe conditions to the laboratory supervisor, Principal Investigator, or EH&S Laboratory Safety Staff.

E. Shares responsibility with the laboratory supervisor/Principal Investigator for collecting, labeling, segregating and storing chemical hazardous wastes properly.

F. Attends required training sessions and follows Standard Laboratory Practices.

G. Wears prescribed personal protective equipment (e.g. safety glasses, goggles, gloves, lab coat etc.) in accordance with site specific training.

H. Informs visitors entering the laboratory of potential hazards, safety rules/precautions, and provide appropriate PPE with training on proper use.

I. Reports to the laboratory supervisor, Principal Investigator or EH&S any accidents/incidents that resulted in the potential exposure to toxic chemicals, and/or any action or condition that exists which could result in future exposure(s).

3. KEY DEFINITIONS (Refer to Glossary for complete list of definitions)

3.1. Definition of a "Laboratory":

For the purposes of the MIOSHA Laboratory Standard, a "Laboratory" is defined as a facility where the laboratory use of hazardous chemicals occurs. It is a workplace where relatively small quantities of hazardous chemicals are used on a nonproduction basis.

3.2. Definition of a "Physical Hazard":

A chemical poses a *physical hazard* if it is (see **Part III.** for more information on each):

● Flammable, aerosol,liquid,solid	● Combustible	● Oxidizer
● Unstable (reactive)	● Compressed gas	● Pyrophoric
● Water-reactive	● Explosive	● Organic peroxide
● Corrosive to Metals	● **Self-heating**	● Self-reactive
● **Chemicals, which in contact with water, emit flammable gases**		

3.3. Definition of a "Health Hazard"

A. For the purposes of the academic laboratories at OU, the Office of EH&S has determined that a laboratory chemical poses a foreseeable "*health hazard*" if it:

1) Poses documented health hazards (see dose/concentration parameters below) via foreseeable routes of exposure (e.g., inhalation, skin contact or incidental/accidental ingestion) presented in academic/research labs;

and/or

2) Presents “moderate” to “high” toxicity (based on LC50/LD50 for 200-300 gram albino rats as follows):

- ♦ Toxic by Inhalation: LC_{50} < 20,000 ppm
- ♦ Toxic by ingestion: (Given that ingestion in a lab would most likely be accidental/incidental), a maximum oral-LD_{50} of 50 mg/kg
- ♦ Toxic by Skin Contact: Skin-LD_{50} of < 340 mg/kg

B. *Classes* of health hazards include (see Part IV. for additional toxicology information):

1) Carcinogen
2) Reproductive toxins (i.e., teratogens and mutagens)
3) Corrosive agents (damage lungs, skin, eyes, or mucous membranes upon contact)
4) Sensitizers (produce extreme allergies upon repeated or prolonged exposure)
5) Irritants
6) Hepatotoxins- (liver) toxins
7) Hematopoietic Toxins- (blood) toxins
8) Neurotoxins- (central nervous system) toxins
9) Nephrotoxins- (kidney) toxins

C. *There are 10 established chemical health classifications:*

1) Acute Toxicity
2) Skin Corrosion/Irritation
3) Respiratory or Skin Sensitization
4) Germ Cell Mutagenicity
5) Carcinogenicity
6) Reproductive Toxicity
7) Specific Target Organ Toxicity – Single Exposure
8) Specific Target Organ Toxicity – Repeated Exposure
9) Aspiration
10) Simple Asphyxiants

4. CHEMICAL/LABORATORY SAFETY TRAINING

Prior to working in a lab, all employees and volunteers must receive information and training regarding the MIOSHA Laboratory Standard, OU's Chemical Hygiene Plan (CHP), and

Standard Laboratory Practices (SLPs). Oakland University's training program for laboratory workers consists of **two parts:**

4.1. Chemical Hygiene Training

EH&S will conduct general chemical hygiene training to Principal Investigators, laboratory supervisors and laboratory workers before they conduct any chemical manipulations in the lab.

A. Refresher training will be completed every five (5) years.

B. Attendance records and associated exam scores are maintained in an EH&S database.

4.2. Site-Specific Training

Supervisor shall provide employees with information and training to ensure that they are apprised of and understand the hazards of chemicals present in their work areas. Such information shall be provided at the time of an employee's initial assignment to a work area where hazardous chemicals are present.

A. Laboratory Requirement

1) When laboratory supervisors should conduct site-specific training:

- ♦ When an employee is initially assigned to a laboratory where hazardous chemicals are present.
- ♦ Whenever an employee is to perform a non-routine task presenting hazards for which he or she has not already been trained.

2) What should be included in Site-specific training and information:

- ♦ A "Site-Specific Training Checklist" has been provided to every laboratory supervisor/PI on campus (copy also included as Appendix A; additional copies may be obtained upon request from EH&S, ext 4196. This Checklist identifies topics which must be presented during site-specific training.

3) Site-Specific Training Recordkeeping

- ♦ A copy of the checklist signed by both the trainee and the instructor should be maintained at the "site" for which training was provided (e.g., laboratory).

5. HAZARD COMMUNICATION DOCUMENTS

5.1. MANAGEMENT/ACCESSIBILITY

The Office of EH&S has a Laboratory Chemicals Inventory (LCI) Checklist, which lists chemicals (and their associated hazards) that are commonly found in academic/research laboratories, AND which present one or more physical or health hazard**s.**

"Hard" copies of this LCI are maintained in the Office of EH&S, and are distributed to OU Police and located in knox boxes throughout campus..

5.2. Safety Reference Literature (Non- SDS) available in EH&S

- The Merck Index
- Hazardous Chemicals Desk Reference (Richard Lewis)
- Prudent Practices in the Laboratory (National Academy Press)
- Prudent Practices for Disposal of Chemicals from Labs (National Academy Press)
- NFPA 491 Guide to Hazardous Chemical Reactions
- NIOSH Pocket Guide to Chemical Hazards, HH, CDC

5.3. Safety Data Sheets (SDS)

- All **SDS** s that are received with incoming reagents are housed in their respective departments, under the immediate control of the departments' laboratory manager
- **SDS** s may be requested (verbally or in writing) from the Office of EH&S.
- EH&S web page: http://www.oakland.edu/labsafety/

5.4. Container Labels

A. Policy. Containers of laboratory chemicals which pose a foreseeable physical or health hazard to employees must bear a hazard communication label.

B. Labels Missing/Removed. If an employee finds a container with a missing, torn or illegible label, he/she should report it to the laboratory supervisor so that the label can be replaced immediately. Labels should never be removed or defaced, *except when container is empty*. Empty containers must have their labels defaced prior to disposal. Label must indicate the following information:

1. Product Identifier (mandatory)
2. Health/Physical Hazards (mandatory)
3. Pictograms/Graphics (optional)

C. Secondary Container Labels. If secondary ("generic") working containers are used that will take more than one work shift to empty, or if there is a chance that someone else will handle the container during that shift, the handler must label the container. (See section 4.1 Container Labels.)

D. New Hazard Information. Users should examine labels each time a newly purchased chemical is employed. It is possible the manufacturer may have added new hazard information or reformulated the product since the last purchase, and thus altered the potential hazards presented by the product.

E. Unpacking new chemicals. Employees involved in unpacking are responsible for inspecting each incoming container to ensure that it is labeled with the information outlined above.

F. New Chemical Substance Synthesis. Laboratory personnel who synthesize, or combine, chemical substances must label the respective containers with the potentially hazardous properties of the new substances.

5.5. Laboratory Signs

A. Exterior Doors. EH&S is responsible to ensure that prominent signs are displayed on the hallway doors leading to each laboratory. Information includes:

1) **Emergency Contact Information:** Telephone extensions of OU Police and that laboratory's primary and secondary contacts.
2) **Warnings:** Special hazards including flammable chemicals, radioactive material or biohazards.

B. Inside Laboratories EH&S is responsible to ensure that prominent signs/tapes are displayed inside laboratories as follows:

1) Designate areas for working with/storing highly **toxic** chemicals (including carcinogens, **teratogens** and/or mutagens).
2) Provide emergency response information (e.g. closest campus phone, OU Police ext.,etc.)
3) **SDS** Location Sign
4) Other Physical Hazards (e.g. laser, high voltages, magnetic fields, robotic systems)
5) Hazardous Waste Storage Areas
6) Label chemical storage areas for corrosives, flammables, oxidizers, highly

reactives and toxics.

6. EMPLOYEE EXPOSURE ASSESSMENTS

Regular environmental or employee exposure monitoring of airborne concentrations is not generally warranted in academic laboratories because small quantities are used for relatively short periods of time. However, air monitoring may be conducted if Personal Air Monitoring Indicators in 6.1 suggest an exposure.

6.1. Personal Air Monitoring – Indicators

A. Suspected Exposure to Chemicals of Acute Toxicity

- Air monitoring may become necessary if/when laboratory employees exhibit signs/symptoms that correspond to the acute toxicity presented by one or more chemical(s) with which they are working, or there is some other indication (e.g., odor) that chemical exposure is exceeding its MIOSHA Permissible Exposure Limit (PEL).

B. Suspected Exposure to Chemicals of Chronic Toxicity

Air monitoring may become necessary if/when it is suspected that exposure to a chemical which poses chronic (e.g., a carcinogen) toxicity has exceeded the MIOSHA Permissible Exposure Limit (PEL) for that chemical.

C. MIOSHA-Regulated Carcinogens

- MIOSHA explicitly regulates 22 carcinogens (see Part I. Table 6.2), each with its own comprehensive health standard (and associated PELs). Whenever the "action level" (typically one-half the MIOSHA PEL) is routinely exceeded, exposure monitoring and medical surveillance is required by MIOSHA.

Table 6.2 - MIOSHA-Regulated Carcinogens

Compounds Regulated by MIOSHA	
2-acetylaminofluorene **	ethylenimine **
acrylonitrile	ethylene oxide
4-aminodiphenyl *	formaldehyde
asbestos	lead and lead compounds
arsenic and arsenic compounds	alpha-naphthylamine **
benzene	beta-naphthylamine *
benzidine *	4-nitrobiphenyl *

Compounds Regulated by MIOSHA	
bis-chloromethyl ether *	N-nitrosodimethylamine **
1,2-dibromo-3-chloropropane	beta-propiolactone **
3,3'-dichlorobenzidine (& its salts) **	vinyl chloride
4-dimethylaminoazobenzene **	methyl chloromethyl ether *****

***** (mixture > 0.1 % by wt. or vol) ** (mixture > 1.0 % by wt. or vol)

7. "DESIGNATED" WORK/STORAGE AREAS

All chemicals exhibiting high acute, high chronic or reproductive toxicity should be used **<u>and</u>** stored in **"designated areas".** See **Part III. Section 7** of this Chemical Hygiene Plan for guidelines on handling/storing these chemicals, and a list of chemical examples.

Routine laboratory work should not be conducted in these designated areas until they have been decontaminated, or determined to be acceptable by the Principal Investigator.

Employees working in the area should be informed of the toxic hazards associated with these substances and the appropriate precautions that are necessary for preventing exposures. (Signs and "toxic area hazard warning tape" are available in the Office of EH&S, ext. 4196)

A. Special Precautions For Employees Working With Reproductive Toxins

- **Pregnant Employees** and lab personnel of childbearing age, who will be working with teratogens, shall be informed of any reproductive toxins used in the lab. They may also contact the OU Chemical Hygiene Officer to evaluate reproductive toxins used in the lab, and should inform their personal physicians of the possibility of exposure. A list of common reproductive toxins is found in Part III. Table 7.7 (R).

NOTE: The OU Chemical Hygiene Officer can assess potential exposures and work with the employee and laboratory supervisor, if necessary, to adjust work practices to minimize the potential risk.

❖ All of these "designated" areas shall either be posted with a sign which reads:

> CAUTION
> THIS IS A DESIGNATED AREA FOR THE USE AND/OR STORAGE OF CHEMICALS THAT EXHIBIT HIGH ACUTE OR CHRONIC TOXICITY.
>
> SEE YOUR DEPARTMENT SUPERVISOR OR YOUR DEPARTMENT'S CHEMICAL HYGIENE PLAN FOR MORE INFORMATION.
>
> Contact EH&S with Safety Concerns, ext. 4196

AND/OR

- Labeling tape which reads:

CAUTION: SPECIFICALLY DESIGNATED TOXIC CHEMICALS ARE USED/STORED HERE

- Additionally, all chemicals which exhibit **high chronic toxicity** shall be labeled with warning tape which reads as follows (tape is available in the Office of EH&S):

WARNING: AUTHORIZED PERSONNEL ONLY This chemical is considered to exhibit HIGH CHRONIC TOXICITY Authorization from your Supervisor or Instructor is required PRIOR to use. Contact EH&S with Safety Concerns, ext. 4196

NOTE: Authorization is required by the laboratory supervisor/PI prior to using chemicals of high chronic toxicity. It is the supervisor's responsibility to enforce this requirement.

7.1. Medical Consultation

A. Oakland University will provide 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, whenever an employee:

1) Exhibits signs/symptoms which correspond to the ***acute toxicity*** hazards of the chemical(s) with which they're working.

2) Is found or suspected to have been exposed routinely to chemical concentrations which exceed the MIOSHA PEL for MIOSHA-regulated carcinogens (see Part I. Table 6.2) or other chemicals which present ***chronic toxicity***.

3) May have been exposed to a hazardous chemical during a chemical incident such as a spill, leak, explosion or fire; and

4) Is referred for medical follow-up by the OU Chemical Hygiene Officer.

B. Medical examination/consultation visits (non-life threatening) can be handled by the Graham Health Center (GHC). Appointments can be arranged by contacting the GHC staff at x 2341.

C. Where medical consultations or examinations are provided, the examining physician shall be provided with the following information:

1) The identity of the chemical(s) to which the employee may have been exposed.

2) The exposure conditions

3) The signs and symptoms of exposure the laboratory employee is experiencing, if any.

D. Individuals with life threatening emergencies should contact OU Police (ext. 911 on a university phone or (248) 370-3333 on a cell phone) to arrange for emergency transport to the hospital. OU Police and the laboratory supervisors shall report all incidents resulting in serious injury/illness to the OU Chemical Hygiene Officer.

8. SAFETY EQUIPMENT INSPECTIONS

8.1. Chemical Fume Hoods

A. One or more pieces of yarn should be strung from the sashes of those fume hoods which do not possess direct reading capabilities or alarm systems, in order to provide a *qualitative* indicator of whether the fume hoods are operating.

B. To ensure that adequate airflow is being maintained, every chemical fume hood shall be *quantitatively* tested annually by the Office of EH&S or a qualified contractor. Laboratory hood airflow shall be considered adequate when the average face velocity inside the hood achieves 80 - 100 feet/minute with a working sash height between 8-20 inches.

C. Other local exhaust ventilation, such as ventilation snorkels or canopy hoods, will also be tested, for which the criteria for minimal acceptable flow shall be determined by EH&S.

D. Results of laboratory ventilation tests shall be recorded and maintained by EH&S.

E. Fume hoods without self adjusting face velocity controls shall be marked with an optimal sash height label.

F. Fume hoods which are not working properly should be immediately reported online to Work Control, or by dialing extension 2381. Following repairs, the Office of Environmental Health and Safety should be contacted to retest the hood.

8.2. Eye Wash Stations and Safety Showers

Passageways or access to eye wash stations and safety showers should be kept clear of any obstacles (even temporarily parked chemical carts).

8.3. EH&S Inspections

A. EH&S shall annually inspect all eye wash stations to ensure that 1) access is not restricted and 2) water flows at a minimum rate of 0.4 gallons per minute (gpm).

B. EH&S shall annually inspect all emergency showers to make certain that 1) access is not restricted, 2) the actuator is within reach, and 3) flow rate is a min. of 30 gpm.

C. Eyewash/Safety shower inspection records shall be maintained by EH&S.

D. PIs, lab supervisors and/or lab workers should also make it a point to visually inspect the function or water quality of the eyewash stations on a weekly basis. Any concerns with the eyewash should be immediately reported online to Work Control, or by dialing extension 2381.

9. "HIGH HAZARD" OPERATIONS

Under some circumstances a particular chemical substance or procedure may be considered highly hazardous, and requires that the Office of Environmental Health and Safety be notified before research begins.

A. This requirement automatically applies (but is not limited) to the use of chemicals with the following properties:

- Highly Toxic chemicals or chemicals without reliable toxicity information
- Explosive or violently reacting chemicals
- Concentrated Acids
- Acutely Toxic gases (refer to Part I. Table 9.1 below)

Table 9.1 - Pressurized Gases Requiring EH&S Notification and an SOP

Highly Toxic Gases	
Arsine and gaseous derivatives	Hydrogen cyanide
Chloropicrin in gas mixtures	Hydrogen selenide
Cyanogen chloride	Iron Pentacarbonyl
Cyanogen	Nitric oxide
Diborane	Nitrogen dioxide
Germane	Nitrogen Tetroxide
Hexaethyltetraphosphate	Phosgene
	Phosphine

B. This requirement also applies to physical hazards associated with the following operations:

- High Pressures
- Machining
- Lasers (Class 3b and 4)
- UV radiation
- High Voltages
- Robotic Systems
- Hot Work

In these cases, PIs will also be required to generate explicit **SOPs (Standard Operating** Procedures), which clearly identify the safety protocols/safeguards that will be utilized.

Laboratory employees anticipating use of these materials in a manner requiring SOP review must notify the **Office of Environmental Health and Safety**, prior to commencing these operations. The OU Chemical Hygiene Officer will then visit the laboratory, conduct a survey of facility's engineering controls, and review the SOP.

SOPs are then maintained and posted in the area where work will be conducted.

10. RECORD KEEPING

All laboratory health and safety records shall be maintained and kept by either the Environmental, Health and Safety department or by the specific laboratory supervisors or PIs with 2 exceptions: The **personnel exposure assessments and occupational medical consultation/examination reports** which will be maintained in a secure area in accordance with MIOSHA's medical records rule (29 CFR 1910.20) and the privacy and confidentiality Health Insurance Portability and Accountability Act (HIPAA). Individuals may obtain copies or read their reports by making a request in writing to the Office of EH&S for exposure assessment records or the Graham Health Center for occupational medical records.

PART II. STANDARD LABORATORY PRACTICES (SLPS)

1. INTRODUCTION - SLPs

Part II. of this Chemical Hygiene Plan describes the required Standard Laboratory Practices (SLPs) for managing and working with laboratory chemicals at Oakland University and is in compliance with the MIOSHA Laboratory Standard which is aligned with the Globally Harmonized System (GHS) of Classification and Labeling of Chemicals as amended by MIOSHA in January, 2014.

Although these practices are the minimum requirement, research activities involving high hazard operations, highly hazardous chemicals, or unknown compounds must be supplemented with a written Standard Operating Procedure (SOP). The SOP must detail specific procedures and safety precautions for performing particularly hazardous experiments or procedures.

The following categories are detailed in this section:

- Handling Laboratory Chemicals
- Hazard Communication
- Personal Protection Equipment
- Laboratory Safety Equipment
- Chemical Procurement, Distribution and Storage
- Chemical Spills and Accidents
- Personal Contamination and Injury
- Fire and Fire Related Emergencies
- Chemical Waste Disposal

2. HANDLING LABORATORY CHEMICALS

2.1. General Guidelines

A. Labels should be carefully examined before using laboratory chemicals. The manufacturer's or supplier's Safety Data Sheet (SDS) will often provide handling information.

B. Employees should **be aware of the potential hazards** which exist in the laboratory and use appropriate safety precautions.

C. Employees should know the location and proper use of **emergency equipment**, the appropriate procedures for responding to emergencies, and the proper methods for use, storage, transport and disposal of chemicals within the facility.

D. Employees should **avoid working alone** in the laboratory. If a laboratory employee must work alone, he/she should arrange for a co-worker to check in periodically with the employee. Employees must not work alone when conducting high hazard operations (See Part 1 section 9 “High Hazard Operations”)

E. All secondary chemical containers should be labeled with appropriate identification and hazard information (see Part 1 Section 5.3 on Container Labels).

F. Only those chemicals for which there are effective engineering controls (e.g., chemical fume hoods) and/or documented administrative controls (see Part 2 Section 5.1) may be used.

G. Adequate ventilation should always be used when working with volatile chemicals. Operations with a potential to form aerosols should be performed inside chemical fume hoods.

H. Chemicals and lab equipment should be used as directed and for their intended purposes ONLY.

I. Equipment and supplies should be inspected for damage before adding laboratory chemicals. Damaged equipment/supplies should never be used.

J. Personal protective apparel/equipment should be inspected for integrity and proper functioning before use. Laboratory workers shall not deviate from assigned PPE.

K. Malfunctioning laboratory equipment (e.g. fume hoods) should be labeled or tagged "out of service," so that others will not use the equipment before repairs are made.

L. Laboratory glassware should be handled and stored with care to avoid the hazards of breaking/broken glass. Damaged glassware should never be used. Extra care should be taken with Dewar flasks and other evacuated glass apparatus; flasks should be shielded or wrapped to contain chemicals or fragments should implosion occur. Use glassware that is specifically designed for excessive pressures.

M. Laboratory chemicals should be dispensed so that no more than is needed for immediate use is transferred to secondary containers.

2.2. Personal Hygiene

A. **Contaminated clothing and gloves** should be removed before leaving laboratory.

B. **Direct contact with any chemical should be avoided.** Chemicals should be kept off the hands, face and clothing, including shoes. Chemicals should never be "sampled" or "tested" by smell or taste. Employees should wash their hands thoroughly with soap and water after handling chemicals.

C. MIOSHA strictly prohibits **smoking, drinking, eating and the application of cosmetics** in laboratories where chemicals are being used.

D. **Pipetting** should be performed using pipette bulbs or other mechanical devices ONLY.

2.3. Housekeeping

A. **Floors** should be kept clean and dry.

B. **Aisles, hallways, and stairways** should be kept clear of lab chemicals at all times.

C. **Work areas**, and especially workbenches, should be kept clear of clutter and obstructions.

D. **All working surfaces** should be cleaned regularly.

E. **Access to emergency equipment,** utility controls, showers, eye washes and exits should never be blocked.

F. **Hazardous wastes** should be kept in the appropriate containers and labeled properly. Do not store hazardous waste near exit doors. Lab shall provide secondary containment for waste containers when not present.

G. **Unlabeled containers containing unknown materials** should be considered hazardous wastes and a disposal request should be immediately arranged.

3. REVIEW OF EXISTING SAFETY PROCEDURES

The following are situational indicators wherefore lab employees must identify whether new hazards are being introduced to existing operations, and formulate associated safety practices:

A. A significant change or **substitution of ingredient chemicals** in the procedure.

B. A **scale-up** of experimental procedures which results in a substantial change (i.e., 200%) in the amount of chemicals used.

C. A **failure of any of the equipment** used in the process, especially safety equipment such as chemical fume hoods.

D. **Unexpected experimental results** (such as a pressure increase, increased reaction rates, unanticipated byproducts) which could impact safety.

E. **Chemical odors or health symptoms** that appear to be related to chemical exposure.

4. HAZARD COMMUNICATION

The Hazard Communication Standard (HCS) is now aligned with the Globally Harmonized System (GHS) of classification and labelling of chemicals as created by the United Nations. After the substance has been classified according to the GHS criteria, the hazards need to be communicated. The communication methods incorporated in GHS include Safety Data Sheets (SDS) and labels.

5. SAFETY DATA SHEETS (SDS)

A Safety Data Sheet, often referred to by the acronym SDS, is a detailed informational document prepared by the manufacturer or distributor of a hazardous chemical which **describes physical and chemical properties** of the product, and associated **safety** recommendations with regard to routine handling, PPE and/or spill response (or other emergencies).

All SDSs are required to have a consistent 16-section format:

Section 1 – Identification
Section 2 – Hazard(s) identification
Section 3 – Composition / Information on Ingredients
Section 4 – First-aid Measures
Section 5 – Fire-fighting Measures
Section 6 – Accidental Release Measures
Section 7 – Handling and Storage
Section 8 – Exposure Controls / Personal Protection
Section 9 – Physical and Chemical Properties
Section 10 – Stability and Reactivity
Section 11 – Toxicological Information
Section 12 – Ecological Information
Section 13 – Disposal Consideration
Section 14 – Transport Information
Section 15 – Regulatory Information
Section 16 – Other information including date of preparation of last revision

❖ A Glossary of Terms commonly found on SDSs is available as Part V of this CHP.

A. Limitations

1) **SDSs are *highly* variable in their format, content and <u>accuracy</u>.** Statements are often generic, vague, legalistic and/or inaccurate.

2) Thus, SDS should **<u>NOT</u>** be used as the **exclusive** source of safety information regarding laboratory chemicals.

6. LABELS

A. Basic Information Provided by Labels

1) Containers of laboratory chemicals which pose a physical or health hazard to employees and/or the environment must have a hazard communication label attached. Labels on hazardous chemicals should include:

- Product Identification- Common name of the chemical.
- Supplier/Manufacturer Identification- Name and contact information for the product's manufacturer or distributor.
- Symbols called "Pictograms"

- Signal Word- Danger or Warning
- Hazard Statement- a statement assigned to a hazard class and category that describes the nature of the hazard(s) of a chemical including, where appropriate, the degree of hazard.
- Precautionary Statement- a phrase that describes recommended measures related to:
    - Prevention
    - Response
    - Storage
    - Disposal

2) Hazard warning(s). Warning(s) may be a single word (e.g., "danger," "warning" or "caution"), or may identify the primary physical or health hazard(s)

B. Additional Information Provided by Labels

Some labels will also provide additional safety information. This includes:

1) Protective measures to be used when handling the material.
2) Clothing and other personal protection equipment that should be worn.
3) First aid instructions.
4) Storage information.
5) Procedures to follow in the event of a fire, leak or spill.

Some labels will also provide additional safety information. This includes:

- Physical state
- Color
- Hazards not otherwise classified
- First aid instructions.
- Route of exposure
- Storage and disposal
- Hazard prevention and emergency response instructions- Procedures to follow in the event of a fire, leak or spill.

C. Labels Missing/Removed.

- If an employee finds a container with a missing, torn or illegible label, he/she should report it to the laboratory supervisor so that the label can be replaced. Labels should never be removed or defaced, except when container is empty.

D. Secondary Container Labels.

- If secondary ("generic") working containers are used that will take more than one work shift to empty, or if there is a chance that someone else will handle the container during that shift, the handler must label the container with the following information:
  1) Product Identifier (mandatory)
  2) Health/Physical Hazards (mandatory)
  3) Pictograms/Graphics (optional)

E. New Hazard Information.

- Users should examine labels <u>each</u> <u>time</u> a newly purchased chemical is employed. It is possible the manufacturer may have added new hazard information or reformulated the product since the last purchase, and thus altered the potential hazards presented by the product.

F. New Chemical Substance Synthesis.

- Laboratory personnel who synthesize, or combine, chemical substances must label the respective containers with the potentially hazardous properties of the new substances.

6.1. Working Alone Procedure

Researchers who work alone and rarely interact with others during a work shift are often unable to call for help when an emergency situation arises. Researchers conducting high hazard operations are particularly at risk. According to The National Institute of Health (NIH), "Alone" means beyond the visual or audible range of any other individual for more than a few minutes at a time." For the purposes of this CHP, the Lab Safety Committee has defined "working alone" as any situation where a worker cannot be seen or heard by another worker; and there is no system available to provide immediate assistance when disabled.

A. Highly Hazardous Procedures

1) Highly Hazardous Procedures as defined by Part I Section 9 of the Chemical Hygiene Plan may **ONLY** be conducted when there is another person present capable of arranging for emergency assistance.

2) Undergraduate students shall only conduct hazardous operations under the direct supervision of an experienced graduate student, Laboratory Supervisor or Principal Investigator.

7. PERSONAL PROTECTIVE EQUIPMENT

7.1. Engineering and Administrative Controls

Preference. PPE is viewed as less reliable than engineering/administrative controls because they minimize (or eliminate) employee warning senses, and rely exclusively on employee conscientiousness to provide protection. Thus, laboratory supervisors, in combination with laboratory workers, should consider **first** whether the following engineering and administrative controls are adequately in place before personal protective equipment is selected and donned:

A. Administrative Controls

1) ***Substitution*** of a less hazardous substance
2) ***Scaling*** down size of experiment
3) ***Substitution*** of less hazardous equipment/processes (e.g., safety cans for glass bottles)

B. Engineering Controls

1) **Local** ventilation (e.g., fume hoods)

7.2. Selection Resources

A. The Safety Data Sheet (SDS) or other resource literature will list the PPE **recommended** for use with the chemical. The SDS addresses worst case conditions; therefore, all the equipment shown may not be necessary for a laboratory-scale task.

B. **Other resources** for assistance with selecting proper PPE include the **laboratory supervisor**, other Sections of this **CHP**, or the **OU Chemical Hygiene Officer**.

7.3. Laboratory Clothing

A. **Even** where there is no immediate danger to the skin from contact with a hazardous chemical, it is still prudent to select clothing which will minimize exposed skin surfaces, including **long-sleeved shirts and long-legged pants.**

B. A **laboratory** coat should be worn over street clothes; they are intended to prevent contact with dirt, chemical dusts and minor chemical splashes/spills.

C. Laboratory coats should be laundered regularly and separately from street clothes. Lab coats contaminated with hazardous chemicals must not be laundered at home. Disposable lab coats are recommended when laundry services are not available.

D. If any lab clothing becomes contaminated, it should be removed immediately (and laundered separately from street clothing), and any affected skin surface washed thoroughly.

E. Shoes should always be worn in the lab. Open toed shoes, sandals/perforated shoes are inappropriate. Forbidden.

F. Long hair and loose clothing should be confined. Care should be taken to secure any loose head covering and confine scarves beneath lab coats.

7.4. Additional Protective Clothing

A. Additional protective clothing may be required for performing certain procedures or working with particular substances (e.g., carcinogens, or large volumes of corrosives, oxidizing **agents or organic solvents**).

B. Additional clothing may include **impermeable aprons and gloves**, as well as **plastic coated coveralls, shoe covers, and arm sleeves**.

C. **Protective sleeves** should always be considered when wearing an apron. These garments can be washable or disposable in nature, and should never be worn outside the laboratory.

D. **Choice of garment** depends on the degree of protection required and the areas of the body which may become contaminated. Rubberized aprons, plastic coated coveralls, shoe covers, and arm sleeves offer much greater resistance to permeation by chemicals than laboratory coats and, therefore, provide additional time to react (i.e., to remove the garment and wash affected area) if contaminated.

7.5. Chemical Resistant Gloves

Gloves should be selected on the basis of the chemicals being handled, the hazards these materials present, and their suitability for the operation being conducted. Chemical-resistant gloves are made with different kinds of rubber or plastic which can be blended or laminated for better performance. Since many chemicals can penetrate incompatible gloves in a short time, gloves should be carefully selected. When selecting chemical-resistant gloves be sure to consult the manufacturer's recommendations. The following Tables can be used to assist in the selection of appropriate laboratory gloves. Reference: http://www.osha.gov/Publications/osha3151.pdf

Table 2.1 GLOVE TYPES

Type	Advantages	Disadvantages	Use Against
Natural (latex) rubber & rubber blends	Low cost, comfortable to wear, popular general-purpose glove. Good dexterity. Outstanding tensile strength, elasticity and temperature resistance. Good for resisting abrasions caused by grinding and polishing, Gloves protect workers' hands from most water solutions of acids, alkalis, salts & ketones.Blends better chemical resistance than natural with some chemicals. Rubber blends physical properties frequently inferior to natural rubber	Poor with oils, greases, organics. Often cause allergic reactions and not appropriate for all employees.Glove liners, hypoallergenic gloves, and powderless gloves are possible alternatives for workers who are allergic to latex gloves. Frequently imported; may be poor quality	Bases, alcohols, dilute water solutions; fair with aldehydes, ketones.
Polyvinyl chloride (PVC)	Low cost, very good physical properties, medium cost, medium chemical resistance	Plasticizers can be stripped; often imported may be poor quality	Strong acids and bases, salts, water solutions, alcohols
Neoprene made of synthetic rubber	Medium cost, medium chemical resistance. Good pliability &dexterity, high density & tear resistance. Protects against hydraulic fluids, gasoline, alcohols, organic acids and alkalis. Generally chemical &wear resistant properties superior to those made of natural rubber.	NA	Oxidizing acids, anilines, phenol, glycol ethers
Nitrile made of a copolymer	Low cost, excellent physical properties, & dexterity. Provides protection from chlorinated solvents; trichloroethylene & perchloroethylene, etc. Durable for heavy use w/ prolonged exposure to substances that cause other gloves to deteriorate. Not recommended with strong oxidizing agents, aromatic solvents, ketones & acetates.	Poor with benzene, methylene chloride, trichloroethylene, & many ketones	Oils, greases, acids, caustics, alcohols, aliphatic chemicals, perchloroethylene, trichloroethane, xylene, fair w/ toluene
Butyl-made of synthetic rubber	Speciality glove, polar organics. Resists oxidation, ozone corrosion and abrasion, and remain flexible at low temperatures. Protects against wide variety of chemicals.	Expensive. Does not perform well with aliphatic and aromatic hydrocarbons and halogenated solvents.	Peroxide, rocket fuels, strong acids, (nitric, sulfuric, hydrofluoric & red fuming nitric acid), strong bases, alcohols, aldehydes, ketones, esters & glycol ethers, nitrocompounds
Polyvinyl alcohol (PVA)	Specialty glove, resists broad range of organics, good physical properties	Very expensive, water sensitive, poor vs. light alcohols	Aliphatics, aromatics, chlorinated solvents, ketones,(not acetone), esters, ethers
Fluoro-elastomer (Viton) ™ *	Specialty glove, organic solvents	Extremely expensive, poor physical properties, poor w/ some ketones, esters, amines	Aromatics, chlorinated solvents, aliphatics, alcohols

Type	Advantages	Disadvantages	Use Against
Norfoil-(Silver shield)	Excellent chemical resistance.	Stiff,poor fit&grip, punctures easily punctures	Use for Hazmat work

Table 2.2 GLOVE TYPE AND CHEMICAL USE* *Limited service VG= Very Good G= Good F=Fair P=Poor (not recommended)				
Chemical	**Neoprene**	**Latex/ Rubber**	**Butyl**	**Nitrile**
Acetaldehyde*	VG	G	VG	G
Acetic acid	VG	VG	VG	VG
Acetone*	G	VG	VG	P
Ammonium hydroxide	VG	VG	VG	VG
Amy acetate*	F	P	F	P
Aniline	G	F	F	P
Benzaldehyde*	F	F	G	G
Benzene*	P	P	P	F
Butyl acetate	G	F	F	P
Butyl alcohol	VG	VG	VG	VG
Carbon disulfide	F	F	F	F
Carbon tetrachloride*	F	P	P	G
Castor oil	F	P	F	VG
Chlorobenzene*	F	P	F	P
Chloroform*	G	P	P	F
Chloronaphthalene	F	P	F	F
Chromic acid (50%)	F	P	F	F
Citric acid (10%)	VG	VG	VG	VG
Cyclohexanol	G	F	G	VG
Dibutyl phthalate*	G	P	G	G
Diesel fuel	G	P	P	VG
Diisobutyl ketone	P	F	G	P
Dimethylformamide	F	F	G	G
Dimethylformamide	F	F	G	G
Dioctyl phthalate	G	P	F	VG
Dioxane	VG	G	G	G
Epoxy resins, dry	VG	VG	VG	VG
Ethyl acetate*	G	F	G	F
Ethyl alcohol	VG	VG	VG	VG
Ethyl ether*	VG	G	VG	G
Ethylene dichloride*	F	P	F	P
Ethylene glycol	VG	VG	VG	VG
Formaldehyde	VG	VG	VG	VG

Table 2.2 GLOVE TYPE AND CHEMICAL USE* *Limited service VG= Very Good G= Good F=Fair P=Poor (not recommended)				
Chemical	**Neoprene**	**Latex/ Rubber**	**Butyl**	**Nitrile**
Formic acid	VG	VG	VG	VG
Freon 11	G	P	F	G
Freon 12	G	P	F	G
Freon 21	G	P	F	G
Freon 22	G	P	F	G
Furfural*	G	G	G	G
Gasoline,leaded	G	P	F	VG
Gasoline,unleaded	G	P	F	VG
Glycerine	VG	VG	VG	VG
Hexane	F	P	G	G
Hydrazine(65%)	F	G	G	G
Hydrochloric acid	VG	G	G	G
Hydrofluoric acid (48%)	VG	G	G	G
Hydrogen peroxide (30%)	G	G	G	G
Hydroquinone	G	G	G	F
Isooctane	F	P	P	VG
Kerosene	VG	F	F	VG
Ketones	G	VG	VG	P
Lacquer thinners	G	F	F	P
Lactic acid (85%)	VG	VG	VG	VG
Lauric acid (36%)	VG	F	VG	VG
Lineolic acid	VG	P	F	G
Linseed oil	VG	P	F	VG
Maleic acid	VG	VG	VG	VG
Methyl alcohol	VG	VG	VG	VG
Methylamine	F	F	G	G
Methyl bromide	G	F	G	F
Methyl chloride*	P	P	P	P
Methyl ethyl ketone*	G	G	VG	P
Methyl isobutyl ketone*	F	F	VG	P
Methyl metharcrylate	G	G	VG	F
Monoethanolamine	VG	G	VG	VG
Morpholine	VG	VG	VG	G
Naphthalene	G	F	F	G
Napthas, aliphatic	VG	F	F	VG

Table 2.2 GLOVE TYPE AND CHEMICAL USE* *Limited service VG= Very Good G= Good F=Fair P=Poor (not recommended)				
Chemical	**Neoprene**	**Latex/ Rubber**	**Butyl**	**Nitrile**
Napthas, aromatic	G	P	P	G
Nitric acid*	G	F	F	F
Nitric acid, red and white fuming	P	P	P	P
Nitromethane (95.5%)*	F	P	F	F
Nitropropane (95.5%)	F	P	F	F
Octyl alcohol	VG	VG	VG	VG
Oleic acid	VG	VG	VG	VG
Oxalic acid	VG	VG	VG	VG
Palmitic acid	VG	VG	VG	VG
Perchloric acid (60%)	VG	F	G	G
Perchloroethylene	F	P	P	G
Petroleum distillates (naphtha)	G	P	P	VG
Phenol	VG	F	G	F
Phosphoric acid	VG	G	VG	VG
Potassium hydroxide	VG	VG	VG	VG
Propyl acetate	G	F	G	F
Propyl alcohol	VG	VG	VG	VG
Propyl alcohol (iso)	VG	VG	VG	VG
Sodium hydroxide	VG	VG	VG	VG
Styrene (mixture)	P	P	P	F
Styrene (100%)	P	P	P	F
Sulfuric acid	G	G	G	G
Tannic acid (65)	VG	VG	VG	VG
Tetrahydrofuran	P	F	F	F
Toluene*	F	P	P	F
Toluene diisocyanate (TDI)	F	G	G	F
Trichloroethylene*	F	F	P	G
Triethanolamine (85%)	VG	G	G	VG
Tung oil	VG	P	F	VG
Turpentine	G	F	F	VG
Xylene*	P	P	P	F

Reference: http://www.osha.gov/Publications/osha3151.pdf

Chemical-resistant gloves should be worn whenever handling substances which are corrosive or toxic if absorbed through the skin.

A. **Before** each use, gloves should be checked for **integrity**. Gloves should be washed prior to removal whenever possible to prevent skin contamination.

B. **Non-disposable gloves** should be replaced periodically, depending on frequency of use and their resistance to the substances handled.

C. **The Chemical Hygiene Officer**, ext. 4196, is available for personal protection equipment selection assistance or information.

7.6. Protection of the Eyes

Eye protection is required for all employees and/or visitors present in locations where chemicals which are hazardous to the eyes are handled, particularly while dispensing or working with solvents, corrosives, bulk chemicals, or irritant/toxic liquids/gases. All eye protective devices must be stamped with "Z87" by the manufacturer if they meet ANSI standards. If the eye protection is not marked, it may not be the most effective protection available.

A. Selection

❖ Safety glasses, goggles or goggles with face shield should be **selected** based upon the physical state, the operation and the potential hazards of the chemical(s) being handled. A hazard assessment should determine the risk of exposure to eye and face hazards, including those which may be encountered in an emergency. The lab principal investigator should be aware of the possibility of multiple and simultaneous hazard exposures and be prepared to protect against the highest level of each hazard. [29 CFR 1910 Subpart I App B]

1) Safety **glasses** effectively protect the eye from solid materials (dusts and flying objects) but are less effective at protecting the eyes from chemical splashes.

2) Goggles should be worn in situations where bulk quantities of chemicals are handled and chemical splashes to the face are possible. Goggles form a liquid proof seal around the eyes, protecting them from a splash.

3) Goggles **with face shield** should be worn when handling highly reactive substances or large quantities of hazardous chemicals, corrosives, poisons, or hot chemicals.

❖ A comparison chart of Eye Protection Devices is shown in **Table 2.3** below:

Table 2.3. - COMPARISON CHART OF EYE PROTECTION DEVICES

TYPE	FRONT SPLASH Protection	SIDE SPLASH Protection	FRONT FLYING OBJECT IMPACT Protection	SIDE IMPACT Protection	NECK, FACE Protection	COMFORT TO WEARER	USER ACCEPTANCE	USE LIFETIME	COST
Goggles	Excellent	Excellent	Excellent	Excellent	Poor	Fair	Poor	Fair	Moderate
Safety Glasses (no shields)	Good	Poor	Excellent	Poor	Poor	Good to very good	Very good	Very good	Moderate
Safety Glasses (shields)	Good	Good	Good	Fair	Poor	Good	Good	Very good	Moderate
Face shield	Excellent	Good to excellent	Excellent (if adequate thickness)	Good to excellent	Depends on type and length	Fair	Good for short periods	Fair	Moderate (depending on type)

SOURCE: ANSI Z87.1(1979) Occupational and Educational Eye and Face Protection, available from American National Standards Institute, Inc., 1430 Broadway, New York, N.Y. 10018. ANSI Z87.1-2003, "American National Standard Practice for Occupational and Educational Eye and Face Protection," which is incorporated by reference in § 1910.6;**1910.6(e)(67)**ANSI Z87.1-2003, American National Standard Practice for Occupational and Educational Eye and Face Protection; IBR approved for §§ 1910.133(b)(1)(i) and 1910.252(b)(2)(ii)(I)(1). Copies of ANSI Z87.1-2003 are available for purchase only from the American Society of Safety Engineers, 1800 East Oakton Street, Des Plaines, IL 60018-2187; telephone: 847-699-2929; or from the International Safety Equipment Association (ISEA), 1901 North Moore Street, Arlington, VA 22209-1762; telephone: 703-525-1695; fax: 703-528-2148; Web site: http://www.safetyequipment.org.

B. Contact lenses

- ❖ NIOSH recommends that workers be permitted to wear contact lenses when handling hazardous chemicals. However, contact lenses are not eye protective devices, and wearing them does not reduce the requirement for eye and face protection. The following guidelines for contact lens use must be followed (NIOSH Bulletin 59, 2005):
- ❖ Ensure contact lenses are not banned by regulation or contraindicated by medical or industrial hygiene recommendations.
  - MIOSHA health standards currently ban the use of contact lenses when working with methylenedianiline (Part 303), ethylene oxide (304), acrylonitrile (Part 307), methylene chloride (Part 313) and 1,2 dibromo-3-chloropropane (OSHA 1910.1044).

1) In the event of a chemical exposure, begin eye irrigation immediately and remove contact lenses as soon as practical.

2) Instruct workers who wear contact lenses to remove the lenses at the first signs of eye redness or irritation.

7.7. Protection of the Respiratory System

Per the requirements of the MIOSHA Respiratory Protection Standard (Part 451), OU has adopted a **written plan** for using respirators. The Plan outlines university responsibilities for the following respirator program components:

- Exposure assessment
- Respirator Selection
- Medical Approval/Surveillance
- Fit Testing
- User Training
- Respirator Inspection/Repair
- Respirator Storage
- Respirator Cleaning/Disinfection

NOTE: Respirators may only be used in conjunction with OU's complete respiratory protection program. Anyone who suspects that his/her work will require the use of a respirator including a "dust mask," (i.e. an elastomeric respirator), must contact the Office of EH&S, ext. 4196 Voluntary respirator use (for comfort and not required for task) use of a dust mask must also contact EH&S to complete MIOSHA required forms. Information on OU's Respirator Protection can be found at the EH&S website [https://www.oakland.edu/ehs/occupational-safety-and-health/respiratory-protection/.](https://www.oakland.edu/ehs/occupational-safety-and-health/respiratory-protection/).

A. Respiratory Warnings

1) Product labels and SDS are good sources for information on inhalation hazards and special ventilation requirements. Labels and/or SDS will state warning such as:

- Use with adequate ventilation
- Avoid inhalation of vapors
- Use in a fume hood
- Provide local ventilation

B. Respirator Use

1) **Laboratories** shall persistently attempt to minimize respiratory exposure to potentially hazardous chemical substances through **engineering methods** or **administrative controls** (see **Part II. Section 5.1**).

2) It is recognized that for certain situations or operations, the use of these controls may not be feasible or practical, (e.g., during/following unanticipated releases), the use of **respiratory protective equipment** may be necessary.

3) Respirators are designed to protect against specific types of substances in limited concentration ranges. Accordingly, they must be selected based on the specific *type* of hazards, anticipated airborne *concentrations*, and required *protection* *factors*.

4) The following types of Respirators are available at OU:

- ➢ Negative Pressure Air-Purifying Respirators
  - Full Face
  - Half Mask

- ➢ Positive Pressure (Powered) Air-Purifying Respirators (PAPR)

8. LABORATORY SAFETY EQUIPMENT

8.1. Chemical Fume Hoods

A. Purposes

1) Chemical fume hood s are designed to **control inhalation exposures** by retaining vapors and **gases** released within them, thereby protecting laboratory employees' breathing zones from contaminants. This protection is accomplished by having a curtain of air (approximately 100 linear feet per minute) which moves through the "face" of the hood.

2) Chemical fume hoods are also used to **isolate apparatus or chemicals** that may present physical hazards to employees. The closed sash on a hood serves as an effective barrier to fires, flying objects, chemical splashes or spattering and small implosions and explosions.

3) Hoods effectively **contain spills** which might occur during dispensing procedures particularly if trays are placed in the bottom of the hoods.

B. Principles of Safe Fume Hood Operation

1) Keep all chemicals and apparatus at least **six inches** inside the hood (behind sash).

2) **Hoods are not intended for storage of chemicals**. Materials stored in them should be kept to a minimum. Stored chemicals should not block vents or alter air flow patterns.

3) When working in front of a fume hood, employees should make sure the sash opening is appropriate. This is generally achieved by lining up corresponding arrows which are placed on the sash door and hood frame. This sash opening will ensure an adequate air velocity through the face of the hood.

4) Variable air volume hoods found in MSC will provide 100 fpm airflow regardless of sash height, therefore no arrow markings are provided. The fume hood glass provides reasonable protection from an explosion or liquid splashes; it is therefore recommended that the MSC fume hoods be kept at the lowest comfortable sash height during use.

5) **Employees should not allow objects such as paper to enter the exhaust ducts.** This can clog duct work and adversely affect operation.

6) The **chemical manufacturer's or supplier's specific instructions** (located on the products SDS and/or label) should be followed for controlling inhalation exposures with chemical fume hoods. *[Note: These instructions are often intended for non-laboratory work environments, and must be adapted to suit the laboratory environment as well as the specific procedure or process]*

7) If specific guidance is not available from the chemical manufacturer or supplier, or if the guidance is inappropriate for the lab environment, employees may contact the **OU Chemical Hygiene Officer** or review the hood use guidelines in **Table 2.4**.

NOTE: The following guidelines provided in **Table 2.4** below are based on the following information, which is readily available on SDS or other common reference materials:

- Applicable workplace exposure standards (i.e., Threshold Limit Values (TLV) or Permissible Exposure Limits (PEL)).
- Acute and chronic toxicity data (LD_{50} and/or specific organ toxicity).
- Potential for generating airborne concentrations (i.e., vapor pressure).

❖ *These terms are defined in the glossary at the back of this manual.*

Table 2.4 - Guidelines For Chemical Fume Hood Use	
It may be appropriate to use a chemical fume hood when handling the type of substance listed in column 1 if the exposure standard or toxicological criteria in column 2 applies.	
Column 1 **Type Substance & Handling Procedure**	**Column 2** **Exposure Standard or Toxicity of Substance**
Substance handled is solid, liquid or gaseous **and** When other effective controls are not being used.	TLV or PEL < 5 ppm (vapor) or < 0.2 mg/m^3 (particulate) **or** Oral LD_{50} < 10 mg/kg (rat or mouse) (See Note Below) **or** Chemicals handled are respiratory sensitizers.

Table 2.4 - Guidelines For Chemical Fume Hood Use	
It may be appropriate to use a chemical fume hood when handling the type of substance listed in column 1 if the exposure standard or toxicological criteria in column 2 applies.	
Column 1 **Type Substance & Handling Procedure**	**Column 2** **Exposure Standard or Toxicity of Substance**
Substance handled is liquid or gaseous **and** It is handled in large quantities (greater than 500 milliliters) or the procedure used could release the substance to the laboratory atmosphere (heating). **or** Employee may be exposed to the substance (handling it in open containers) for an extended period of time (greater than 2 hrs. per day).	TLV or PEL >5 ppm, but < 50 ppm **or** Substances handled are toxic to specific organ systems, carcinogens or reproductive toxins with a vapor pressure exceeding 25 mm Hg at 25°C. **or** Oral LD_{50} >10 but < 500 mg/kg (rat or mouse)(See Note Below)
Substance handled is a solid **and** The particle size of the material is respirable (i.e., less than 10 microns, μ, in size)	TLV or PEL >0.2 mg/m^3, but < 2 mg/m^3 **or** Oral LD_{50} >10 but < 50 mg/kg (rat or mouse)(See Note Below)

The oral LD_{50} criteria has been included (even though it refer to "ingestion" rather than "inhalation" toxicity) because it is often the only toxicological data available on a Material Safety Data Sheet. The species of animals most often used in these acute toxicity tests are the rat and/or the mouse. The LD_{50} criteria outlined in the Table is a reasonable "rule of thumb" for materials that require control due to their acute toxicity characteristics. LD_{50} data should only be used if other criteria (e.g. LC_{50}) are unavailable.

8.2. Eye Washes and Safety Showers

A. Access

1) All laboratories in which bulk quantities of corrosive or toxic (through skin/membrane absorption) chemicals are handled must have immediate and direct access to eyewash stations and safety showers.

2) **Passageways** to the eyewash and shower should be kept clear of any obstacle (even a temporarily parked chemical cart). Eyewashes installed in or near sinks should be free of clutter and immediately accessible.

B. Measurements and Inspections

1) **EH&S** shall **annually inspect all eye wash stations** to make certain that 1) **access** is not restricted and 2) water flows through it at ε 0**.4 gallons per minute**. It is recommended that laboratory personnel flush eyewashes that are located within the lab periodically to remove any accumulated contaminates.

2) **EH&S shall annually inspect all emergency showers** to make certain that 1) **access** is not restricted, 2) the **start chain** is within reach, and 3) flow is a minimum of **30 gallons per minute**.

3) **Eyewash** and shower flow inspections shall be **recorded** and maintained in the EH&S **department.**

8.3. Fire Safety Equipment

8.4. Extinguishers

Extinguishers are bar-coded and tracked through a maintenance/inspection and testing database program and are inspected regularly. Fire extinguishing equipment located in the labs must be a type ABC extinguisher and readily accessible. If you notice a missing extinguisher or an extinguisher with a missing tag or pin or showing any sign of damage or discharge, notify EH&S immediately at (248) 370-4196 or via e-mail.

Additional Fire equipment should be easily accessible and should include:

- Fire hoses
- Fire blankets (required IF/WHEN there is a blanket holder)
- Automatic extinguishing systems

Contact OU's **Fire Safety Inspector** at ext. 4427 for questions regarding fire safety equipment.

8.5. Smoke Detectors

Several laboratories have smoke detectors which are hard wired and report directly to the Campus Fire Alarm Reporting System (CFAR) at the OUPD Dispatch. Smoke detectors should not be removed, covered, obstructed or tampered with in any way. Report any signs of damaged or defective smoke detectors immediately by contacting EH&S at (248) 370-4196 or via e-mail.

8.6. Sprinklers

Several laboratories have sprinklers which are heat activated and distribute water to cool and extinguish a fire. The majority of sprinkler heads in use on campus are designed to activate at temperatures of 135-155 °F but can be damaged and possibly discharge if they are struck due to horseplay or careless work practices. Do not hang objects from, cover, strike or obstruct a sprinkler head. Report any leaking sprinkler system equipment:

- **Business Hours (M-F 8 a.m.-5 p.m.):** Work Control Center at (248) 370-2381
- **After Hours:** OUPD Dispatch at (248) 370-3333

8.7. Lab Facility Design:

❖ **All** Lab Facility Designs shall **ensure**:

A. Facilities and maintenance are adequate.
B. Stockrooms/store rooms are well ventilated.
C. Laboratory hoods and sinks are adequate for lab operations.
D. There are arrangements for waste disposal.
E. That the work conducted and its scale is appropriate to the physical facilities available and, especially, to the quality of ventilation.

9. CHEMICAL PROCUREMENT, DISTRIBUTION, AND STORAGE

9.1. Procurement

A. Before a **new** chemical is received, those who will handle it should have information on proper use, handling, storage and disposal.

B. It is the responsibility of the Principal Investigator to make every effort to ensure that the laboratory facilities in which each chemical substance will be handled are adequate, and that those employees who will handle the substances have received proper training.

C. The necessary information on proper handling of hazardous substances can be obtained from the Safety Data Sheets (which are provided by the vendor) or other suitable safety reference literature.

D. No container should be accepted without an adequate identifying label as outlined in Part I. Section 5.3 of this CHP.

9.2. Distribution

A. When hand-carrying 1) open containers of ANY chemicals or 2) unopened containers of corrosive or highly acute or chronically toxic chemicals, the container should be placed in a secondary container or a bucket.

B. Rubberized buckets are commercially available and provide both secondary containment as well as "bump" protection.

C. If several bottles must be moved at once, the bottles should be transported on a small cart with a substantial rim to prevent slippage from the cart.

9.3. Storage

A. General Chemical Storage Guidelines

1) Chemicals should **never** be stored on bench tops or in hoods**.**

2) Do not store or use chemicals in rooms without appropriate ventilation. Storage in offices, unventilated closets or using chemicals which require a fume hood can result in an exposure hazard if chemical is spilled.

3) **Secondary containment** (one inside the other) such as **spill trays** should be used for high hazardous chemicals (e.g., especially strong reagents etc.).

4) Chemicals should not be exposed while in storage to **heat sources** (especially open flames) or **direct sunlight.**

5) **Periodic** (e.g. annual) **inventories** of chemicals stored in the laboratory should be performed by the department, and old or unwanted chemicals disposed of properly in accordance with the OU Hazardous Waste Management Program.

6) All containers containing **hazardous waste** must be properly labeled as directed in the Oakland University Hazardous Waste Management Guidance Manual

B. Chemical Storage Guidelines

1) Liquid chemicals which are stored in glass containers, and/or large volumes of compatible chemicals (regardless of container) should be grouped first into major hazard groups, and THEN stored in alphabetical order. The following **Table 2.5** provides these Chemical Storage Guidelines:

Table 2.5 - Chemical Storage Groups

Large volumes of chemicals and/or those stored in **glass** containers, should be grouped into the following hazard groups first before they are placed alphabetical.

Phase	Hazard Group	Common Chemical Examples-Always Group Together
Solid	Explosive (shock sensitive)	picric acid (dried), picrates
	oxidizer	chlorates, dichromates, nitrates, perchlorates, permanganates, peroxides
	very reactive (w/ water or other protic chemicals)	aluminum chloride (anhydrous), calcium, calcium carbide, lithium, phosphorus pentachloride, phosphorus pentoxide, potassium, sodium, white phosphorus
Liquid	strong acid	hydrogen fluoride, hydrochloric acid, H2SO4, H3PO4, HClO4
	strong caustic	sodium hydroxide, potassium hydroxide
	flammable	acetaldehyde, acetic acid, acetone, acetonitrile, acrylonitrile, allyl alcohol, n-amyl acetate, sec-amyl acetate, n-amyl alcohol, tert-amyl alcohol, benzene, 1-butanol, tert-butyl alcohol, carbon disulfide, chlorobenzene, cyclohexane, cyclohexene, 1,1- and 1,2-dichloroethane, 1,1- and1,2-dimethylhydrazine, dioxane, ethanol, ethyl acrylate, ethylenediamine, ethyl formate, –heptane, –hexane, hydrazine, isoamyl alcohol, isobutanol, isobutyl alcohol, isopropyl acetate, isopropyl alcohol, methyl alcohol, isopropylamine, methyl ethyl ketone, morpholine, nitromethane, 2-nitropropane, pentane, propylene oxide, pyridine, TEMED, toluene, triethylamine, vinyl acetate, xylene
	oxidizer	acid dichromate, chromic acid, chromium trioxide, hydrogen peroxide (>30%), nitric acid, sodium peroxide, sulfuric acid
	perchloric acid	NA
	very reactive/explosive	chlorosulfuric acid, chlorates, organic peroxides
Gas	Caustic or strong acid/	ammonia, hydrogen chloride
	flammable	acetylene
	oxidizer	chlorine, nitrous oxide,

2) Chemical Segregation Guidelines

Segregation of Chemicals by Type: Many chemicals in your lab may react adversely when combined, whether during an experimental protocol, accidentally when spilled, or when waste mixtures are improperly consolidated for disposal. It's recommended that incompatible chemicals are stored in separate areas of your lab when feasible. It's impossible, of course, to cover all reaction hazards in this document, but here are some general suggestions.

TABLE 2.6 Chemical Segregation

Segregate							
Acids from:	**Bases-** possible exothermic reaction	**Most metals-** produces flammable hydrogen gas	**Cyanides-** forms toxic & flammable hydrogen cyanide gas	**Sulfides-** forms toxic & flammable hydrogen sulfide gas	**Azides;-** may form explosive hydrazoic acid	**Phosphides** - may form toxic & flammable phosphene gas	**Oxidizers** - may form toxic and/or explosive compound
Oxidizers from:	**Acids-** may form toxic &/or explosive compound (i.e. concentrated sulfuric acid mixed with chlorates or perchlorates forms explosive compounds)		**Organic materials-** especially when mixed with flammables, may ignite		**Metals-** may form explosive compound	**Reducing agents-** i.e. boranes, hydrides, sodium hydrosulfite, etc.	**Ammonia** (anhydrous or aqueous)
Water-reactive chemicals from:	**Aqueous solutions** and in many cases just the moisture in the air. For example: metal hydrides, alkali metals and certain metal dusts in moist air will form hydrogen gas and ignite; halosilanes and acid halides will react with water to form toxic acid gases						

Reference: http://orf.od.nih.gov/Environmental+Protection/Waste+Disposal/chem_compat.htm

3) Chemical Incompatibility

Chemical incompatibility data are presented in Tables 2.7 and 2.8 below. These are recommended guidelines that may be used in combination with container labels, SDSs , and user knowledge for storing and segregating chemicals.

Table 2.7: Incompatibilities by Hazard Class

X indicates "Do Not Store with"

	Acids, inorganic	Acids, oxidizing	Acids, organic	Alkalis (bases)	Oxidizers	Poisons, inorganic	Poisons, organic	Water-reactives	Organic solvents
Acids, inorganic			X	X		X	X	X	X
Acids, oxidizing			X	X		X	X	X	X
Acids, organic	X	X		X	X	X	X	X	
Alkalis (bases)	X	X	X				X	X	X
Oxidizers			X				X	X	X
Poisons, inorganic	X	X	X				X	X	X
Poisons, organic	X	X	X	X	X	X			
Water-reactives	X	X	X	X	X	X			
Organic solvents	X	X		X	X	X			

http://www.lbl.gov/ehs/chsp/html/storage.shtml

Table 2.8: Specific Chemical Incompatibility Table

CHEMICAL	KEEP OUT OF CONTACT WITH
Acetic acid	Chromic acid, nitric acid, perchloric acid, peroxides, permanganates and

	other oxidizers
Acetone	Concentrated nitric and sulfuric acid mixtures, and strong bases
Acetylene	Chlorine, bromine, copper, fluorine, silver, mercury
Alkali metals	Water, carbon tetrachloride or other chlorinated hydrocarbons, carbon dioxide, halogens
Ammonia, anhydrous	Mercury, chlorine, calcium hypochlorite, iodine, bromine, hydrofluoric acid
Ammonium nitrate	Acids, metal powders, flammable liquids, chlorates, nitrites, sulfur, finely divided organic or combustible materials
Aniline	Nitric acid, hydrogen peroxide
Arsenic materials	Any reducing agent
Azides	Acids
Bromine	Same as chlorine
Calcium oxide	Water
Carbon (activated)	Calcium hypochlorite, all oxidizing agents
Carbon tetrachloride	Sodium
Chlorates	Ammonium salts, acids, metal powders, sulfur, finely divided organic or combustible materials
Chromic acid and chromium trioxide	Acetic acid, naphthalene, camphor, glycerol, glycerin, turpentine, alcohol, flammable liquids in general
Chlorine	Ammonia, acetylene, butadiene, butane, methane, propane (or other petroleum gases), hydrogen, sodium carbide, turpentine, benzene, finely divided metals
Chlorine dioxide	Ammonia, methane, phosphine, hydrogen sulfide
Copper	Acetylene, hydrogen peroxide
Cumene hydroperoxide	Acids, organic or inorganic
Cyanides	Acids
Flammable liquids	Ammonium nitrate, chromic acid, hydrogen peroxide, nitric acid, sodium peroxide, halogens
Hydrocarbons	Fluorine, chlorine, bromine, chromic acid, sodium peroxide
Hydrocyanic acid	Acids
Hydrofluoric acid	Ammonia, aqueous or anhydrous, bases and silica

Hydrogen peroxide	Copper, chromium, iron, most metals or their salts, alcohols, acetone, organic materials, aniline, nitromethane, flammable liquids
Hydrogen sulfide	Fuming nitric acid, other acids, oxidizing gases, acetylene, ammonia (aqueous or anhydrous), hydrogen
Hypochlorites	Acids, activated carbon
Iodine	Acetylene, ammonia (aqueous or anhydrous), hydrogen
Mercury	Acetylene, fulminic acid, ammonia
Nitrates	Sulfuric acid
Nitric acid (concentrated)	Acetic acid, aniline, chromic acid, hydrocyanic acid, hydrogen sulfide, flammable liquids, flammable gases, copper, brass, any heavy metals
Nitrites	Acids
Nitroparaffins	Inorganic bases, amines
Oxalic acid	Silver, mercury
Oxygen	Oils, grease, hydrogen; flammable liquids, solids, or gases
Perchloric acid	Acetic anhydride, bismuth and its alloys, alcohol, paper, wood, grease, and oils
Peroxides, organic	Acids (organic or mineral), avoid friction, store cold
Phosphorus (white)	Air, oxygen, alkalis, reducing agents
Potassium	Carbon tetrachloride, carbon dioxide, water
Potassium chlorate and perchlorate	Sulfuric and other acids, alkali metals, magnesium and calcium.
Potassium permanganate	Glycerin, ethylene glycol, benzaldehyde, sulfuric acid
Selenides	Reducing agents
Silver	Acetylene, oxalic acid, tartaric acid, ammonium compounds, fulminic acid
Sodium	Carbon tetrachloride, carbon dioxide, water
Sodium nitrite	Ammonium nitrate and other ammonium salts
Sodium peroxide	Ethyl or methyl alcohol, glacial acetic acid, acetic anhydride, benzaldehyde, carbon disulfide, glycerin, ethylene glycol, ethyl acetate, methyl acetate, furfural
Sulfides	Acids
Sulfuric Acid	Potassium chlorate, potassium perchlorate, potassium permanganate (or

	compounds with similar light metals, such as sodium, lithium, etc.)
Tellurides	Reducing agents
From Manufacturing Chemists' Association, *Guide for Safety in the Chemical Laboratory*, **pp. 215–217, Van Nostrand** Available at: http://www.lbl.gov/ehs/chsp/html/storage.shtml	

9.4. Flammables Storage

- Flammable liquids should be *stored* as described below when not in use; those kept out in the **open** for use should be kept to the **minimum volumes necessary for the work being performed.**
- **Flammable** liquids must be stored in safety cans or other **approved storage containers.**
- Any quantities ε 5 gallons must be stored in **flammable storage cabinets.**
- Flammable chemicals requiring **refrigeration** should be stored only in the refrigerators and freezers *specifically designed* for flammables storage.
- Flammable chemicals should be **stored per the limits** provided in **Table 2.9** below.

Table 2.9 - Flammable Liquid Storage Limits

	MAXIMUM ALLOWABLE VOLUME			
STORAGE CONTAINER	**Class Ia** (fp <73°F & bp <100°F)	**Class Ib** (fp <73°F & bp ≥100°F)	**Class Ic** (73°F ≤ fp < 100°F)	**Class II** (100°F ≤ fp < 140°F)
Glass or Compatible Plastic	500 ml (1 pt).	1 liter (1 qt.)	4 liters (1 gal.)	4 liters (1 gal.)
Metal (other than DOT Drums)	4 liters (1 gal.)	20 liters (5 gal.)	20 liters (5 gal.)	20 liters (5 gal.)
Safety Can	10 liters (2.6 gal.)	20 liters (5 gal.)	20 liters (5 gal.)	20 liters (5 gal.)
Safety Cabinet	240 liters (60 gal.)	240 liters (60 gal.)	240 liters (60 gal.)	240 liters (60 gal)
Total volume per lab OUTSIDE of safety cans or cabinets	40 liters (10 gal.)	40 liters (10 gal.)	40 liters (10 gal.)	40 liters (10 gal.)
Total volume per floor OUTSIDE of safety cans or cabinets:	Floors **with** Undergrad Instructional Laboratories: 150 liters (37.5 gal.) for all Class I			200 L for Class I and II *combined*
	Floors **without** Undergrad Instructional Laboratories: 300 liters (75 gal.) for all Class I			400 L for Class I and II *combined*
Total volume per floor INSIDE	Floors **with** Instructional Laboratories:			400 L for Class I and II

(PLUS OUTSIDE) of safety cans or cabinets:	300 liters (75 gal.) for all Class I	*combined*
	Floors **without** Instructional Laboratories: 600 liters (150 gal.) for all Class I	800 L for Class I and II *combined*

Examples of Flammable Liquid Hazard Classes Listed in Table 2.9

Class Ia Examples	Class Ib Examples			Class Ic Examples
acetaldehyde	acetal	cyclohexene	methyl	n-amyl acetate
acetylene dichloride	acetone	cyclohexylamine	chloromethyl ether	sec-amyl acetate
acrolein	acetonitrile	propylene	methyl hydrazine	o-anisidine
acrylonitrile	acetyl chloride	dichloride	methyl isobutyl ketone	p-anisidine
butane	acetylene	diethylamine	methyl isocyanate	butyl alcohol
1-3-butadiene	dichloride	diisopropylamine	methyl methacrylate	sec-butyl alcohol
ethane	acrolein	dimethylhydrazine	methylal	chlorobenzene
ethylaine	acrylonitrile	dimethyl	α-methylacrylonitrile	cyclopentadiene
ethylene	allyl alcohol	acetamide	methylcyclohexane	1,3-dichoropropene
ethyl bromide	allyl choride	dioxane	nickel carbonyl	ethylenediamine
ethyl chloride	aluminum methyl	ethyl acetate	octane	N-
ethylene oxide	benzene	ethyl acrylate	2-pentanone	methylmorpholine
ethyl ether	2-butanone	ethyl alcohol	3-pentanone	isobutyl alcohol
ethyl mercaptan	butyl acetate	ethyl silicate	petroleum spirit	isopropyl glycidyl
gasoline	isobutyl acetate	ethylbenzene	phosphorus yellow	ether
hydrocyanic acid	sec-butyl acetate	ethylene	n-propyl acetate	mesityl oxide
hydrogen cyanide	tert-butyl acetate	dichloride	n-propyl alcohol	methyl n-butyl
isoprene	tert-butyl alcohol	ethylenimine	n-propyl nitrate	ketone
isoprolyamine	butylamine	ethyl formate	propylenimine	morpholine
methane	1-	1,1-	propylene dichloride	nitroethane
methylamine	mercaptobutane	dichloroethane	pyridine	nitromethane
methyl formate	carbon disulfide	n-heptane	methyltrichlorosilane	1-nitropropane
methyl mercaptan	4-chloro-m-	–hexane	tetrahydrofuran	2-nitropropane
pentane	cresol	4-hydroxy-4-	toluene	n-nonane
propane	2-chloroethyl	methyl-2	triethylamine	pentaborane
propylene	vinyl	pentanone	vinyl acetate	propargyl alcohol
propylene oxide	ether	isopropyl acetate		phenyl ethylene
trimethylamine	chloroprene	isopropyl alcohol		xylene
vinyl chloride	crotonaldehyde	isopropyl ether		
vinylidene chloride	cyclohexane	methyl acetate		
		methyl acrylate		
		methyl alcohol		

9.5. Chemical Storage of Unstable Chemicals

Stability refers to the susceptibility of a chemical to dangerous decomposition. The label and SDS will indicate if a chemical is unstable.

A. Peroxide formers such as ethers, liquid paraffins, and olefins form peroxides on exposure to air and light, which are extremely sensitive (more so than primary explosives such as TNT) to shock, sparks, or other forms of accidental ignition.

1) Since these chemicals are often packaged in an air atmosphere, peroxides can form even though the containers have not been opened.

2) All such containers should be **dated upon receipt and upon opening**.

3) Unless an inhibitor was added by the manufacturer, **sealed containers of ethers should be discarded after one (1) year. Opened containers of ethers should be discarded within six months of opening.**

- ❖ See **Part III. Section 3,** "Highly Reactive Chemicals" and **Part III. Section 4,** "High Energy Oxidizers", for additional information and examples of materials which may form explosive peroxides.

10. CHEMICAL SPILLS & ACCIDENTS

10.1. Chemical Spills Preparation

A. Laboratory Supervisors/PIs should **anticipate** the types of chemical spills that could occur in each experiment, and have prepared the equipment **(e.g., spill kits, protective equipment, etc.)** to respond.

B. General guidelines are provided on the following pages to assist laboratory personnel to assess and subsequently respond to chemical spills.

10.2. Assessing the Type of Spill: Incidental or Emergency

A. Incidental Release.

Release of a material which meets ALL of the following criteria:

1) Identity of material is KNOWN; and

2) Material presents negligible hazards **OR** presents hazards which are:

- **Fully** understood by one or more persons in the immediate area; AND
- Safely and easily (based on volumes and/or hazards presented) controlled (e.g. by absorption, neutralization, ventilation and so forth.
- "Trained" individuals are readily available to perform/coordinate clean-up of the material. "Trained" = Those individuals who have been "formally" instructed in spill response, and/or otherwise possess the knowledge, background, experience and/or reference materials (e.g., SDS) necessary to respond safely and effectively to the accidental and/or uncontrolled release of a hazardous material.

B. Emergency Release

An accidental release of a hazardous material which does not meet the criteria of an "Incidental Release", and consequently requires the response of personnel ***outside*** the immediate release area (this could include EH&S employees, OU Police and/or external emergency response personnel).

10.3. General Spill Response Guidelines

A. Responding to "Incidental" Spills

1) People in the immediate area of the spill should be alerted.

2) Spills should only be cleaned up by "trained" personnel, i.e., those individuals who have been "formally" instructed in spill response, and/or otherwise possess the knowledge, background, experience and/or reference materials (e.g. SDS or other safety literature) necessary to respond safely and effectively to the accidental and/or uncontrolled release of a hazardous material.

3) The laboratory employee should make certain that he/she has adequate ventilation (e.g., windows open or emergency purge button in MSC) in addition to ensuring that the fume hoods in the room are on.

4) The laboratory employee must ensure he/she has proper personal protective equipment (minimum - gloves, goggles, and lab coat).

5) Spill kits, and/or vermiculite, dry sand, diatomaceous earth, paper towel, etc. (as appropriate to the material and its hazards) should be used to clean up the material.

6) Contaminated absorbent materials should be collected, placed in a container, and disposed of as with hazardous waste regulations in mind. EH&S can be contacted for disposal instructions if uncertainty exists regarding how to handle the waste (see Part II. Section 12).

B. Responding to "Emergency" Spills

1) Evacuate the room or immediate area in which the material was released, close door(s) upon exit if possible, and solicit the assistance of others to keep unauthorized personnel at *least* 25 feet from the room/area

2) Door(s) to affected room(s) should be closed. Activate the air flow purge upon evacuation. **For chemical spills only. Do not depress purge when there is a fire.**

3) Activate call box button or call "911" on an OU campus phone or (248) 370-3333 on a cell phone, which connects to the OU Police Dispatcher directly. Be prepared to provide the OU Police dispatcher with the following information if/when it is available without re-entering the immediate area (i.e. within 25 feet) of the release:

- Location of the release (be as specific as possible).

- Description of injuries, illnesses or negative health symptoms resulting from release

- Approximate **amount** released.

- If the release is due to a **leak**: (1) whether the material continues to "flow;" (2) if so, at what "rate" (e.g. dribbling, streaming, gushing); and (3) approximate size of container from which the material is leaking.

- **Identity** of material spilled (with correct spelling and manufacturer name/city).

- Any **hazards** which are known to be associated with release of the material (based on previous knowledge, information from SDS, placards on the product's transport vehicle, hazard warning label(s) on its container or packaging, and so on).

- If the material is known to be flammable or ignitable, whether any open flames or other significant **ignition sources** exist in the area.

- **Physical characteristics** of the release (e.g. color, odor, liquid/solid/gas), *particularly* for the release of "unknown" materials

- Whether release of a liquid has been **"contained"** (to prevent its spread) and whether it entered sewer or drain.

4) Oakland University Police should dispatch one or more officers to the scene, and **immediately thereafter** reference its ***Emergency Contact List*** in order to reach an individual in the Office of Environmental Health and summarize for him/her "**Responding to "Emergency" Spills"** information found at the end of this section. The responding EH&S employee shall report to the site and begin preliminary assessment and mitigation procedure/recommendations.

5) The **Office of Environmental Health and Safety** is available for guidance and advice for all chemical spills and accidents. **Other OU resources** include: Department of Chemistry Chair and the Department of Chemistry Lab Managers who can also assist with the spill "assessment process" if EH&S is not immediately available.

6) Within 48 hours of the incident, the laboratory supervisor should complete a ***"Chemical Incident Report Form"*** (form located at the end of this Section), and submit it to the Office of Environmental Health and Safety.

10.4. Mercury (Hg) Spills

A. Mercury should be cleaned up using a Mercury Spill Kit. Consists of:

1) A vacuum line with an in-line dry trap attached to a tapered glass tube (similar to a medicine dropper).

and/or

2) Powdered sulfur or powdered zinc, which converts Hg to a non-hazardous amalgam.

B. *A domestic or commercial vacuum cleaner should never be used to vacuum mercury.*

C. Mercury residues should be placed in a labeled container and disposed of as hazardous chemical waste, through the Office of EH&S (see **Part II. Section 12**).

10.5. Alkali Metal Spills

A. Spill should be smothered with powdered graphite, sodium carbonate, calcium carbonate or "Met-L-X".

10.6. White Phosphorus Spills

B. Spill should be smothered with wet sand or wet "noncombustible" absorbent.

11. PERSONAL CONTAMINATION AND INJURY

11.1. General Information

A. Laboratory workers should all know the locations of the nearest **safety showers, eye wash stations** and **telephones**, both in and outside the laboratories.

B. All **incidents and injuries should be reported** to the laboratory supervisor.

C. **Seriously injured persons should**:

1) **Obtain medical attention** promptly by dialing ext. 911 on an OU campus phone or (248) 370-3333 on a cellphone.

2) **Not be moved** unless remaining in that location will place that individual in additional danger

3) **Be covered** immediately with a blanket to protect against shock.

11.2. Chemical Spills onto the Body

A. **Contaminated clothing and footwear should be removed immediately** and laundered separately from uncontaminated clothing, or disposed of.

B. The affected body area should be **flooded with cold water for at least 15 minutes**. Jewelry should be removed to facilitate removal of any residual material.

C. Chemicals should be washed off with **<u>water</u> <u>only</u>**. *Neutralizing chemicals, unguents, creams, lotions or salves are NOT appropriate.*

D. **Medical attention** should be obtained promptly.

E. **Skin-absorbed chemicals**.

1) It should be noted that some toxic chemicals (e.g. phenol, aniline,) are rapidly adsorbed through the skin. If a large enough area of skin is contaminated, an adverse health effect (systemic toxicological reaction) may occur immediately to several hours after initial exposure. Thus, if more than 9 square inches of skin

area has been exposed to a toxic chemical, seek medical attention after washing the material off the skin.

2) If the incident involves **hydrofluoric acid (HF)**, medical attention should be sought immediately, regardless of the skin area exposed.

11.3. Chemical Splash in the Eye

A. Eyeball and inner surface of eyelid should be **irrigated with plenty of cool water for at least 15 minutes**. The eyelids should be forcibly held open to ensure wash.

B. Allow eyewash water stream to remove **Contact lenses or carefully remove the lenses while flushing the eye**.

C. **Medical attention** should be obtained promptly by calling OU Police at ext. 911 on an OU campus phone or (248) 370-3333 on a cellphone.

11.4. Ingestion of Hazardous Chemicals

A. **Chemical** and **approximate volume** ingested should be identified.

B. **OU Police** should be notified by dialing ext. 911 on an OU campus phone or (248) 370-3333 on a cellphone.

C. The **Poison Information Center** can be contacted by dialing 1-800-462-6642.

D. The injured person should be **covered** with a blanket to prevent shock.

E. The ambulance crew and attending physician(s) should be provided with the chemical name and any other information, including the SDS and/or label if possible. Inhalation of Smoke, Vapors or fumes

F. Anyone overcome with smoke or chemical vapors or fumes should be **removed to uncontaminated air** and treated for shock.

G. CPR certified individuals can begin standard CPR protocols until rescue personnel arrive.

H. Medical attention should be obtained promptly.

I. The area should not be re-entered if it is expected that a life threatening condition still exists (e.g. oxygen depletion, explosive vapors or highly toxic gases such as cyanide, hydrogen sulfide, nitrogen oxides, carbon monoxide)

11.5. Chemical Fires Involving Clothing

A. Burning clothes should be extinguished by using the **drop-and-roll** technique and/or dousing area with cold water (i.e., using an emergency shower **if it is immediately available**).

B. Contaminated **clothing should be removed immediately**; however, further damage to the burned area should be avoided. If possible, the contaminated clothing should be sent to the hospital with the victim.

C. **Cool water/ice packs** should be applied until tissue around burn feels normal to the touch.

D. Injured person should be **covered** with a blanket to prevent shock.

E. **Medical attention** should be obtained promptly.

11.6. Actions to be Avoided During Emergencies

A. Liquids should never be forced into the mouth of an unconscious person.

B. Emergencies should never be handled alone

C. Individuals should not linger at the accident scene if they are not intrinsic to the emergency response, as they may impede emergency response efforts.

12. FIRE AND FIRE RELATED EMERGENCIES

12.1. Discovery or Suspicion of Fire

A. **Procedures to Follow:** Upon discovery of a fire or fire-related emergency (such as a significant and uncontrollable leak of a flammable gas, a large volume flammable liquid spill, smoke of undisclosed origin, or undiagnosed burning odor), employees should follow these procedures immediately:

1) **Notify OU Police** by dialing ext. 911 on an OU campus phone or (248) 370-3333 on a cellphone.

2) **Activate** the building alarm (fire pull station). **Do not** activate the air flow purge button.

3) **Isolate** the area by closing windows and doors and evacuate the building.

4) **Shut down** equipment in the immediate area, if possible without personal risk.

5) **Provide** the fire/police teams with the details of the incident upon their arrival, and alert them to the known hazards of other chemicals in that laboratory.

B. Portable fire extinguisher should ONLY be used to:

1) control **small** fires **OR**

2) assist oneself or others to **evacuate**

12.2. Fire Alarm Response

A. Once a fire alarm has been sounded, the building should be **evacuated**.

B. Individuals should move (and stay) **up-wind from the building**, and remain clear of streets, driveways, sidewalks and other access ways to the building.

C. Supervisors should try to account for their employees, keep them together and **report any missing persons** to the emergency personnel at the scene.

13. CHEMICAL WASTE DISPOSAL PROGRAM

❖ Laboratory chemical waste must be disposed of in accordance with local, state, federal and Oakland University requirements.

❖ Compliance is accomplished through periodic removal of chemical waste and disposal of these wastes in compliance with all regulations and policies. Specific guidance on how to identify, handle, collect, segregate, store and dispose of chemical waste is documented in the *OU Hazardous Waste Management Guidance Manual.* Hoods should not be used for disposing of volatile chemicals by evaporation (EPA violation).

❖ Waste materials should be accumulated in a designated storage area which is consistent with the guidelines identified in the *OU Hazardous Waste Management Guidance Manual.*

13.1. Drain Disposal

❖ Drain disposal should be used for disposal of chemicals in strict accordance with the OU Hazardous Waste Management Program. Guidelines for drain disposal, as provided in the *OU Hazardous Waste Management Guidance Manual*, are as follows:

A. Drain disposal is NOT an option unless the generating department:

1) is aware of the **exact chemical composition** of the waste being considered for drain disposal; AND

2) has determined whether a general or specific **City of Detroit prohibition** exists regarding (any of) the chemical constituents in the waste; AND

3) is confident that the chemical does not pose a **fire/explosion hazard**.

B. A copy of DETROIT CITY ORDINANCE NO. 23-86 ARTICLE III. SEWERS AND DRAINS Wastewater Discharge Prohibitions Sec. 56-3-59.1, is located in the Appendices of the *OU Hazardous Waste Management Guidance Manual*.

C. Chemicals which are **ABSOLUTELY prohibited** from drain disposal, regardless of concentration, due to their fire/explosion hazards are as follows:

- strong oxidizers
- peroxides
- elemental sodium, potassium or lithium
- fulminates
- Any other chemicals which present known or suspected fire/explosion hazards in the presence of water

13.2. Contaminated Sharps disposal (Non-Infectious):

❖ Chemically contaminated sharps can be picked up by EH&S as hazardous waste.

❖ The following items should be handled as **sharps**:

- Hypodermic needles, syringes and tubing
- Blades (scalpels, razors)
- Glass capillary tubes
- Pasteur pipettes
- Glass slides or cover slips
- Laboratory glassware or plastic pipette tips
- 'Plasticware' which can break into shards or sharp edges.

❖ Please package the sharps container as follows:

A. Package in a puncture proof container.

B. Use of a commercially available sharps container is recommended, but make sure to deface any biohazard or infectious material markings. Do not autoclave the container.

C. Label should list the name of the chemicals used with the needles. The following label is recommended: "**Chemically Contaminates Sharps – Do Not Autoclave**".

CHEMICAL EMERGENCY
Telephone Reporting Format
CALL OUPD-911 on campus phone or (248) 370-3333 on cell phone

When you reach OU Police Dispatch, provide the following information:

- There is a __________ (fire, explosion, spill, burned person, unconscious person, etc
- In room _________ of building _________________
- There are __________ injured or sick people (describe injuries or illnesses)
- My name is _____________
- I am calling from extension
- I shall remain at ___________________ *(give location at least 25 feet from incident)*

Is the area being evacuated? YES or NO

FOR CHEMICAL SPILLS:

- Amount of chemical spilled is **approximately ____________ or is leaking_______**
- Is the name of the material known? YES or NO *If known, list chemical*__________ *(spell for dispatcher if possible)*
  - ➢ *If the release is due to a leak*: **Does the material continue to "flow"? YES or NO**
  - ➢ *If leak is still being released, what is the RATE?* **(e.g. dribbling, streaming, gushing**)
- **The size of the container from which it spilled was approximately the size of a (e.g. milk carton, 2-liter soda bottle) ___________**
- **Known hazards of this material are ___________________.** *Give any **hazards** which are known to be associated with release of the material (based on previous knowledge, information from SDS, placards on the product's transport vehicle, hazard warning label(s) on its container or packaging, and so on).*
- **Is the material a flammable? YES or NO If yes, are there any obvious ignition sources nearby.** *If there are ignition sources,* **They are ____________** *(list them).*
- *Particularly if the release is of unknown identify:* **This material has the following physical characteristics _________________** *(e.g. color, odor, liquid/solid/gas)*
- Has the release been contained to prevent its spread? YES or NO. Did it enter the sewer? YES or NO. **If yes,** *give location of sewer if material did enter it..*

-- DO NOT HANG UP UNTIL REQUESTED --

POST CHEMICAL INCIDENT REPORT

1. Nature of Incident: (check all applicable)

   ___Exposure ___Facility System Failure ____Injury

2. Route of Entry:

   ___ Inoculation ___Ingestion ___Dermal ___Inhalation

   ___Mechanical Problem ___Chemical Spill ___Fire

3. Date and Time of Incident: ____

4. Person(s) Involved: ____

   ____

5. Precise Location of Incident: ____

   ____

6. Description of Incident: (Include chemicals involved and exactly how the incident occurred)

   ____

   ____

   ____

   ____

   ____

7. Corrective Action Taken:

   ____

   ____

   ____

8.

   Laboratory Supervisor/PI Date

Copy: Office of Environmental Health and Safety

PART III. IDENTIFICATION AND CLASSIFICATION OF HAZARDOUS CHEMICALS

1. INTRODUCTION

Chemicals are classified using a harmonized system that provides standardized language for:

- Health Hazard Categories
- Physical Hazard Categories
- Environmental Hazard Categories

The OSHA Laboratory Standard defines a hazardous chemical as "a chemical for which there is statistically significant evidence based on at least one study conducted in accordance with established scientific principles that acute or chronic health effects may occur in exposed employees. The term 'health hazard' includes chemicals which are:

- ➢ Acute Toxicity
- ➢ Skin Corrosion/Irritation
- ➢ Respiratory or Skin Sensitization
- ➢ Germ Cell Mutagenicity
- ➢ Carcinogenicity
- ➢ Reproductive Toxicity
- ➢ Specific Target Organ Toxicity – Single Exposure
- ➢ Specific Target Organ Toxicity – Repeated Exposure
- ➢ Aspiration
- ➢ Simple Asphyxiants

carcinogens, toxic or highly toxic agents, reproductive toxins, irritants, corrosives, sensitizers, hepatotoxins, nephrotoxins, neurotoxins, agents which act on the hematopoietic systems, and agents which damage the lungs, skin, eyes, or mucous membranes".

In laboratories many of the hazardous chemicals that are encountered are known to be toxic or corrosive, or both. Compounds that are explosive and/or are highly flammable pose another significant type of hazard. New and untested substances that may be hazardous are also frequently encountered. Thus, it is essential that all laboratory workers understand the types of toxicity, recognize the routes of exposure, and are familiar with the major hazard classes of chemicals. The most important single generalization regarding toxicity in chemical research is to treat all compounds as potentially harmful, especially new and unfamiliar materials, and work with them under conditions to minimize exposure by skin contact and inhalation. When considering possible toxicity hazards while planning an experiment, it is important to recognize that the combination of the toxic effects of two substances may be significantly greater than the toxic effect of either substance alone. Because most chemical reactions are likely to contain mixtures of substances whose combined toxicities have never been evaluated, it is prudent to assume that mixtures of different substances (e.g., chemical reaction mixtures) will be more toxic than the most toxic ingredient contained in the mixture. Furthermore, chemical reactions involving two or more substances may form reaction products that are significantly more toxic than the starting reactants.

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

NOTE:

For your convenience, an alphabetical list of common laboratory chemicals and their corresponding hazard classes is provided in the Laboratory Chemical Inventory (LCI) which is available on-line. For access to the LCI, contact EH&S at ext 4196.

Additionally, a list of chemical examples in each of the following hazard classes are listed <u>within</u> their corresponding segments (below).

2. HEALTH AND SAFETY INFORMATION FOR HAZARD CLASSES

Determine the physical and health hazards associated with chemicals before working with them.

2.1. Flammable Liquids

A. General Information

1) Flammable liquids are among the **most common** of the hazardous materials found in laboratories. **Table 3.1 of Part III.** provides a list of the most common flammable chemicals.

2) It is important to remember that the liquids themselves do not burn; rather it is the **vapors** from the liquid which ignite and burn. That is why the liquid's vapor pressure (volatility), which increases with temperature, plays such a pivotal role in the safe handling of these substances.

3) Flammable liquids are usually **highly volatile** (i.e., have high vapor pressures at room temperature) and their vapors can ignite and burn when combined with 1) air at the appropriate ratio and 2) an ignition source.

4) Liquids are termed "flammable" (OSHA & NFPA) when they have a **flash point δ 37.8°C (100°F)**. By definition, the **flash point** is the lowest temperature at which liquids produce ignitable vapors.

5) Concentrated vapors of flammable liquids are heavier than air and can **travel** away from a source a considerable distance (e.g., across laboratories, into hallways, down elevator shafts or stairways). When/if these vapors then reach a source of ignition, a flame can result that may flash back to the source of the vapor(s).

6) For vapors of a flammable liquid to ignite/burn, **three conditions must exist** simultaneously:

- **Vapor Concentration** must be between the upper and lower flammable limits of the substance (i.e., the fuel/air ratio is such that the vapors can burn);
- An oxidizing atmosphere, usually **air**, must be available; and,
- A **source of ignition** must be present.

B. Flammable liquids should be *stored* as described below when <u>not in use</u>; those kept out in the open <u>for use</u> should be kept to the **minimum volumes necessary for the work being performed.**

C. Flammable liquids should **not be stored *inside* fume hoods** for long periods of time, as the containers can obstruct air flow, thereby reducing hood performance.

D. Large volumes of flammable liquids, and those stored in glass containers, should be **stored separately** from all other hazard groups (e.g., strong acids/bases, oxidizers, perchloric acid and/or reactive/explosive liquids), see **Table 2.5 (Part II. of this CHP**)

E. Flammable liquids which require refrigeration must only be stored or chilled in units *specifically designed* for this purpose (="**flammables storage refrigerators**") or **ultra-low temperature units**. **Traditional refrigerators and freezers should never be used.**

F. Flammable chemicals should be **stored per the limits** provided in Table 3.1 on the next page (limits also provided as Table 2.5 in Part II of this CHP):

Part III. Table 3.1 - Flammable Liquid Storage Limits

	MAXIMUM ALLOWABLE VOLUME			
STORAGE CONTAINER	**Class Ia** (fp <73°F & bp <100°F)	**Class Ib** (fp <73°F & bp ε100°F)	**Class Ic** (73°F δ fp < 100°F)	**Class II** (100°F δ fp < 140°F)
Glass or Compatible Plastic	500 ml (1 pt).	1 liter (1 qt.)	4 liters (1 gal.)	4 liters (1 gal.)
Metal (other than DOT Drums)	4 liters (1 gal.)	20 liters (5 gal.)	20 liters (5 gal.)	20 liters (5 gal.)
Safety Can	10 liters (2.6 gal.)	20 liters (5 gal.)	20 liters (5 gal.)	20 liters (5 gal.)
Safety Cabinet	240 liters (60 gal.)	240 liters (60 gal.)	240 liters (60 gal.)	240 liters (60 gal)
Total volume per lab OUTSIDE of safety cans or cabinets	40 liters (10 gal.)	40 liters (10 gal.)	40 liters (10 gal.)	40 liters (10 gal.)
Total volume per floor OUTSIDE of safety cans or cabinets:	Floors **with** Undergrad Instructional Laboratories: 150 liters (37.5 gal.) for all Class I			200 L for Class I and II *combined*
	Floors **without** Undergrad Instructional Laboratories: 300 liters (75 gal.) for all Class I			400 L for Class I and II *combined*
Total volume per floor INSIDE (PLUS OUTSIDE) of safety cans or cabinets:	Floors **with** Instructional Laboratories: 300 liters (75 gal.) for all Class I			400 L for Class I and II *combined*

	Floors **without** Instructional Laboratories: 600 liters (150 gal.) for all Class I	800 L for Class I and II *combined*

Examples of Flammable Liquid Hazard Classes

Class Ia Examples	Class Ib Examples			Class Ic Examples
acetaldehyde	acetal	diethylamine	methyl methacrylate	n-amyl acetate
acetylene dichloride	acetone	diisopropylamine	methylal	sec-amyl acetate
acrolein	acetonitrile	dimethylhydrazine	α-methylacrylonitrile	o-anisidine
acrylonitrile	acetyl chloride	dimethyl acetamide	methylcyclohexane	p-anisidine
butane	acetylene dichloride	dioxane	nickel carbonyl	butyl alcohol
1-3-butadiene	acrolein	ethyl acetate	octane	sec-butyl alcohol
ethane	acrylonitrile	ethyl acrylate	2-pentanone	chlorobenzene
ethylaine	allyl alcohol	ethyl alcohol	3-pentanone	cyclopentadiene
ethylene	allyl choride	ethyl silicate	petroleum spirit	1,3-dichoropropene
ethyl bromide	aluminum methyl	ethylbenzene	phosphorus yellow	ethylenediamine
ethyl chloride	benzene	ethylene dichloride	n-propyl acetate	N-methylmorpholine
ethylene oxide	2-butanone	ethylenimine	n-propyl alcohol	isobutyl alcohol
ethyl ether	butyl acetate	ethyl formate	n-propyl nitrate	isopropyl glycidyl ether
ethyl mercaptan	isobutyl acetate	1,1-dichloroethane	propylenimine	mesityl oxide
gasoline	sec-butyl acetate	n-heptane	propylene dichloride	methyl n-butyl ketone
hydrocyanic acid	tert-butyl acetate	n-hexane	pyridine	morpholine
hydrogen cyanide	tert-butyl alcohol	4-hydroxy-4-methyl-2 pentanone	methyltrichlorosilane	nitroethane
isoprene	butylamine	isopropyl acetate	tetrahydrofuran	nitromethane
isopropylamine	1-mercaptobutane	isopropyl alcohol	toluene	1-nitropropane
methane	carbon disulfide	isopropyl ether	triethylamine	2-nitropropane
methylamine	4-chloro-m-cresol	methyl acetate	vinyl acetate	n-nonane
methyl formate	2-chloroethyl vinyl ether	methyl acrylate		pentaborane
methyl mercaptan	chloroprene	methyl alcohol		propargyl alcohol
pentane	crotonaldehyde	methyl chloromethyl ether		phenyl ethylene
propane	cyclohexane	methyl hydrazine		xylene
propylene	cyclohexene	methyl isobutyl ketone		
propylene oxide	cyclohexylamine	methyl isocyanate		
trimethylamine	propylene dichloride			
vinyl chloride				
vinylidene chloride				

3. HIGHLY REACTIVE CHEMICALS

3.1. General Description

A. Highly reactive chemicals include those which:

1) Are **inherently unstable** and susceptible to rapid decomposition; **or**

2) React violently or form potentially explosive mixtures or generate toxic gases, vapors or fumes, when **mixed with water**; **or**

3) Are cyanide- or sulfide- bearing chemicals that **generate toxic vapors** at a pH < 4.0; **or**

4) Are capable of detonation or explosive reaction when subjected to a strong initiating source or if heated in confinement.

B. **Air, light, heat, mechanical shock (when struck, vibrated or otherwise agitated), water, and certain catalysts** can cause decomposition of some highly reactive chemicals, and initiate an explosive reaction.

3.2. "Classes" of Reactive Materials

A. **Reactive to Light:** Mixtures of hydrogen and chlorine react together explosively in presence of light.

B. **Reactive to Water:** Alkali metals, such as sodium, potassium and lithium, react violently with water liberating hydrogen gas. (K > Na > Li)

C. **Shock Sensitive:** Acetylides, azides, organic nitrates, nitro compounds, and many peroxides are shock sensitive. NI_3

D. **Organic peroxides:**

1) Organic peroxides constitute a special class of compounds with instability characteristics that make them among the **most hazardous substances** normally handled in the laboratories.

2) As a class, organic peroxides are **low- to high-powered explosives.**

3) Organic peroxides are **extremely sensitive to light, heat, shock, sparks, and other forms of accidental ignition**; as well as to strong oxidizing and reducing materials.

4) Organic peroxides are also **highly flammable.**

5) **"Peroxide formers"**

- Can form peroxides during storage and after exposure to the air once opened.

6) **Peroxide Formers Include**:

- Aldehydes
- Ethers (especially cyclic ether)
- Compounds containing benzylic hydrogen atoms
- Compounds containing the allylic structure (including most alkenes)

- Per acids
- Vinyl and vinylidene compounds

7) Peroxides may also be formed (or present) as impurities in common solvents (e.g., diethyl ether), which can decompose when the solvent is distilled to dryness.

❖ **Additional Examples** of shock sensitive chemicals and substances which can form explosive peroxides are listed at the end of this Section [**Part III. Tables 3.8 (SS) and 3.7 (PF)**].

3.3. Handling Reactive Chemicals

Before working with highly reactive materials, **available reference literature should be reviewed** to obtain specific safety information and the proposed reactions should be discussed with laboratory supervisors.

The **key** to safely handling reactive chemicals is to **keep them isolated** from the substances that initiate their violent reactions, and **limit** quantities used.

A. All manipulations of highly reactive chemicals **should be performed in chemical fume hoods.**

1) Some factors to be considered in judging the adequacy of a hood include:

- Its size in relation to the reaction and required equipment;
- The ability to fully close the sash; and
- The composition of the sash.

B. The following **personal protection equipment** should always be worn:

1) Lab coats
2) Gloves
3) Protective glasses/goggles.
4) A face shield long enough to give throat protection during the reaction.

C. **Unused organic peroxides should <u>never</u> be returned to the original container.**

D. **Shock sensitive substances should be handled gently**, avoiding friction, grinding, and all forms of impact.

E. Shock sensitive materials should be **dated upon receipt**.

1) Sealed containers should be **discarded after one year** of receipt;

2) Containers that have been opened should be discarded **within six months of opening,** unless an inhibitor was added by the manufacturer.

F. Glass containers that have **screw-cap lids or glass stoppers should not be used** to contain reactive materials.

G. Water-sensitive compounds should be handled away from water sources.

H. Highly reactive chemicals should be handled away from direct light, open flames, and other sources of heat.

I. Highly reactive compounds should not be purchased, synthesized, or stored in the laboratories in quantities beyond what is immediately needed.

J. The laboratory worker should make certain that the reaction equipment is properly secured. Reaction vessels should be supported from beneath with tripods or lab jacks, and shields or guards should be used which are clamped or secured.

K. Wherever possible, remote controls should be used for controlling the reactions (including cooling, heating and stirring controls). These controls should be located either outside the hood or at least outside the shield.

L. The amount of material used in experiments involving reactives should always be minimized; the smallest amount sufficient to achieve the desired result should be used. Scale-ups should be handled with great care, giving consideration to the reaction vessel size and cooling, heating, stirring and equilibration rates.

3.4. Storage of Reactive Chemicals

A. Store **water-sensitive** compounds away from water sources.

B. Storage of reactives should be in closed cabinets segregated from the materials with which they react and, if possible, in secondary containers.

C. Large volumes of reactive chemicals, and those stored in glass containers, should be stored separately from all other hazard groups (e.g., strong acids/bases, flammable liquids, perchloric acid and/or oxidizers), see Table 2.5 (Part II. of this CHP)

D. Reactive substances should never be stored above eye level or on open shelves.

3.5. Storage of Peroxide Forming Substances

A. **Labels** on peroxide forming substances should contain the date the container was received, and then first opened.

B. Containers should be checked for the presence of peroxides before using, and quarterly, while in storage via peroxide test strips. If peroxides are found, the containers should be labeled, and the materials decontaminated or disposed of through EH&S.

C. Peroxide forming substances that have been open for >1 year should be discarded.

D. Peroxides and peroxide forming compounds should be stored at the lowest possible temperature. If a refrigerator is used, it must be designed for the flammables storage.

3.6. Examples of Reactive Chemicals

A. List of Peroxide Formers (PF)

Table 3.2. (PF)

The following are common laboratory chemicals which may form explosive peroxides:

Acetal	Dimethyl ether	Potassium solid (In Mineral Oil)
Cyclohexene	Dioxane	Sodium amide
Decahydronaphthalene	Divinyl acetylene	Tetrahydrofuran
Diacetylene	Ether (glyme)	Tetrahydronaphthalene
Dicyclopentadiene	Ethylene glycol dimethyl ether	Vinyl ethers
Diethyl ether	Isopropyl ether	Vinylidene chloride
Diethylene glycol	Methyl acetylene	

B. List of Shock Sensitive Chemicals (SS)

Table 3.3 (SS)

Shock sensitive refers to the susceptibility of the chemical to rapidly decompose or explode when struck, vibrated or otherwise agitated. The following are examples of shock sensitive chemicals:

Acetylides of heavy metals	Hexanitrodiphenylamine	Picratol
Amatol	Hexanitrostilbene	Picric acid
Ammonal	Hexogen	Picryl chloride
Ammonium perchlorate	Hydrazinium nitrate	Picryl fluoride
Ammonium picrate	Hyrazoic acid	Polynitro aliphatic compounds
Butyl tetryl	Lead azide	Potassium nitroaminotetrazole
Copper acetylide	Lead mannite	Silver acetylide
Cyanuric triazide	Lead mononitroresorcinate	Silver azide
Cyclotrimethylenetrinitramine	Lead picrate	Silver styphnate
Cyclotetramethylenetranitramine	Lead styphnate	Silver tetrazene
Dinitroethyleneurea	Magnesium ophorite	Sodatol
Dinitroglycerine	Mannitol hexanitrate	Sodium amatol
Dinitrophenol	Mercury oxalate	Sodium dinitro-orthocresolate
Dinitrophenolates	Mercury tartrate	Sodium picramate
Dinitrophenyl hydrazine	Mononitrotoluene	Styphnic acid
Dinitrotoluene	Nitrated carbohydrate	Tetrazene
Dipicryl sulfone	Nitrated glucoside	Tetranitrocarbazole
Dipicrylamine	Nitrated polyhydric alcohol	Tetrytol
Erythritol tetranitrate	Nitrogen trichloride	Trimonite
Fulminate of mercury	Nitrogen tri-iodide	Trinitroanisole
Fulminate of silver	Nitroglycerin	Trinitrobenzene
Fulminating gold	Nitroglycide	Trinitrobenzoic acid
Fulminating mercury	Nitroglycol	Trinitrocresol
Fulminating platinum	Nitroguanidine	Trinitro-meta-cresol
Fulminating silver	Nitroparaffins	Trinitronaphthalene
Gelatinized nitrocellulose	Nitronium perchlorate	Trinitrophenetol
Germane	Nitrourea	Trinitrophloroglucinol
Guanyl nitrosamino-guanyl-tetrazene	Organic amine nitrates	Trinitroresorcinol
Guanyl nitrosaminoguanylidene-hydrazine	Organic nitramines	Tritonal
Heavy metal azides	Organic peroxides	Urea nitrate
Hexanite	Picramic acid	
	Picramide	

4. HIGH ENERGY OXIDIZERS

4.1. Definition of High Energy Oxidizers: High energy oxidizers are those chemicals which readily support combustion or produce vigorous reactions, e.g., by giving off oxygen.

4.2. Handling High Energy Oxidizers

A. Always…

1) Always heat oxidizing agents **with fiberglass heating mantles or sand baths.**

2) Always handle high energy oxidizers such as perchloric acid in a wash down hood if the oxidizer will volatilize and potentially condense in the ventilation system.

3) Always review safety literature and discuss proposed reactions with supervisors.

4) Always manipulate oxidizing chemicals inside fume hoods.

5) Always wear the following personal protection equipment:

- Lab coats
- Gloves
- Protective glasses/goggles.

6) Always wear a **face shield long enough to give throat protection** during reaction.

B. Never....

1) Never expose inorganic oxidizers (e.g., perchloric acid) to **organic materials**.

2) Never use a metal spatula with peroxides; metals can lead to explosive decompositions.

3) Never work alone.

4.3. Storage of Oxidizers

A. Storage of high energy oxidizers should be in closed cabinets segregated from the materials with which they react and, if possible, in secondary containers.

B. Large volumes of oxidizers, and those stored in glass containers, should be stored separately from all other hazard groups (e.g., strong acids/bases, flammable liquids, perchloric acid, reducing agents and/or reactive/explosive liquids), see Table 2.5 (Part II.).

C. Reactive/oxidizing substances should never be stored above eye level or on open shelves.

4.4. Examples of High Energy Oxidizers

A. The following are examples of powerful oxidizing reagents:

Table 3.4- List of High Energy Oxidizers

Ammonium perchlorate	Dibenzoyl peroxide	Potassium chlorate
Ammonium permaganate	Fluorine	Potassium perchlorate
Barium peroxide	Hydrogen peroxide (>30%)	Potassium peroxide
Bromine	Magnesium perchlorate	Propyl nitrate
Calcium chlorate	Nitric acid	Sodium chlorate
Calcium hypochlorite	Nitrogen dioxide	Sodium chlorite
Chlorine	Perchloric acid	Sodium perchlorate
Chromium anhydride or chromic acid	Potassium bromate	Sodium Peroxide

5. COMPRESSED GASES

5.1. General Hazard Information

A. Compressed gases are unique in that they can **represent both a physical and a chemical hazard** (depending on the particular gas).

B. Gases contained in cylinders may be from **any of the hazard classes** described in this Section (flammable, reactive, corrosive, or toxic).

C. **Concentrations of compressed gases can increase instantaneously** if leaks develop at the regulator or piping systems, creating the potential for a toxic chemical exposure or a fire/explosion hazard.

D. The large amount of potential energy resulting from compression of the gas makes a compressed gas cylinder a **potential rocket or fragmentation bomb** if the tank or valve is physically broken.

5.2. Handling Compressed Gases

A. Personal Protection

1) Small compressed gas cylinders should be used in **fume hoods** or under other local exhaust ventilation.

2) **Safety goggles** should be worn when handling compressed gases which are irritants, corrosive or toxic.

3) **Flashback arrestors** and compatible metal tubing are required for all compressed flammable gases.

B. Cylinder Size

1) Cylinders of toxic, flammable or reactive gases should be purchased in the **smallest quantity possible,** but chemical purchasers should make every effort to ensure that **lecture cylinders** are returnable to the manufacturers/distributors once empty.

C. Content ID.

1) The contents of any compressed gas cylinder should be clearly identified.

2) No cylinder should be accepted for use that does not legibly **identify its contents** by name.

3) **Color coding is not a reliable means of identification**.

4) Compressed gas cylinder labels **should be carefully examined** before the gas is used or stored. The SDS will provide any special hazard information. Note: Labels on caps have no value, as caps are interchangeable

D. Transportation.

1) Transport gas cylinders **in carts one or two at a time** only while they are **secured to the cart and capped.**

E. Equipment/Parts/Supplies

1) Only Compressed Gas Association **standard combinations of valves and fittings** for compressed gas installations should be used.

2) <u>ONLY the appropriate **pressure regulator** should be used.</u>

3) **A regulator adaptor should NEVER be used.**

4) **Gas lines.** All gas lines leading from a compressed gas supply should be **clearly labeled** identifying the gas and the laboratory served.

5) **Cylinder Valves**

- Gas cylinders should be positioned in such a way that the **cylinder valve is accessible** at all times.
- **Main cylinder valve should be closed** as soon as the gas flow is no longer needed.
- <u>Gas cylinders should NEVER be stored with pressure on the regulator.</u>
- **Only the appropriate wrenches or other tools provided by the <u>cylinder supplier</u>** should be used to open valves. Under no circumstances should pliers, pipe wrenches, or monkey wrenches be used to open cylinder valve.

F. Leaks

1) **Soapy water** should be used to detect leaks.

2) **After any maintenance** or modifications, the regulator, piping system and other couplings should be tested.

G. Empty Cylinders

1) Cylinders should never be bled completely empty. A slight pressure is necessary to keep contaminants out (172 kPa or 25 psi).

2) Empty cylinders should not be refilled in the labs unless equipped to prevent overfilling.

3) Employees should return empty cylinders to the manufacturer/supplier.

H. Disposal

1) Only cylinders guaranteed to be returnable by the manufacturer or supplier may be purchased by University investigators. (Purchased after month/date/year Cylinder Disposal Policy is approved.)

2) Principal investigators whose research requires the purchase of compressed gas cylinders that cannot be returned to the supplier or manufacturer must submit a letter of financial assurance agreeing to pay a $1,000.00 hazardous waste disposal fee for the of the non-returnable cylinder.

5.3. Special Precautions for Hydrogen

A. Hydrogen gas has the following **unique properties** which make it potentially hazardous to work with. Caution should therefore be exercised when approaching a hydrogen flame.

1) Hydrogen has an extremely **wide flammability range** (LEL 4%, UEL 74.5%), making it easier to ignite than most other flammable gases.

2) Hydrogen's temperature increases as it is liberated from its cylinder

3) Hydrogen burns with an invisible flame.

4) A piece of paper can be used to tell if the hydrogen is burning.

5) Indoor use of 400 standard cubic feet or more of hydrogen gas may only be conducted in labs designed to meet or exceed NFPA and OSHA standards for hydrogen gas. A written letter of approval from the Office of EH&S must confirm compliance with these standards.

5.4. Special Precautions for Oxygen

A. Oil or grease on the high pressure side of an oxygen cylinder can cause an **explosion**; thus oxygen regulators should not be lubricated.

B. **Fuel/gas regulators should never be used on oxygen cylinders.**

5.5. Storage of Compressed Gases

A. All gas cylinders should be **capped and secured** when stored.

B. Suitable racks, straps, chains or stands must be used to support cylinders.

C. All cylinders, full or empty, must be restrained and kept away from heat sources.

D. The number of cylinders stored in the laboratory should be kept to minimum.

E. Gas cylinders must be separated from incompatible cylinders by a minimum of 20 feet or separated by a fire resistant partition (e.g. never store oxygen, or other oxidizing reagent, cylinders next to flammable gas cylinders).

F. All gas cylinders should be clearly marked with appropriate tags indicating whether they are in use, full, or empty.

G. Empty and full cylinders should be separated by a minimum of 20 feet or separated by a fire resistant partition**.**

5.6. Highly Toxic Gases

A. The pressurized gases identified in **Table 5.9** below are particularly hazardous. Part I. Section **7** of this CHP describes what is **required** of OU employees who work with these gases.

Table 3.5 - Highly Toxic Gases

Highly Toxic Gases	
Arsine and gaseous derivatives	Hydrogen cyanide
Chloropicrin in gas mixtures	Hydrogen selenide
Cyanogen chloride	Nitric oxide
Cyanogen	Nitrogen dioxide
Diborane	Nitrogen Tetroxide
Germane	Phosgene
Hexaethyltetraphosphate	Phosphine

6. CORROSIVE CHEMICALS

6.1. General Information

A. **Major classes** of corrosive chemicals.

1) **Strong acids** (e.g., hydrogen fluoride, hydrochloric acid)

2) **Strong bases** (e.g., potassium hydroxide, ammonia)

3) **Dehydrating agents** (e.g., sulfuric acid, sodium hydroxide, phosphorus pentoxide)

4) **Oxidizing agents** (e.g., acid dichromate, chromic acid, chromium trioxide, hydrogen peroxide>30%, nitric acid, sodium peroxide, sulfuric acid)

5) **Corrosive** chemicals can erode the **skin** or **respiratory tract**, and are particularly damaging to **eyes**.

6) Inhalation of vapors or mists of these substances can cause severe bronchial irritation.

7) If **skin** is exposed to a corrosive, it should be flushed with water for at least fifteen minutes and medical treatment sought immediately.

6.2. Classes of Corrosives

A. Strong acids

1) Many concentrated liquid acids can damage the skin and eyes and their **burns are very painful.**
2) **Nitric, chromic, and hydrofluoric acids** are especially dangerous because of the type of burns they inflict. Medical assistance should be obtained immediately following chemical burns from these acids.

B. Strong alkalis

1) **Common** strong bases include potassium hydroxide, sodium hydroxide and ammonia.

2) Burns from alkalis are often less painful than acids, however damage may be more severe than acid burns because the injured person, feeling little pain, may not take immediate action and thus the material is allowed to penetrate into the tissue.

3) While high concentrations of acids and bases will both cause damage to the eye, low concentrations of alkalis **often injure the eye more severely** (because basic chemicals do not form the precipitates that acids do, and will thus penetrate more deeply into the eye).

C. Dehydrating agents

1) This group of chemicals **includes** concentrated sulfuric acid, sodium hydroxide, phosphorus pentoxide, and calcium oxide.

2) Because so much heat is generated when these substances are mixed with water, mixing should always be done by **adding the agent to water**, and not the reverse, to avoid violent reaction and spattering.

3) Because of their affinity for water, these substances **cause severe burns** on contact with skin/eyes**.** Affected areas should be washed promptly with large volumes of water for at least 15 minutes.

D. Oxidizing Corrosive Agents

1) In addition to their **corrosive** properties, powerful oxidizing agents (e.g., perchloric and chromic acids), present **fire and explosion hazards** on contact with oxidizable substances.

2) See **Part III. Sections 3 & 4** of this CHP for more information on reactives and high energy oxidizers.

6.3. Handling Corrosives

A. Corrosive chemicals should be handled **over plastic trays** when working with bulk quantities (> 1 liter) or dispensing.

B. **Gloves, face shields, lab coats, and rubber aprons** are needed when working with bulk quantities of these chemicals.

C. An **eyewash** and an **emergency shower** must be immediately accessible, particularly when dispensing or working with bulk quantities of corrosive chemicals.

D. **Spill materials** (e.g. absorbent pillows, neutral absorbent materials, or neutralizing materials) should be available in the laboratory whenever working with corrosive chemicals.

E. If it is necessary to move bulk quantities of corrosive materials from one laboratory to another, a **safety carrier** (e.g., a rubber bucket for secondary containment) should be used.

6.4. Storage of Corrosives

A. Corrosives should be stored in **cabinets or on low shelving**, preferably on impervious trays.

B. Large volumes of strong acids and bases, and/or those stored in glass containers, should be **stored separately** from each other, and from all other hazard groups (e.g., oxidizers, perchloric acid, flammable liquids, and reactive/explosive liquids), see **Table 2.5 (Part II. of this CHP)**.

6.5. Examples of Corrosive Chemicals

❖ A list of corrosive laboratory agents (and their physical states) is presented in **Table 3.6** below.

Table 3.6. - List of Corrosive Chemicals

Chemical Name	Physical State	Type of Corrosive Hazard

acetic acid (>1M)	L	corrosive
acid dichromate	L	corrosive/oxidizer
ammonia (anhydrous)	L	strong base
ammonium hydroxide (>1M)	L	corrosive
benzylamine	L	corrosive
chromic acid	L	strong acid/oxidizer
1,1-dimethylhydrazine	L	corrosive
formic acid	L	corrosive
hydrochloric acid (>1M)	L	strong acid
hydrogen fluoride	L	strong acid
hydroiodic acid (>1M)	L	corrosive
lithium hydroxide	S	corrosive
nitric acid (>1M)	L	strong acid/oxidizer
paraformaldehyde	S	corrosive
perchloric acid (>1M)	L	corrosive/oxidizer
phosphoric acid (>1M)	L	corrosive
phosphorus pentoxide	S	corrosive, dehydrating
potassium hydroxide	S	strong base
sodium hydroxide	S	strong base, dehydrating
sodium methoxide	L	corrosive
sodium-potassium alloys	S	corrosive
sulfuric acid (>1M)	L	strong acid, dehydrating +oxidizer
TEMED	L	corrosive
thioglycolic acid	L	corrosive
trichloroacetic acid	S	corrosive

zinc chloride	S	corrosive

7. TOXIC CHEMICALS

7.1. General Information - Acute Toxicity

Chemicals that possess the characteristic of **acute toxicity** can cause illness after a single or short-term exposure.

A. Short-Term Effects

- Headache
- Dizziness
- Nausea
- Shortness of Breath
- Vomiting
- Eye, Pulmonary or Skin Irritation

B. The Oral-LD_{50} toxicity test

1) The **Oral-LD_{50}** identifies the **ingested** dose (in milligrams per kilogram body weight of the test animals) at which 50% of the test animals died

2) Oral-**LD_{50}** is usually the first toxicological test performed, and is a good indicator of a substance's ***"relative"*** toxicity.

3) Oral LD_{50} data (for rats or mice) is generally listed in the substance's SDS.

4) It should be kept in mind however, that an ***oral*** indicator is not a perfect means of determining toxicity for laboratory chemicals, as ingestion is not the typical route of exposure presented in laboratories (unless it is incidental/accidental). LC_{50} and Skin-LD_{50} are much more accurate indicators of laboratory chemical toxicity (*when* this toxicological data are available).

C. Irritants

1) Pulmonary Irritants

- Pulmonary irritants cause inflammation of mucous membranes
- Can result in cough, tightness in chest, shortness of breath

- Corrosive chemicals are often irritating at concentrations far below those required to cause chemical burns (or ulcerations) to the respiratory tract.

- Irritants can also cause changes in lung functioning. Long term exposure to irritants can also result in increased mucous secretions and chronic bronchitis.
- "**Primary"** versus **"Secondary"** Irritants
  - **Secondary** pulmonary irritants exert *systemic* toxic reactions if inhaled.
  - **Primary** pulmonary irritants do *not* exert systemic toxic reactions, either because the products formed on the respiratory tract tissue are non-toxic to other organs, OR because the irritant action on exposed mucous membranes far outweigh any systemic reactions.

❖ Examples of pulmonary irritants can be found in **Table 3.7(A)** below.

2) Skin Irritants

- Skin irritants cause inflammation (redness, swelling, rash, itching, burning) of skin with which they come into contact.

- Corrosive chemicals are often irritating to the skin at concentrations far below those required to cause burns.

- Examples of skin irritants are included in Table 3.7(A) below.

3) Examples of Acutely Toxic Chemicals

❖ A list of common laboratory chemicals which exhibit acute toxicity (including eye, skin or pulmonary irritation), and the corresponding routes of exposure are listed in **Table 3.7 (A)**:

Table 3.7. (A) Chemicals of Acute Toxicity

Chemical Name	Toxicity	Route of Exposure
acrylamide	toxic	inhalation, contact
allyl alcohol	toxic	inhalation, contact
ammonium chloride	irritant, eye/skin/pulmonary	inhalation, contact
ammonium molybate	toxic	inhalation, contact
antimony (compounds)	toxic	inhalation, contact
benzoyl peroxide	irritant, eye/skin	inhalation, contact
bromine	highly toxic	inhalation, contact
1-butanol (n-butanol)	toxic	inhalation, contact
cadmium compounds	toxic, irritant, pulmonary	inhalation
calcium hydroxide	irritant, eye/skin	inhalation, contact
carbolic acid (phenol)	toxic	inhalation, contact
chlorine	irritant, eye	inhalation, contact
chromic compounds	irritant, eye/skin	inhalation, contact
cobalt compounds	irritant, eye/skin	inhalation, contact
cupric sulfate	irritant, eye/skin/pulmonary	inhalation, contact
DMSO (dimethylsulfoxide)	toxic	inhalation, contact
dimethyl sulfate	toxic	inhalation, contact
dimethylacetamide	toxic	inhalation, contact

1,1-dimethylhydrazine	toxic	inhalation, contact
dioxane	toxic	inhalation, contact
diphenylamine	toxic	inhalation, contact
ethylenediamine	toxic irritant, eye/skin/pulmonary	inhalation, contact
ethyl acrylate	toxic irritant, eye/skin/pulmonary	inhalation, contact
formaldehyde (formalin)	irritant, eye/skin	inhalation, contact
formic acid	toxic irritant, eye/skin/pulmonary	inhalation, contact
freon 113	toxic, irritant, skin	inhalation, contact
n-hexane	toxic, irritant, eye/skin	inhalation, contact
hydrazine	toxic, irritant, eye/skin/pulmonary	inhalation, contact
isobutyl alcohol	irritant, eye/skin	inhalation, contact
magnesium chloride	irritant, eye/skin	inhalation
β-Mercaptoethanol	toxic, irritant, eye/skin	inhalation, contact
mercury, alkyl compounds	toxic	inhalation, contact
nickel compounds	irritant, eye/skin	inhalation, contact
nitric oxide	toxic	inhalation
p-nitroaniline	toxic	inhalation, contact
osmium tetroxide	highly toxic	inhalation, contact
ouabain	toxic	inhalation
paraformaldehyde	irritant, eye/skin/pulmonary	inhalation, contact
pentachlorophenol	toxic	inhalation, contact
polychlorinated biphenyls (PCBs)	irritant, eye/skin	inhalation, contact
potassium cyanide	highly toxic	inhalation, contact
propylene oxide	toxic	inhalation, contact
selenious acid	highly toxic	inhalation, contact

sodium azide	highly toxic	inhalation, contact
sodium cyanide	highly toxic	inhalation, contact
sodium nitrate	irritant, eye/skin	inhalation, contact
strychnine	highly toxic	inhalation, contact
sulfur dioxide	highly toxic	inhalation
sulfuric acid (>1M)	irritant, eye/skin/pulmonary	inhalation, contact
tetrachloroethylene	toxic	inhalation, contact
o-toluidine	toxic	inhalation, contact
trichloroacetic acid	Toxic, irritant, eye/skin	inhalation, contact
uranium compounds	toxic	inhalation
zinc chloride	toxic	inhalation, contact
zinc sulfate	irritant, eye/skin/pulmonary	inhalation, contact

7.2. General Description – High Acute Toxicity

Chemicals which present ***high*** acute toxicity can produce **serious illness** following short-term exposure to **very low concentrations**.

A. A chemical is considered to be "highly toxic" if it...

1) has an **oral LD_{50}** of less then 50 milligrams per kg body weight (for solid materials or non-volatile liquids) OR

2) has an LC50 less than 2,000 ppm (for volatile liquids or gases) OR

3) has the **skin-LD_{50}** is less than 43 mg/kg OR

4) Chemical Examples of High Acute Toxicity

❖ A list of common laboratory chemicals which exhibit ***high*** acute toxicity, and the corresponding routes of exposure, are listed in **Table 3.8. (HA)**.

Table 3.8 (HA) - Chemicals of High Acute Toxicity

Chemicals Which Pose High Toxicity Following Acute (Short-Term) Exposure	
Chemical Name	**Routes of Exposure**
bromine	contact, ingestion, inhalation
hydrazine	contact, ingestion, inhalation
osmium tetroxide	contact, ingestion, inhalation
potassium cyanide	contact, ingestion, inhalation
selenious acid	inhalation, ingestion
sodium azide	contact, ingestion, inhalation
sodium cyanide	contact, ingestion, inhalation
strychnine	contact, ingestion, inhalation
sulfur dioxide	inhalation

7.3. General Description – Chronic Toxicity

Substances that possess the characteristic of chronic toxicity cause damage/illness after **repeated exposure or exposure over long periods** of time. Health effects often do not become evident until after a long latency period (twenty to thirty years).

Specific chronic toxicity information on the substances used in the laboratory can be found on these substances' SDS. See Part I. Section 5.2 for information on how to obtain/locate SDS. Additional questions can be directed to the OU Chemical Hygiene Officer.

However, most data regarding carcinogenicity is expressed in imprecise terms, such as "suspected carcinogen with experimental neoplastigenic and tumorigenic data", or "questionable carcinogen with experimental carcinogenic data", and it is even harder to pin down the routes of exposure that are linked with these experimental conclusions.

NOTE: Chemical questions can be directed to the OU Chemical Hygiene Officer.

❖ A substance considered to present **chronic toxicity**....

1) can **damage one or more target organs** or organ systems;

- hepatotoxins (liver)
- nephrotoxins (kidney)
- neurotoxins (CNS)
- agents toxic to the hematopoietic system (blood)
- agents toxic to the pulmonary tissue (lungs)

2) is a carcinogen or suspected carcinogen;

3) is a reproductive toxin (mutagen or teratogen)

4) is a skin or pulmonary sensitizer

A. Reproductive Toxins

1) Information regarding reproductive toxicity can be found on SDS. See **Part I. Section 5.2** for information on how to obtain/locate SDS.

2) However, most data regarding reproductive toxicity is expressed in imprecise terms, such as "experimental reproductive effects" or "mutation data reported" or "experimental teratogen", and it is often even more difficult to pin down the routes of exposure that are linked with these experimental conclusions. Questions can be directed to the OU Chemical Hygiene Officer.

3) There are two types of toxins which can be toxic to future generations:

- **Mutagens** can cause a change (or "mutate") to the genetic material (DNA) of living cells (in exposed men *or* women).

- **Teratogens** can cause physical defects in a developing embryo/fetus of an exposed (pregnant) female.

B. Sensitizers

1) Sensitizers are chemicals which, following repeated and unremarkable exposures to those chemicals, cause immediate and dramatic allergic skin and/or pulmonary reactions.

- **Reactions** range from allergic dermatitis to anaphylactic shock.

❖ A list of common laboratory chemicals which are known sensitizers are provided in **Table 3.11(S)** below.

C. Examples of Chemicals which Exhibit High Chronic Toxicity

1) A list of common laboratory chemicals which exhibit **high chronic toxicity** to organ systems and/or suspected **carcinogenicity** is provided as **Table 3.9 C) below.** ***Note****: Those listed present their toxicity via inhalation or skin contact, since other routes of exposure are less apt to be presented on a* <u>*chronic*</u> *basis in academic/research laboratories.*

2) A list of common laboratory chemicals which exhibit reproductive toxicity is provided as Table 3.10 (R) below. Note: Those listed present their toxicity via inhalation or skin contact, since other routes of exposure are less apt to be presented on a chronic basis in academic/research laboratories.

3) A list of common laboratory chemicals which are known sensitizers is provided as Table 3.11(S) below.

Table 3.9 (C) - Chemicals of High Chronic Toxicity

Suspect Carcinogens and Chemicals Which Pose High Toxicity Following Chronic (Long-Term or Repeated) Exposure via Inhalation OR Skin-Contact

* = chemical is explicitly regulated by OSHA (See Section 1.6 for more information on exposure monitoring and medical surveillance requirements)

Chemicals	Type of Chronic Hazard	Route of Exposure
acetaldehyde	carcinogenic	inhalation
acrylamide	carcinogenic	contact
acrylonitrile*	carcinogenic	contact, inhalation
arsenic compounds*	carcinogenic	inhalation
asbestos	carcinogenic	inhalation
benzene*	carcinogenic	contact, inhalation
benzidine*	carcinogenic	inhalation
cadmium compounds	carcinogenic	inhalation
carbolic acid (phenol)	toxic	contact
carbon tetrachloride	carcinogenic	inhalation
chloroform	carcinogenic	inhalation
chromic compounds, hexavalent (chromates and dichromates)	carcinogenic toxic	inhalation
cobalt compounds	carcinogenic toxic	inhalation
cresol (all isomers)	toxic	contact
DMSO (dimethylsulfoxide)	carcinogenic	contact
1,2-dibromoethane (EDB)	carcinogenic	inhalation
dichloromethane	carcinogenic	inhalation

1,1-dimethylethylamine	toxic	inhalation
dimethyl sulfate	carcinogenic	inhalation
1,1-dimethylhydrazine	carcinogenic	contact, inhalation
1,2-dimethylhydrazine	carcinogenic	inhalation
dioxane	carcinogenic toxic	contact, inhalation
ethyl acrylate	carcinogenic	contact
ethyl methansulfonate (or methansulphonate)	carcinogenic toxic	contact, inhalation
formaldehyde (formalin)*	carcinogenic	inhalation
halothane	toxic	inhalation
hexamethyl phosphoramide	carcinogenic	contact
n-hexane	toxic (polyneuropathy)	contact, inhalation
hydrazine	carcinogenic	inhalation
lead and lead cmpnds, inorganic*	carcinogenic	inhalation
mercury and mercuric compounds	toxic	inhalation
methyl iodide	carcinogenic	inhalation
methylene chloride	carcinogenic toxic	inhalation
1-naphthylamine*	toxic	contact, inhalation
nickel compounds	carcinogenic toxic	inhalation
2-nitropropane	carcinogenic	inhalation
polychlorinated biphenyls (PCBs)	carcinogenic	contact
propylene oxide	carcinogenic	contact, inhalation

tetrachloroethylene	carcinogenic	inhalation
o-toluidine	carcinogenic	contact
1,1,2-trichloroethane	toxic	contact, inhalation
uranium compounds	toxic	inhalation

Table 3.10. (R) - List of Reproductive Toxins

Chemicals Which Pose Toxicity to Fetus (Mutagens) or to DNA (Teratogens) Following Inhalation or Skin-Contact	
Chemical Name	**Route of Exposure**
cadmium compounds	Inhalation
carbon disulfide	Inhalation
chloroform	Inhalation
DMSO (dimethylsulfoxide)	skin contact
halothane	inhalation
zinc chloride	inhalation

Table 3.11. (S) - List of Sensitizers

Chemical Name	Sensitizers	
	Pulmonary	**Skin**
benzoyl peroxide	X	
chromic compounds	X	
cobalt compounds	X	
ethylenediamine	X	
formaldehyde (formalin)		X
Isocyanates	X	X
nickel compounds	X	
paraformaldehyde	X	X

7.4. Handling Chemicals Which Present High Acute or Chronic Toxicity

A. General Work Practices

1) Skin surfaces - hands, forearms, face and neck - should be **washed** immediately following completion of the procedure(s).

2) **Work surfaces should be decontaminated after completing work with these chemicals.**

3) **Laboratory personnel should solicit an exposure assessment for OU's Chemical Hygiene Officer IF one or more of these chemicals is used...**

- in **large quantities** (i.e.,ε 1 liter)**; AND/OR**
- on a **regular basis** (i.e., ε 3 separate handling sessions per week); **AND/OR**
- for **long periods of time** (i.e., 4-6 hours at a time)

4) **Chemical wastes** from procedures using these substances should be placed in containers and disposed of as hazardous waste (through your department's Hazardous Waste Coordinator and/or the Office of EH&S) if they cannot be safely converted to nontoxic materials ***as part of*** the experimental procedure.

B. Engineering Controls

1) These chemicals should be used in a **chemical fume hood** or other appropriate containment device if the material is volatile or the procedure may generate aerosols.

2) These chemicals should be transported between laboratories in durable outer containers.

3) Vacuum pumps used in procedures with these chemicals should be protected from contamination with scrubbers or filters.

4) When working with these chemicals using laboratory equipment (e.g., analytical instruments) which generate vapors or aerosols during their operation, this equipment should be locally exhausted or vented in a chemical fume hood.

C. Personal Protective Equipment

1) **Contact with these chemicals by any route of exposure should be avoided or minimized.** The hands and forearms should be protected by wearing gloves and laboratory coat. Hands should be washed after every use, even though gloves were worn.

2) **Full body protection (disposable coveralls) should be considered if the**

potential for extensive personal contamination exists.

3) **All protective** equipment should be removed when leaving the designated area and **decontaminated** (washed) or, if disposable, placed in a plastic bag and secured.

D. **Designated Work Areas**

1) All chemicals exhibiting high acute or high chronic toxicity should be used in **designated (posted) areas.** See **Part I. Section 7** for more information regarding this OSHA requirement.

2) Additionally, all chemicals which exhibit **high chronic toxicity** shall be **labeled** with shipping tape which designates them as presenting high chronic toxicity (tape is available in the Office of EH&S). These labeled chemicals are then used only in the designated work areas. See **Part I Section 7** for more information regarding this OSHA requirement.

7.5. Storage of Chemicals Which Present High Acute or Chronic Toxicity

A. **Volatile chemicals** of high acute or chronic toxicity should be stored in unbreakable primary or secondary containers, or placed in chemically resistant trays (to contain spills).

B. Nonvolatile chemicals of high acute or chronic toxicity should be stored in cabinets (versus open shelves or counters).

C. All chemicals exhibiting high acute or chronic toxicity should be stored in **designated (posted) areas. Part I. Section 7** for more information regarding this OSHA requirement.

7.6. Engineered Nanoparticles / Nanomaterials

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A. <u>Introduction</u>

1) Nanoparticles are particles that have at least one dimension in the 1 to 100 nanometer scale.

2) Materials containing these nanoparticles or "nanomaterials," have been found to have chemical or biological properties not present in the macro scale. The National Institute of Safety and Health recognizes the challenges involved in protecting workers against the effects of exposures to nanomaterials especially when the effects of nanomaterials exposure are not well understood. Work

involving the use of engineered nanomaterials (excluding biomolecules such as proteins, carbohydrates, lipids and nucleic acids or polymeric materials) must be reported to the Chemical Hygiene Officer.

B. Liquid Solutions of nanomaterials

Where there is no potential for aerosol production or potential to be evaporated to a powder form shall be managed according to standard chemical hygiene practices outlined in this Chemical Hygiene Plan.

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C. Engineered nanoparticle

Operations may be considered "High Hazard Work." The Chemical Hygiene Officer must be contacted to provide a "hazard assessment," and a SOP may be required. Researchers conducting work with engineered nanoparticles must follow guidelines provided in **Environmental Health & Safety Fact Sheet: 1, "**Nanotechnology: Guidelines for Safe Research."

PART IV. CHEMICAL TOXICOLOGY

1. CHEMICAL TOXICOLOGY OVERVIEW

1.1. Toxicology Definitions

A. **Dose** is a combination of chemical concentration, rate and duration of exposure.

B. **Exposure** occurs when a chemical enters a biological system**.**

C. **Route of exposure** is the route by which a chemical can enter a biological system**.** There are **three** main routes by which hazardous chemicals enter the body:

1) Absorption through the **respiratory tract** via inhalation.

2) Absorption through the skin via dermal contact.

3) Absorption through the digestive tract via ingestion (i.e., through eating or smoking with contaminated hands or in contaminated work areas.)

D. **Toxicity** is the ability of a chemical substance or compound to produce illness or injury once it enters a biological system.

1.2. Dose-Response Relationship

A. **Toxicity** of a substance is exhibited only when:

1) a living biological system is **exposed** to that substance (via one or more of the **exposure routes**); ***and***

2) the biological system is exposed to a **dose** which is high enough to cause illness/injury to that system.

B. **Dose-Response Premise**

1) Dose, then, is a primary factor in determining the toxic **response**, whereby the potential toxic effect increases as the dose increases. This is the so called **"dose-response relationship."**

2) Dose-response relationships are specific to chemicals as well as biological systems.

3) All chemicals **will exhibit a toxic effect given a large enough dose.**

1.3. Occupational Exposure Standards

A. Organizations:

There are two organizations that are primarily responsible for setting safe exposure concentration limits for chemicals:

1) The **ACGIH** (American Conference of Governmental Industrial Hygienists) is an organization devoted to the administrative and technical aspects of occupational and environmental health, the ACGIH is a **professional society** that develops **TLVs** (Threshold Limit Values), and is NOT a governmental agency.

    - ACGIH TLVs are developed as ***guidelines*** or ***recommendations*** for use in the practice of industrial hygiene, and **not for use as legal standards**.

    - TLVs are meant to represent the average concentration of a chemical that most people can be exposed to for a **working lifetime** with no ill effects.

2) **OSHA** (Occupational Safety and Health Administration) develops and publishes the **legal** and binding **8-hour** (time-weighted average) **PELs** (permissible exposure limits) for industrial and laboratory workers.

B. Exposure Standard Guidelines

Most TLVs and PELs are **based on the inhalation route of exposure**, and are normally expressed in terms of either parts per million **(ppm)** or milligrams per cubic meter **(mg/m^3)** concentration in air.

Ceiling concentrations (C), which should not be exceeded for ***any*** period of time, will often be noted with the TLV.

Unless specified, the PEL is a Time Weighted (**8-hour**) Average **(TWA)**.

1) **"Skin Notations"**

- While most chemicals exhibit their toxicity if/when they are inhaled or ingested, **some chemicals can cause injury or illness if they are absorbed through the skin.**

- If a chemical exhibits toxicity when absorbed through the skin, the chemical name or the PEL/TLV will generally have appended to it the word **"SKIN"** or some other skin notation.

1.4. Types of Toxic Effects

A. Acute Effects

1) Toxic effects (symptoms) are experienced after a **short, single exposure**

B. Chronic Effects

1) Toxic effects (symptoms) are experienced after **prolonged or repeated exposures** of a duration measured in days, months or years.

2) Symptoms are not apparent during, or immediately following, exposure.

C. Cumulative Effects

1) Toxic effects which occur as a result of chemical "build up" in the body as a result of numerous chronic exposures.

2) Effects are not seen until a **"critical body burden"** is reached.

D. Local Effects

Adverse health effects that take place at the point or **area of contact.**

- Site may be skin, mucous membranes, the respiratory tract, gastrointestinal system, eyes, etc.

- Absorption does not necessarily occur.

E. Systemic Effects

Adverse health effects that take place at a location distant from the body's initial point of contact.

F. Synergistic or Potentiating Effects

Negative effects of exposure to **two or more hazardous materials**, which is *greater* than predicted based on the known effects of each individual substance.

1.5. Factors Affecting Toxicity

A. Nature of the Chemical

B. Route of exposure, i.e., inhalation, skin contact and/or ingestion

C. Duration of exposure, i.e., length of the TOTAL exposure (either at one time or over a series of repeated exposures)

D. Rate of entry, or how fast the chemical dose is delivered

E. Concentration of the chemical

F. Host factors, including genetic predisposition, gender and age of the exposed individual

G. Previous exposure to the substance (can lead to tolerance, increased sensitivity or make no difference)

H. State of health, physical condition and life style of the exposed individual. For example, pre-existing disease or a compromised immunodeficiency system can result in increased sensitivity.

1.6. Toxicity by Physical Classification

A. Aerosol Toxicity

1) Aerosols are composed of solid or liquid microscopic particles dispersed in gaseous medium.

2) The toxic potential of an aerosol is only partially described by its airborne concentration.

3) Assessment of toxic potential is also based on the size of the aerosol's particles, as that will determine whether the particle is deposited within the respiratory system, and the location of deposition:

- Particles over 10 micrometers (μ=microns) in size tend to deposit in the nose and other areas of the upper respiratory tract, without entering the lungs.
- Particles under 10 μ can enter the lungs;
- Particles between .5 and 2.5 μ can be deposited and retained in the lung alveoli, and are termed "respirable particles."
- Very small particles (<0.2 μ) enter the alveoli easily, but are generally exhaled without deposition.

B. Gas or Vapor Toxicity

1) Solubility is a key factor affecting the toxicity of gases and vapors

- Highly soluble materials, like ammonia, irritate the upper respiratory tract.

- Relatively insoluble materials, like nitrogen dioxide, penetrate deep into the lung.

1.7. Physiological Classifications

A. Asphyxiants

B. Simple asphyxiants are...

1) Inert gases that displace oxygen

2) Examples include:

- Nitrogen
- Helium
- Nitrous oxide
- Carbon dioxide
- Hydrogen

C. Chemical asphyxiants...

1) Reduce the body's ability to absorb, transport, or utilize inhaled oxygen

2) They are often active at very low concentrations (a few ppm)

3) Examples include:

- carbon monoxide
- cyanides

1.8. Carcinogens

Agents that can initiate (or increase the proliferation of) malignant neoplastic cells or tumors.

- A list of common laboratory chemicals which exhibit **carcinogenicity** is provided in **Table 3.9(C),** Section 3.0 of this CHP**.** ***Note**: Those listed present their toxicity via inhalation or skin contact, since other routes of exposure are less apt to be presented on a chronic basis in academic/research laboratories.*

1.9. Irritants

A. Pulmonary Irritants

1) Materials that cause inflammation of mucous membranes with which they come in contact.

2) Can result in cough, tightness in chest, shortness of breath

3) Inflammation of tissue results from exposure to concentrations far below those needed to cause corrosion.

4) Irritants can also cause changes in the lung function.

5) Long term exposure to irritants can result in increased mucous secretions and chronic bronchitis.

B. Primary Pulmonary Irritants

1) Primary irritants do **NOT** exert *systemic* toxic reactions, either because the products formed on the tissue of the respiratory tract are non-toxic, or because the irritant action on exposed mucous membranes greatly outweighs any systemic toxic reactions.

C. Secondary Pulmonary irritants

1) Secondary irritants **DO** exert systemic toxic reactions if absorbed by the respiratory tract/lungs.

2) Examples of pulmonary irritants can be found in **Table 3.7(A),** Section 3.0 of this CHP.

D. Skin Irritants

1) Skin irritants cause inflammation (redness, swelling, rash, itching, burning) of skin with which they come into contact.

2) Corrosive chemicals are often irritating to the skin at concentrations far below those required to cause burns.

3) Examples of skin irritants can be found in **Table 3.7(A)**, Section 3.0 of this CHP.

1.10. Mutagens

A. Interfere with the proper replication of genetic material in exposed cells.

B. If germ cells are involved, the effect may be inherited and become part of the genetic pool passed onto future generations.

C. Examples of mutagens can be found in **Table 3.6(R)**, Section 3.0 of this CHP.

1.11. Pneumoconiotic Agents

"Dusts" or “fibers” which enter, remain in, and damage the **lungs** by producing fibrotic changes and/or restrictive lung diseases. Most common example is asbestos.

1.12. Primary Anesthetics =Neurotoxins (see Section 1.15 below)

1.13. Sensitizers

A. Chemicals which, following repeated and unremarkable exposures to that chemical, cause immediate and dramatic allergic reactions.

B. Reactions may be as mild as a rash (allergic dermatitis) or as serious as anaphylactic shock.

C. A list of common laboratory chemicals which are known Sensitizers is provided as **Table 3.11(S)**, Section 3.0 of this CHP.

1.14. Teratogens = embryotoxic or fetotoxic agents

1.15. Target-Organ Agents (chemical examples are in Table 4.1)

A. Embryotoxic or fetotoxic agents interfere with normal embryonic development without causing a lethal effect to the fetus or damage to the mother. Effects are not inherited.
B. Hematopoietic Agents act on the blood or hematopoietic system, including bone marrow
C. Hepatotoxic agents cause damage to the liver
D. Nephrotoxic agents damage the kidneys
E. Neurotoxic agents depress or otherwise damage the brain and or central nervous system

1. EXAMPLES OF TARGET ORGAN EFFECTS

- **Table 4.1** below is a Table of target organ effects which may occur from chemical exposure. Signs/symptoms of these effects, and examples of chemicals which are known to cause these effects, are listed.

Table 4.1 - Target Organ Effects from Chemical Exposures

Toxins	**Target Organ Effects**	**Signs & Symptoms**	**Chemical Examples**
Embryo- or Fetotoxins	Affects Unborn fetus	Interferes with normal development of fetus	• Cadmium • Carbon disulfide • Chloroform • Dimethyl sulfoxide DMSO • Halothane • Zinc chloride
Hematopoietic toxins	Decrease blood function	• Cyanosis • Loss of consciousness	• Arsenic • Benzene • Carbon monoxide • Cyanides • Nitro-benzene • Toluene
Hepatoxin	Liver damage	• Jaundice • Liver enlargement	• Chloroform • Cresol • Dimethylsylfate • Nitrosamine • Perchloro-ethylene • Toluene
Nephrotoxins	kidney damage	• Edema • Proteinuria	• Chloroform • Dimethylsylfate

			● Halogenated hydrocarbons ● Mercury ● Uranium
Neurotoxins	Affect CNS	● Behavior changes ● Decreased coordination ● Narcosis	● Benzene ● Carbon disulfide ● Carbon tetrachloride ● Lead ● Mercury ● Nitrobenzene

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PART 431. HAZARDOUS WORK IN LABORATORIES
PAGE 15 - Nanoparticles and Nanomaterials

Nanoparticles and nanomaterials have different reactivities and interactions with biological systems than bulk materials, and understanding and exploiting these differences is an active area of research. However, these differences also mean that the risks and hazards associated with exposure to engineered nanomaterials are not well known. Because this is an area of ongoing research, consult trusted sources for the most up to date information available.

Note that the higher reactivity of many nanoscale materials suggests that they should be treated as potential sources of ignition, accelerants, and fuel that could result in fire or explosion. Easily dispersed dry nanomaterials may pose the greatest health hazard because of the risk of inhalation.

Consideration should be given to all possible routes of exposure to nanomaterials including inhalation, ingestion, injection, and dermal contact (including eye and mucous membranes).

- **Avoid handling nanomaterials in the open air in a freeparticle state.**
- **Whenever possible, handle and store dispersible nanomaterials, whether suspended in liquids or in a dry particle form, in closed (tightly-sealed) containers.**
- **Unless cutting or grinding occurs, nanomaterials that are not in a free form (encapsulated in a solid or a nanocomposite) typically will not require engineering controls.**
- **If a synthesis is being performed to create nanomaterials, it is not enough to only consider the final material in the risk assessment, but consider the hazardous properties of the precursor materials as well.**
- **To minimize laboratory personnel exposure, conduct any work that could generate engineered nanoparticles in an enclosure that operates at a negative pressure differential compared to the laboratory personnel breathing zone.**
- **Limited data exist regarding the efficacy of PPE and ventilation systems against exposure to nanoparticles.**
- **However, until further information is available, it is prudent to follow standard**

chemical hygiene practices.

- **Conduct a hazard evaluation to determine PPE appropriate for the level of hazard according to the requirements set forth in OSHA's Personal Protective Equipment standard (29 CFR 1910.132).**

PART V. GLOSSARY OF TERMS USED IN SDS

ACGIH - See the AMERICAN CONFERENCE OF GOVERNMENTAL INDUSTRIAL HYGIENISTS

ACTION LEVEL -- A concentration designated in 29 CFR part 1910 for a specific substance, calculated as an eight hour time-weighted average, which initiates certain required activities such as exposure monitoring and medical surveillance.

ACUTE EFFECTS - Severe, often dangerous exposure conditions in which relatively rapid changes occur. Short-term effects (generally reversible)

ACUTE EXPOSURE - Single exposure that takes place over a short period of time.

ADMINISTRATIVE CONTROLS - Policies and procedures established at an administrative level (Example: principal investigator, Department Chair, or Environmental Health and Safety) to ensure safety in the laboratory. Administrative controls include training programs, approval processes, authorizing access to laboratory, posting, etc.

AMERICAN CONFERENCE OF GOVERNMENTAL INDUSTRIAL HYGIENISTS - A voluntary membership organization of professional industrial hygiene personnel in governmental or educational institution. The ACGIH develops and publishes recommended occupational exposure limits each year called Threshold Limit Values (TLV's) for hundreds of chemicals, physical agents, and biological exposure indices.

AMERICAN NATIONAL STANDARDS INSTITUTE - A voluntary membership organization (run with private funding) that develops consensus standards nationally for a wide variety of devices and procedures

ANSI - See the AMERICAN NATIONAL STANDARDS INSTITUTE.

ASPHYXIANT - A chemical (gas or vapor) that can cause death or unconsciousness by suffocation. Simple asphyxiates, such as nitrogen, either remove or displace oxygen in the air. They become especially dangerous in confined or enclosed spaces. Chemical asphyxiants such as carbon monoxide and hydrogen sulfide, interfere with the body's ability to absorb or transport oxygen to the tissues.

AUTOCLAVE -- A device to expose items to steam at a high pressure in order to decontaminate the materials or render them sterile.

BIOHAZARD -- Infectious agents that present a risk or potential risk to the health of humans or other animals, either directly through infection or indirectly through damage to the environment.

BOILING POINT - The temperature at which the vapor pressure of a liquid equals atmospheric pressure or at which the liquid changes to a vapor. If a flammable material has a low boiling point, it indicates a special fire hazard (see FLASH POINT).

"C" OR CEILING - A description usually seen in connection with ACGIH exposure limits. It refers to the concentration that should not be exceeded, even for an instant. It may be written as TLV-C or Threshold Limit Value-Ceiling. (See also THRESHOLD LIMIT VALUE).

°C - Degrees, Celsius; a temperature scale.

CARCINOGEN - A substance or physical agent that may cause cancer in animals or humans. A chemical is considered to be a carcinogen if it has been evaluated by the International Agency for Research on Cancer (IARC); or is listed in the Annual Report on Carcinogens published by the National Toxicology Program (NTP); or is regulated by OSHA as a carcinogen.

C.A.S. NUMBER - Unique number which identifies a particular chemical by the Chemical Abstracts Service, a service of the American Chemical Society that indexes and compiles abstracts of worldwide chemical literature called Chemical Abstracts.

Chemical Hygiene Officer-- An employee who is designated by the employer and who is qualified by training and experience, to provide technical guidance in the development and implementation of the provisions of the Chemical Hygiene Plan.

CHEMICAL HYGIENE PLAN-- A written program developed and implemented by the EH&S department which sets forth procedures, equipment, personal protective equipment and work practices that are capable of protecting laboratory personnel from the health hazards presented by the hazardous chemicals used in the laboratory.

CC - Cubic centimeter, a volumetric measurement which is also equal to one milliliter (ml).

CHRONIC EFFECT - Persistent or prolonged physical effect.

CHRONIC EXPOSURE - A prolonged exposure occurring over a period of days, weeks, or years.

COMBUSTIBLE - According to the DOT and NFPA, combustible liquids are those having a flash point at or above 141°F (60.5°C) and below 200°F (93°C)., or liquids that will burn. They do not ignite as easily as flammable liquids. Oil is considered a combustible material. Substances such as wood, paper, etc., are termed "ordinary combustibles".

COMPRESSED GAS -- A gas or mixture of gases that, in a container, will have an absolute pressure exceeding 40 psi at 70°F or 21.1°C. A gas or mixture of gases having, in a container, an absolute pressure exceeding 104 psi at 130°F or 54.4°C, regardless of the pressure at 70°F. A liquid having a vapor pressure exceeding 40 psi at 100°F or 37.8°C.

CONCENTRATION - The relative amount of a material dissolved or dispersed in another material. For example, 5 parts (of chlorine) per million (parts of air).

CORROSIVE - A substance that causes visible destruction or permanent changes in human tissue at the site of contact (e.g., acids or bases).

CUBIC METER (m^3) - A measure of volume in the metric system.

CUTANEOUS - Pertaining to or affecting the skin.

CYTOTOXIN -- A substance toxic to cells in culture, or to cells in an organism.

DECOMPOSITION - The breakdown of a chemical or substance into other chemicals or substances. Decomposition can occur due to heat, chemical reaction, decay, etc.

DESIGNATED AREA -- An area which may be used for work with "select carcinogens," reproductive toxins or substances which have a high degree of acute toxicity. This area may be the entire laboratory or an area under a device such as a laboratory hood.

U.S. DEPARTMENT OF TRANSPORTATION - federal agency that regulates the labeling and transportation of hazardous materials.

DERMAL - Pertaining to or affecting the skin

DERMATITIS - An inflammation of the skin

DILUTION VENTILATION - See GENERAL VENTILATION

DOT - See the U.S. DEPARTMENT OF TRANSPORTATION

DYSPNEA -Shortness of breath; difficult or labored breathing

ENGINEERING CONTROLS – Method for reducing an exposure to a potential hazard by eliminating or isolating the hazard. Fume hoods, glove boxes and enclosures are examples.

ENVIRONMENTAL PROTECTION AGENCY - governmental agency responsible for administration of laws to control and/or reduce pollution of air, water, and land systems.

EPA - See the ENVIRONMENTAL PROTECTION AGENCY.

EPA NUMBER - The number assigned to chemicals regulated by the Environmental Protection Agency (EPA).

EPIDEMIOLOGY - The study of frequency and occurrence of disease in human populations.

ERYTHEMA - A reddening of the skin.

EVAPORATION RATE - The rate at which a material is converted to vapor (evaporates) at a given temperature and pressure. Health and fire hazard evaluations of materials involve consideration of evaporation rates as one aspect of the evaluation.

EXPLOSIVE -- A chemical that causes a sudden, almost instantaneous release of pressure, gas, and heat when subjected to sudden shock, pressure or high temperature.

EXPOSURE - A process by which a chemical *comes into contact with* (i.e., "enters") a biological system.

°F - Degrees, Fahrenheit; a temperature scale.

FLAMMABLE LIQUID - According to the DOT and NFPA a flammable liquid is one that has a flash point of not more than 60 [deg]C (140 [deg]F), or any material in a liquid phase with a flash point at or above 37.8 [deg]C (100 [deg]F). (See FLASH POINT)

FLASH POINT - The lowest temperature at which a liquid gives off enough vapor to form an ignitable mixture with air and burn when a source of ignition (sparks, open flames, cigarettes, etc.) is present. Two tests are used to determine the flash point: open cup and closed cup. The test method used is generally indicated on the SDS.

g - See GRAM

g/Kg - See GRAMS PER KILOGRAM.

GAS -- Chemical substances that exist in the gaseous state at room temperature.

GENERAL VENTILATION - Also known as general exhaust ventilation, this is a system of ventilation consisting of either natural or mechanically induced fresh air movements to mix with and dilute contaminants in the workroom air (See LOCAL EXHAUST VENTILATION).

GRAM (g) - A metric unit of weight. One ounce equals 28.4 grams.

GRAMS PER KILOGRAM (g/Kg) - This refers to the dose of a substance given to test animals in toxicity studies. For example, a dose may be 2 grams (of substance) per kilogram of body weight (of the experimental animal).

HAZARDOUS CHEMICALS -- Any chemical for which there is significant evidence that acute or chronic health effects may occur in exposed personnel. The term "health hazard" includes
chemicals that are carcinogens, toxins, irritants, corrosives, sensitizers or other agents that can damage the lungs, skin, eyes or mucous membranes.

HEMATO-POIETIC – Toxic agents which act on the blood

HEPATOTOXIN - Chemicals which produce liver damage.

IGNITABLE - A liquid material which has a flash point of less than 140°F (See **flash point**)

INCOMPATIBLE - This term applies to two substances to indicate that, when mixed, the possibility of a dangerous reaction exists.

INGESTION - Taking a substance into the digestive tract by placing the substance into the mouth (includes inadvertent ingestion via eating or smoking with contaminated hands, or during inhalation of particulates, vapors or mists)

INHALATION - Breathing in of an airborne substance that may be in the form of gases, fumes, mists, vapors, dusts, or aerosols.

INHIBITOR - A substance that is added to another to prevent or slow down an unwanted reaction or change.

IRRITANT - A substance that produces an irritating effect when it contacts skin, eyes, nose, or respiratory system.

Kg - See KILOGRAM.

KILOGRAM (Kg) - A metric unit of mass; 1 kg = 2.2 pounds.

L - See LITER

LABORATORY - For the purposes of the MIOSHA Laboratory Standard, a "Laboratory" means a facility where the laboratory use of hazardous chemicals occurs. It is a workplace where relatively small quantities of hazardous chemicals are used on a nonproduction basis

LABORATORY SCALE -- Work with substances in which the containers used for reactions, transfers, and other handling of substances are designed to be easily and safely manipulated by one person.

LABORATORY HOOD -- A device constructed and maintained to draw air from the laboratory
and to prevent or minimize the escape of air contaminants into the laboratory.

LABORATORY USE OF HAZARDOUS MATERIAL -- The handling or use of chemicals in which 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. (4) Protective laboratory practices and equipment are available and in common use to minimize the potential for personnel exposure to hazardous chemicals.

LAMINAR AIR FLOW -- Air flow in which the entire mass of air within a designated space move
with uniform velocity in a single direction along parallel flow lines with a minimum of mixing.

LC_{50} - See LETHAL CONCENTRATION$_{50}$.

LD_{50} - See LETHAL DOSE$_{50}$.

LEL - See LOWER EXPLOSIVE LIMIT

LETHAL CONCENTRATION$_{50}$ (LC$_{50}$) - The concentration of an air contaminant that research has shown to kill 50 percent of the animals tested during a single exposure.

LETHAL DOSE$_{50}$ (LD$_{50}$) - The dose of a substance or chemical that research has shown to kill 50 percent of the animals tested during a single exposure.

LFL - See LOWER EXPLOSIVE LIMIT.

LITER (L) - A metric measure of volume; one quart equals .9 liters.

LOCAL EXHAUST VENTILATION - (Also known as exhaust ventilation.) A ventilation system that captures and removes the contaminants at the point where they are being produced before they escape into the workroom air. The system consists of hoods, ducts, a fan and possibly an air cleaning device. Advantages of local exhaust ventilation over general ventilation include: it removes the contaminant rather than dilutes it; it requires less air flow and thus is more economical over the long term; and the system can be used to conserve or reclaim valuable materials. However, the system must be properly designed with the correctly shaped and placed hoods, and correctly sized fans and duct work.

LOWER EXPLOSIVE LIMIT (LEL) - (Also known as Lower Flammable Limit, LFL). The lowest concentration of a substance that will produce a fire or flash when an ignition source (flame, spark, etc.) is present. It is expressed in percent of vapor or gas in the air by volume. Below the LEL or LFL, the air/contaminant mixture is theoretically too "lean" to burn. (See also UEL).

m^3 - See CUBIC METER.

MEDICAL SURVEILLANCE – The evaluation of an employee's medical condition by the employer or an employee to ensure that they have not been overexposed to a hazardous substance known to be present in the employees work environment.

MELTING POINT - The temperature at which a solid changes to a liquid. A melting range may be given for mixtures.

mg - See MILLIGRAM

mg/Kg - See MILLIGRAMS PER KILOGRAM

mg/M^3 - See MILLIGRAMS PER CUBIC METER

MILLIGRAM (mg) - A metric unit of mass

MILLIGRAMS PER CUBIC METER (mg/m^3) - Units used to measure air concentrations of dusts, gases, mists, and fumes

MILLIGRAMS PER KILOGRAM (mg/kg) of body weight - This indicates the dose of a substance given to test animals in toxicity studies. For example, a dose may be 2 milligrams (of substance) per kilogram of body weight (of the experimental animal).

MILLILITER (ml) - A metric unit used to measure volume. One milliliter equals one cubic centimeter. One thousand milliliters equal one liter.

ml - See MILLILITER

MSHA - The Mine Safety and Health Administration; a federal agency that regulates the mining industry in the safety and health area

MUTAGEN - Anything that can cause a change (or mutation) in the genetic material of a living cell

NANOPARTICLES - Particles that have at least one dimension between 1-100 nanometers. Particles in this size range have always been present in Earth's air. Nanoparticles may be naturally occurring (such as in volcanic ash), produced as unintentional byproducts (such as in auto emissions) or intentionally created or engineered. These very small particles often possess different properties than larger particles of the same composition, making them of interest to researchers and of potential benefit to society.

NARCOSIS - Stupor or unconsciousness caused by exposure to a chemical

NEPHROTOXINS – Chemicals which produce kidney damage

NEUROTOXINS – Chemicals which produce their primary toxic effects on the nervous system

NFPA - The National Fire Protection Association is a voluntary membership organization whose aims are to promote and improve fire protection and prevention. Within these codes is Standard No. 704, Identification of the Fire Hazards of Materials, which rates the hazard of a material during a fire via a color-coded "diamond". This diamond is divided into health (blue), flammability (red), and reactivity (yellow) hazard categories, each color displaying a number from 0 (no special hazard) through 4 (severe hazard) for that hazard category.

NIOSH - The National Institute of Occupational Safety and Health is a federal agency that, among its various responsibilities, trains occupational health and safety professionals, conducts research on health and safety concerns, and tests and certifies respirators for workplace use.

ODOR THRESHOLD - The minimum concentration of a substance at which a majority of test subjects can detect and identify the substance's characteristic odor. It is important to compare the PEL/TLV with this odor threshold in order to determine the effectiveness of that chemical's odor as a “warning property”.

ORAL - Having to do with the mouth

OSHA - The Occupational Safety and Health Administration - a federal agency under the Department of Labor that publishes and enforces safety and health regulations for most businesses and industries in the United States.

OXIDATION -- The process of combining oxygen with some other substance or a chemical change in which and atom loses electrons.

OXIDIZER -- Is a substance that gives up oxygen easily to stimulate combustion of organic material.

OXYGEN DEFICIENCY - An atmosphere having less than the normal percentage of oxygen found in normal air. Normal air contains 21% oxygen at sea level.

PEL - See PERMISSIBLE EXPOSURE LIMIT.

PERMISSIBLE EXPOSURE LIMIT (PEL) - An exposure limit that is published and enforced by OSHA as a legal standard. PEL may be either a time-weighted-average (TWA) exposure limit (8 hour), a 15-minute short term exposure limit (STEL), or a ceiling (C). These PELs are found in Tables Z-1, Z-2, or Z-3 of OSHA regulations 1910.1000. (See also TLV).

PERSONAL PROTECTIVE EQUIPMENT - Any devices or clothing worn by the worker to protect against hazards in the environment. Examples are respirators, gloves, and chemical splash goggles.

PHYSICAL HAZARD - means a chemical for which there is scientifically valid evidence that it is any of the following: (i) A combustible liquid. (ii) A compressed gas. (iii) Explosive. (iv) Flammable. (v) An organic peroxide. (vi) An oxidizer. (vii) Pyrophoric. (viii)Unstable (reactive). (ix) Water-reactive

POLYMERIZATION - A chemical reaction in which two or more small molecules combine to form larger molecules that contain repeating structural units of the original molecules.

ppm - Parts (of vapor or gas) per million (parts of air) by volume

RAD -- The unit of absorbed dose equal to 100 ergs per gram or 0.01 joules per kilogram of absorbing material.

REACTIVITY - A substance's susceptibility to undergoing a chemical reaction. Some are so reactive that the result is dangerous side effects, such as explosions, burning, and corrosive or toxic emissions. The conditions that cause the strong reaction, such as heat, other chemicals, shock, etc., will usually be specified as "Conditions to Avoid" when a chemical's reactivity is discussed on an SDS.

RESPIRATOR - A device which is designed to protect the wearer from inhaling harmful contaminants

RESPIRATORY HAZARD - A particular concentration of an airborne contaminant that, when it enters the body by way of the respiratory system, results in some bodily function impairment

REPRODUCTIVE TOXINS - Chemicals which affect the reproductive capabilities including chromosomal damage (mutations) and effects on fetuses (teratogenesis)

ROUTE OF ENTRY - The route (specific to each chemical) by which chemical exposure can occur (i.e., inhalation, ingestion or skin contact). See CHEMICAL EXPOSURE.

SELECT CARCINOGEN -- A chemical listed by MIOSHA as a carcinogen, by the National Toxicology Program (NTP) as "known to be carcinogenic" or by the International Agency for Research on Cancer (IARC) as a Group 1 carcinogen. Also included are chemicals or processes listed in either Group 2A or 2B by IARC, or under the category "reasonably anticipated to be carcinogens" by NTP and that cause statistically significant tumor incidence in experimental animals in accordance with any of the following criteria:

- After inhalation exposure of 6-7 hours per day, 5 days per week, for a significant portion of a lifetime to dosages of less than 10 mg/m3
- After repeated skin application of less than 300 mg/kg of body weight per week
- After oral dosages of less than 50 mg/kg of body weight per day

SENSITIZER - A substance that may cause no reaction in a person during initial exposures, but to which further exposures will (without warning) cause a dramatic (and permanent) hypersensitivity (i.e., allergy) to that substance.

SHORT TERM EXPOSURE LIMIT - Represented as STEL or TLV-STEL, this is the maximum concentration to which workers can be exposed for a short period of time (15 minutes) for only four times throughout the day with at least one hour between exposures.

"SKIN" - This designation sometimes appears alongside a TLV or PEL. It refers to the possibility that absorption of the particular chemical through the skin and eyes can result in *systemic* toxicity.

SOP – See Standard Operating Procedures

STANDARD OPERATING PROCEDURES – written directions explaining how to safely conduct work involving hazardous operations.

STEL - Short Term Exposure Limit

SUBSTANCE - Any chemical

SYNONYM - Another name by which the same chemical may be known

SYSTEMIC - Spread throughout the body; affecting many or all body systems or organs; not localized in one spot or area

TERATOGEN - An agent or substance that may cause physical defects in the developing embryo or fetus when a pregnant female is exposed to that substance.

THRESHOLD LIMIT VALUE (TLV) - Airborne concentrations of substances devised by the ACGIH that represent conditions under which it is believed that nearly all workers may be exposed day after day (for a lifetime) with no adverse effect. TLV's are advisory exposure guidelines, not legal standards, that are based on evidence from industrial experience, animal studies, or human studies when they exist. There are three different types of TLV's: Time Weighted Average (TLV-TWA), Short Term Exposure Limit (TLV-STEL) and Ceiling (TLV-C). (See also PEL)

TIME WEIGHTED AVERAGE (TWA) - The average time, over a given work period (e.g. 8-hour work day), of a person's exposure to a chemical or an agent. The average is determined by sampling for the contaminant throughout the time period. Represented as TLV-TWA.

TLV - See THRESHOLD LIMIT VALUE.

TOXICITY - The relative potential for a substance to exert a harmful effect on humans or animals

TRADE NAME - The commercial name by which a chemical is known. One chemical may have a variety of trade names depending on the manufacturers or distributors involved.

TWA - See TIME WEIGHTED AVERAGE.

UEL - See UPPER EXPLOSIVE LIMIT.

UFL - See UPPER EXPLOSIVE LIMIT.

UNSTABLE (REACTIVE) LIQUID - A liquid that, in its pure state or as commercially produced, will react vigorously in some hazardous way under shock conditions (e.g., impact, dropping), certain temperatures, or pressures.

UPPER EXPLOSIVE LIMIT - also known as Upper Flammable Limit, the UEL is the highest concentration (expressed in percent of vapor or gas in the air by volume) of a substance that will burn or explode when an ignition source is present. Theoretically above this limit the mixture is said to be too "rich" to support combustion. The difference between the LEL and the UEL constitutes the flammable range or explosive range of a substance. That is, if the LEL is 1 ppm and the UEL is 5 ppm, then the explosive range of the chemical is 1 ppm to 5 ppm. (see also LEL).

VAPOR - Gases formed as liquids “evaporate” (i.e., change from liquid phase to the gas phase).

VAPOR PRESSURE -- The pressure that a solid or liquid exerts when it is in equilibrium with its vapor at a given temperature.

WATER REACTIVE -- A chemical that reacts with water to release a gas that is either flammable or presents a health hazard.