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APPENDICES

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Section 1.0
IMPLEMENTING OSHA'S LABORATORY STANDARD AND THE CHP

1.1 INTRODUCTION

1.1.1 The OSHA Laboratory Standard

1.1.1.1 Intent

The Occupational Safety and Health Administration's (OSHA) Laboratory Standard [*Occupational Exposures to Hazardous Chemicals in Laboratories* (CFR 1910.1450)] requires employers to convey chemical health and safety information to their laboratory employees, and ensure that proper work practices/procedures are in place to protect them from laboratory/chemical hazards.

1.1.1.2 Approach. OSHA summarizes the approach of its Laboratory Standard in its preamble:

"The new Standard differs from many OSHA health standards in that it does not establish new exposure limits, but sets other performance provisions designed to protect laboratory workers from potential hazards in their work environment. By permitting a greater degree of flexibility to laboratories in developing and implementing employee safety programs, OSHA expects benefits to result from increased worker awareness of potential risks, improved work practices, appropriate use of existing personal protective equipment and greater use of engineering controls."

1.1.2 The Chemical Hygiene Plan (CHP)

1.1.2.1 Intent

This *Chemical Hygiene Plan* is explicitly required by the Standard to communicate those "performance provisions" which are designed to protect workers from potential laboratory hazards.

1.1.2.2 Content

- **Section 1.0 - Documents "regulatory" requirements of the Standard:**
  - 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

- **Section 2.0 - Documents "Standard Laboratory Practices" for working safely in labs.**

- **Section 3.0 ("Standard Laboratory Practices per Chemical Hazard Class") and Section 4.0 ("Chemical Toxicology") - Provide *supplementary* guidance/reference information.**

1.2 CHEMICAL HYGIENE RESPONSIBILITIES

Responsibility for laboratory/chemical health and safety, in addition to implementing compliance with the OSHA Laboratory Standard, rests at all levels.

1.2.1 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.

- The **primary** function of Environmental Health and Safety, then, is to act in an advisory capacity to the individual department supervisors/administrators, and help them provide a safe and healthful workplace. EH&S services pertaining to laboratory chemical hygiene include:

  - Providing the OU **Chemical Hygiene Officer** (per the Standard - See **Section 1.2.2** below).

  - **Conducting laboratory audits** annually, and recommending remedial measures.

  - **Providing disposal services** for chemical, infectious and radioactive wastes.

  - **Consulting with employees regarding laboratory safety and chemical exposures.**

1.2.2 Oakland University Chemical Hygiene Officer

- The OU Chemical Hygiene Officer oversees and manages chemical hygiene for the entire University. He/she can be reached in the Office of EH&S, ext. 4196. Responsibilities are as follows:

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

  - **Works with Department Chairs, laboratory supervisors and/or Principal Investigators to develop specific components of the Chemical Hygiene Plan.** Special attention is given to safe use, storage and disposal of chemicals.

  - **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, students, visiting scholars, etc.

1.2.2 Oakland University Chemical Hygiene Officer (Responsibilities cont.)

- Advises laboratory supervisors regarding implementation of this **Chemical Hygiene Plan**.

- Performs and records **laboratory safety audits (see Appendix C).**

- Knows the contents of the relevant regulation (Occupational Exposures to Hazardous Chemicals in Laboratories, 29 CFR 1910.145) and **updates the Chemical Hygiene Plan** as required.

1.2.3 Oakland University Department Personnel

- Each of the following departments is known to conduct "laboratory work", as defined in the OSHA Laboratory Standard (see **Section 1.3.1** for "laboratory" definition), and is thereby required to implement those requirements identified in this Chemical Hygiene Plan:

  - Department of Biological Sciences
  - Department of Chemistry
  - Clinical Research Laboratory (CRL)
  - Eye Research Institute (ERI)
  - Department of Physics
  - School of Health Sciences, Medical Laboratory Sciences (SHS-MLS)
  - School of Engineering and Computer Science (SECS)
  - School of Education and Human Services - Curriculum, Instruction and Leadership (SEHS-CIL)

1.2.3.1 Committees

- The university's **Laboratory Safety Committee** (Chaired by the Director of Environmental Health and Safety) is in place to assist departments to implement safe work practices in the laboratory (and concurrent compliance with the OSHA Laboratory Standard), and has representatives from each of the departments listed in 1.2.3 above. Employees are welcome to bring chemical hygiene concerns/questions to the Committee or attend (monthly) committee meetings at any time, by contacting the Director of EH&S, ext. 4196.

- 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.

1.2.3.2 Department Heads

- Department Chairs (in Biology, Chemistry, Physics, SECS and SEHS-CIL) are responsible to ensure implementation of this Section (1.0) of the Chemical Hygiene Plan in their departments. This assertion is derived in part from Article XXVI of the 1997-2000 AAUP Agreement (Item 187 b.) which states:

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

- Likewise, Directors/Department Heads (in CRL, ERI and SHS-MLS), as "heads" of their respective departments/programs, are also responsible to ensure implementation of this Section (1.0) of the Chemical Hygiene Plan in their units.

1.2.3.3 Laboratory "Supervisor"

- **General Principle**

    The OSHA Laboratory Standard (and in fact all OSHA Standards) explicitly places the primary responsibility to implement any/all regulatory safety requirements on the "front-line supervisor" of the associated operations. Seeing as OSHA Standards are not written with the *academic* environment in mind, this mandate has historically required vigorous interpretation by university administrators and regulatory enforcement agents alike. In the case of the Laboratory Standard however, given that the operations, materials, equipment, funding and so forth are so unique to each laboratory, virtually all university's 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 (rotating?) persons within their departments, and/or expressly (by department Chairs) relegated to the university's Chemical Hygiene Officer.

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

    ■ General Knowledge and Preparedness

    · Acquires the **knowledge and information** needed to recognize and control chemical hazards in the laboratory.

    · Selects and employs laboratory practices and engineering controls that **reduce the potential for exposure** to hazardous chemicals to the appropriate level.

    · **Defines hazardous operations, designates safe practices and selects protective equipment.**

1.2.3.3 Laboratory "Supervisor" - General Knowledge and Preparedness (cont.)

- Ensures appropriate controls **(engineering and personal protective equipment)** are used and are in good working order.

- **Makes copies of the approved Chemical Hygiene Plan available** to the laboratory employees, students and support staff.

- Works with the department's Hazardous Waste Coordinator, and/or EH&S to collect, label and store <u>all</u> **hazardous wastes** (spilled or otherwise) properly.

■ **Employee training, supervision and surveillance**

- Ensures that program and support staff receive **instructions and training** in safe work practices, use of personal protective equipment, and in procedures for dealing with accidents involving laboratory chemicals. See **Section 1.4** for more information.

- **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)**.**

- **Monitors the injury and illness records** to ensure that one or more safety practices/ techniques are not being routinely neglected.

- **Becomes familiar with the regulatory components of OSHA's Laboratory Standard** (outlined in this CHP) and ensures laboratory compliance therewith**.**

- **Supervises** as necessary the performance of laboratory staff to ensure safe practices in the laboratory, and **enforces** policies/procedures as necessary.

- **Conducts routine lab inspections** to ensure compliance with laboratory SOPs.

- Ensures that lab personnel obtain **medical surveillance** (where required by OSHA). See **Section 1.8** for more information.

■ **High Hazard Chemicals**

- Notifies EH&S prior to using **particularly hazardous substances** (see **Section 1.10** for more information). Upon receipt of this information, EH&S shall cc the OU Police Department and OU's Fire Safety Inspector.

- Works with the Office of Environmental Health and Safety to develop detailed **Standard Operating Procedures**, SOPs, (<u>not</u> covered in the Standard Laboratory Practices, **Section 2.0** of this Manual) for ***high hazard*** operations (see **Section 1.10)**.

- Develops SOPs for working with high hazard chemicals, and maintains these SOPs in **Appendix G** of the CHP.

1.2.3.3 Laboratory "Supervisor" - Responsibilities (cont.)

- Defines and posts the location of work areas where **highly toxic, potentially carcinogenic, mutagenic and/or teratogenic substances** will be used/stored (see **Section 1.7** for more information).

- Ensures that the **Laboratory Chemicals Inventory (LCI) Checklist** (distributed annually by EH&S, see **Appendix A**) is completed properly and in its entirety, returned to EH&S by the requested deadline, and that a copy is readily available and accessible to all laboratory employees.

■ **Incident Response**

- **Investigates** (non-incidental) spills, accidents and injuries, and provides associated documentation (including procedures that will potentially minimize the repetition of the incident) to that department's Laboratory Safety Committee representative (and/or the Director of EH&S).

- 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.

- Ensures that all employees are trained in the **use and accessibility** of laboratory <u>and</u> departmental **spill kits**.

- **Prepares and communicates procedures** for responding to accidents, injuries or illnesses, including (but not limited to) those associated with chemical spills.

- Ensures that action is taken to **correct work practices and conditions** that may result, or have resulted, in the unplanned release of chemicals.

- **Ensures proper clean-up and disposal** of spilled and/or contaminated materials.

1.2.3.4 Laboratory Manager

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

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

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

  - Assists with **distribution of CHP** copies to laboratory employees.

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

1.2.3.5 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:

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

  - Plan and conducts each operation in accordance with established **Standard Laboratory Practices, SLPs** (provided in **Section 2.0** of this CHP)**.**

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

  - **Reports unsafe conditions** to the laboratory supervisor, Principal Investigator, or Oakland University Chemical Hygiene Officer.

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

  - **Informs visitors** entering the laboratory of potential hazards and safety rules/precautions.

  - **Attends required training sessions** and follows Standard Laboratory Practices, SLPs, prescribed therein.

  - **Wears personal protective equipment** (e.g. safety glasses, goggles, gloves etc.) as prescribed by his/her laboratory supervisor, Principal Investigator, EH&S (or site-specific) Chemical Hygiene training, or **Section 2.0** of this CHP.

  - 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).

1.3 DEFINITIONS

1.3.1 Definition of a "Laboratory"

For the purposes of the OSHA Laboratory Standard, a "laboratory" is defined as a facility wherein multiple procedures typically require laboratory reagents to be manipulated in small quantities (i.e., within containers that are easily maneuvered by one person) on a non-production basis.

1.3.2 Definition of a "Physical Hazard"

- A chemical poses a *physical* hazard if it is (see **Section 3.0** for more info on each):

· flammable	· combustible	· explosive	· an oxidizer
· reactive	· compressed gas	· organic peroxide	· a pyrophoric

1.3.3 Definition of a "Health Hazard"

- 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:
  - 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;
  - Presents "moderate" to "high" toxicity (based on LC_{50}/LD_{50} as follows):
    - ➢ Toxic by Inhalation: LC50 < 20,000 ppm
    - ➢ Toxic by ingestion: (Given that ingestion in a lab would most likely be accidental/incidental), a maximum oral-LD50 of 50 mg/kg
    - ➢ Toxic by Skin Contact: Skin-LD50 of < 340 mg/kg

- Classes of health hazards include (See **Section 4.0** for additional toxicology information):
  - carcinogens
  - reproductive toxins (i.e., teratogens and mutagens)
  - corrosive agents (damage lungs, skin, eyes, or mucous membranes upon contact)
  - sensitizers (produce extreme allergies upon repeated or prolonged exposure)
  - irritants
  - hepato- (liver) toxins
  - hematopoietic- (blood) toxins
  - neuro- (central nervous system) toxins
  - nephro- (kidney) toxins

1.4 CHEMICAL/LABORATORY SAFETY TRAINING

All employees exposed, or potentially exposed, to hazardous chemicals while performing their laboratory duties must receive information and training regarding the OSHA 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:**

1.4.1 General Chemical Hygiene Training

- EH&S will conduct general chemical hygiene training annually to Principal Investigators, laboratory supervisors and their designees.

- This (MS Power Point) training is available on videotape (through EH&S) or found on the EH&S web page:

1.4.1 General Chemical Hygiene Training (cont)

- Attendance records (and associated exam scores) are maintained in an EH&S database. Hard copies of this information should also be maintained in **Appendix F** of the CHP.

1.4.2 Site-Specific Training

- **General Requirement**

  - Site specific elements of training are to be conducted by the Principal Investigator/laboratory supervisor or a designee, and provided to *every* individual who will conduct *or observe* chemical manipulations in the PI's laboratory.

- **When laboratory supervisors should conduct Site-specific training:**

  - Training and information will be provided when an employee is **initially assigned** to a laboratory where hazardous chemicals are present.

  - Training and information should also be provided by the laboratory supervisor whenever an employee is to perform a **non-routine task** presenting hazards for which he or she has not already been trained.

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

  - A **"Site-Specific Training Checklist"** has been provided to every laboratory superior/PI on campus (copy also included as **Appendix B**); additional copies may be obtained upon request from EH&S, ext 4196. This Checklist identifies 25 topics which must be presented during site-specific training, including (but not limited to) the following:

    - **Physical and health hazards** of various classes of laboratory chemicals handled at the respective sites;

    - Location, selection and proper use of **personal protective equipment** to be used. [*NOTE*: Information on protective clothing and equipment is contained in **Section 2.4** of this CHP];

    - Response in the event of **chemical (or other laboratory) emergencies** (spills, etc.) - see **Section 2.7** of this CHP; and

    - Any additional (relevant) information from this **Chemical Hygiene Plan.**

- **Site-Specific Training Recordkeeping**

  - A copy of the signed (by both the learner and the instructor) should be maintained (and easily accessible to EH&S auditors) at the "site" for which training was provided (e.g., laboratory).

1.5. HAZARD COMMUNICATION DOCUMENTS -MANAGEMENT/ACCESSIBILITY

1.5.1 Lists of "Hazardous" Chemicals Used (and Potentially Used) in OU Laboratories

- The Office of EH&S has a Laboratory Chemicals Inventory (LCI) Checklist, which lists approximately 200 chemicals (and their associated hazards) that are commonly found in academic/research laboratories, AND which present one or more physical or health hazards, as defined in **Sections 1.3.2 and 1.3.3.** This list is provided as **Appendix A**.

- Laboratory supervisors are asked to complete the LCI Checklist annually, from which an OU Laboratory Chemicals Inventory (LCI) is generated. "Hard" copies of this LCI are maintained in the Office of EH&S, and are distributed to OU Police and all laboratories who complete the Checklist. The LCI database (in MS Access 7.0) is also available on the EH&S webpage at www.oakland.edu/rskmgt/eh&s.html

1.5.2 Safety Reference Literature (non-MSDS) available in EH&S

- The Merck Index
- Hazardous Chemicals Desk Reference (Richard Lewis)
- Sigma Aldrich Library of Chem Safety
- Prudent Practices in the Laboratory (National Academy Press)
- Prudent Practices for Disposal of Chemicals from Labs (National Academy Press)
- EMCIS™ Product, Regulatory & Safety Info (Computer Database)
- NFPA 491 Guide to Hazardous Chemical Reactions
- The Dose Makes the Poison (Nostrand & Reinhold)

1.5.3 Material Safety Data Sheets (MSDS)

- MSDSs are available from the following locations at OU:

  - All MSDSs that are received with incoming reagents are housed in their respective departments, under the immediate control of these departments' laboratory managers.

  - MSDSs may be requested (verbally or in writing) from the Office of EH&S.

  - EH&S web page: http://www.oakland.edu/rskmgt/eh&s.html.

  - Internet: http://hazard.com/msds/

1.5.4 Container Labels

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

1.5.4 Container Labels

- **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.*

- **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.

- **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.

- **Unpacking new chemicals.** Employees involved in unpacking chemicals (e.g., stockroom managers) are responsible for inspecting each incoming container to ensure that it is labeled with the information outlined above.

- **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.

1.5.5 Laboratory Signs

- **Exterior Doors.** EH&S is responsible to ensure that prominent signs are displayed on the hallway doors leading to each laboratory. Information contained therein includes:
  - **Emergency Contact Information:** Telephone extensions of OU Police, that laboratory's Principal Investigator, and that Department's Laboratory Manager.
  - **Warnings:** Special hazards, such as the storage of greater than 2 gallons of flammable liquids, or chemicals which pose radioactivity or bio-toxicity.

- **Inside Laboratories**. EH&S is also responsible to ensure that prominent signs/tapes are displayed *inside* laboratories as follows:
  - Designate areas for working with/storing highly **toxic** chemicals (including carcinogens, teratogens and/or mutagens).
  - Provide emergency response information (e.g. closest campus phone, OU Police ext. etc.)

1.6 EMPLOYEE EXPOSURE ASSESSMENTS

1.6.1 General Circumstances

- Regular environmental or employee exposure monitoring of airborne concentrations is not generally warranted in academic laboratories because...
  - a wide variety of chemicals is typically used for relatively short periods of time, and in small quantities; and
  - laboratories are equipped with fume hoods to trap vapors and maintain negative pressure ventilation in those rooms.

1.6.2 Personal Air Monitoring - Indicators

- **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're working, or there is some other indication (e.g., odor) that chemical exposure is exceeding its OSHA Permissible Exposure Limit (PEL).

- **Suspected Exposure to Chemicals of Chronic Toxicity**
  - Air monitoring may also become necessary if/when it is suspected that exposure to a chemical which poses ***chronic*** toxicity (e.g., a carcinogen) has exceeded the OSHA Permissible Exposure Limit (PEL) for that chemical.
  - **OSHA-Regulated Carcinogens**
    - OSHA explicitly regulates 21 carcinogens (see **Table 1.6.2** below), each with its *own* comprehensive health standard (and associated PELs). And while the Laboratory Standard (and all its requirements) takes precedence over these individual health standards for each chemical, the requirement to limit employees to the specific PELs identified in each standard ***do*** apply to laboratories.
    - Whenever the "action level" (typically one-half the OSHA PEL) is routinely exceeded, exposure monitoring and medical surveillance is required by OSHA

Table 1.6.2 - OSHA-Regulated Carcinogens

Compounds Regulated by OSHA

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

1.6.3 Air Monitoring - Process

- **Personal Sampling Pump/Tubes**

  · The most common method of personal air monitoring consists of using a personal sample pump, which draws in air (from an area near the breathing zone of the employee working with the chemical) for the duration of his/her work shift, experiment etc.

  · This air is drawn into adsorbent tubes (e.g. charcoal or silica gel), from which the chemical is later desorbed and its concentration analyzed (using a gas chromatograph, GC)

  · The purpose of the analysis is to determine whether the chemical concentration (to which the laboratory employee was exposed) has exceeded the OSHA action level, or the PEL, for that chemical.

- **Procedure Following Analysis**

  · If the "action level" is reached, air monitoring becomes necessary whenever that procedure is performed unless engineering/administrative controls can successfully be used to reduce employee exposure to below the action level.

  · If the Permissible Exposure Level (PEL) is reached or exceeded, the procedure may not be repeated unless engineering/administrative controls can successfully be used to reduce employee exposure to below the PEL.

  · If it is decided that one or more employees have *routinely* been exposed to concentrations which exceed the OSHA PEL for a carcinogen (or any chemicals which present chronic toxicity), medical surveillance may be necessary (see **Section 1.7** below).

  · EH&S will submit a report documenting the results (and associated recommendations) to the employee(s) and their supervisor(s), and a copy placed in the CHP (**Appendix H).**

1.7 "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 **Section 3.6** of this Chemical Hygiene Plan for guidelines on handling/storing these chemicals, and a list of chemical examples.

  - 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

  - A "shipping" tape which reads:

> CAUTION: SPECIFICALLY DESIGNATED TOXIC CHEMICALS ARE USED/STORED HERE

- **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 "shipping" tape are available in the Office of EH&S, ext. 4196)

- Additionally, all chemicals which exhibit **high chronic toxicity** shall be labeled with shipping 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

- You will note from this tape that laboratory employees are required to obtain laboratory supervisor/**Principal Investigator approval** prior to using these chemicals. It is the supervisor's responsibility to enforce this requirement.

1.7 "DESIGNATED" WORK/STORAGE AREAS (cont.)

- **Special precautions for employees working with reproductive toxins**

- **Lab personnel of childbearing age** should be informed of any reproductive toxins used in the lab. A list of common reproductive toxins is found in **Table 3.6(R)**.

- **Pregnant Employees**, or those planning to become pregnant, who are working with teratogens, should **contact the OU Chemical Hygiene Officer** to evaluate their exposures and inform their personal physicians. 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.

1.8 MEDICAL CONSULTATION

- 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:
  - exhibits signs/symptoms which correspond to the ***acute toxicity*** hazards of the chemical(s) with which they're working.
  - is found or suspected to have been exposed routinely to chemical concentrations which exceed the OSHA PEL for OSHA-regulated carcinogens (see **Table 1.6.2** above) or other chemicals which present ***chronic toxicity***.
  - may have been exposed to a hazardous chemical during a chemical incident such as a spill, leak, explosion or fire; and
  - is referred for medical follow-up by the OU Chemical Hygiene Officer.

- 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.

- Where medical consultations or examinations are provided, the examining physician shall be provided with the following information:
  - the identity of the chemical(s) to which the employee may have been exposed;
  - the exposure conditions; and
  - the signs and symptoms of exposure the laboratory employee is experiencing, if any.

- Individuals with life threatening emergencies should contact OU Police (ext. 911) for emergency transport to the hospital. OU Police and/or the laboratory supervisors should report all incidents resulting in serious injury/illness to the OU Chemical Hygiene Officer.

1.9 SAFETY EQUIPMENT INSPECTIONS

1.9.1 Chemical Fume Hoods

- 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.

- Every chemical fume hood shall be ***quantitatively*** **tested by the Office of EH&S annually** to ensure that adequate airflow is being maintained to provide protection against employee exposure. Laboratory hood airflow shall be considered adequate when the average face velocity averages (using transverse velometer measurements inside the hood) a minimum of a **100 feet/minute** with the **hood sash at a "working" height (14-20").**

- **Other local exhaust ventilation**, such as ventilation “snorkels”, will also be tested, for which the criteria for minimal acceptable flow shall be determined by EH&S.

- Results of laboratory ventilation tests shall be **recorded and maintained in the EH&S copy and each department's "Reference Copy" of the CHP (Appendix D).**

- In addition to reporting fume hood measurements to laboratory managers, and documenting the results in the CHPs, the **fume hoods shall themselves be labeled** with the sash height at which optimal face velocity was measured.

- **Fume hoods which are not working properly should be reported to CF&O (x 2381)** immediately. Following repairs, the Office of Environmental Health and Safety should be contacted to retest the hood.

1.9.2 Eye Wash Stations and Safety Showers

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

- **Inspections**

  - **EH&S Inspections**

    - **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 a minimum of **.4 gallons per minute** (gpm).

    - **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 min. of **30 gpm.**

    - Eyewash/Safety shower inspection records shall be maintained in **Appendix E** of the CHP.

1.9.2 Eye Wash Stations and Safety Showers (cont.)

· PIs, lab supervisors and/or lab workers should also make it a point to **visually inspect** the quality of the water in the eyewash stations on a regular basis, and report to CF&O any persistently brown or silty water.

1.10 "HIGH HAZARD" OPERATIONS

· Under some circumstances a particular chemical substance and associated laboratory operation, procedure or activity may be considered sufficiently hazardous to require **notification of** the Office of Environmental Health and Safety before research begins.

1.10 "High Hazard" Operations (cont.)

· This requirement automatically applies (but is **not** limited) to the acutely toxic gases in **Table 1.10** below:

Table 1.10 - 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	Nitric oxide
Cyanogen	Nitrogen dioxide
Diborane	Nitrogen Tetroxide
Germane	Phosgene
Hexaethyltetraphosphate	Phosphine

· 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 in **APPENDIX G** of the CHP.

1.11 RECORD KEEPING

· All **personnel exposure assessments and occupational medical consultation/examination reports** will be maintained in a secure area in accordance with OSHA's medical records rule (29 CFR 1910.20). Individuals may obtain copies or read their reports by making a request in writing to the Office of EH&S (exposure assessment records) or the Graham Health Center (occupational medical records).

- All other records shall be maintained in the **EH&S copy of the CHP**, in addition to the (applicable appendices of the) **corresponding departmental copies**.

Section 2.0
STANDARD LABORATORY PRACTICES (SLPs)

2.1 HANDLING LABORATORY CHEMICALS

2.1.1 General Guidelines

- **Labels** should be carefully examined before using the corresponding laboratory chemicals. The manufacturer's or supplier's Material Safety Data Sheet (MSDS) will often provide handling information.

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

- 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.

- Employees should **avoid working alone** in the laboratory. If a laboratory employee must work alone, he/she should let someone else know, and ask that individual to check in periodically on the employee in the lab.

- All **secondary chemical containers** should be labeled with appropriate identification and hazard information (see **Section 1.5.4** on Container Labels).

- Only those chemicals for which there are effective **engineering controls** (e.g., chemical fume hoods) and/or documented **administrative controls** (see **Section 2.4.1.1**) may be used.

- **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.

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

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

- **Personal protective apparel/equipment should be inspected** for integrity and proper functioning before use.

2.1.1 General Guidelines for Handing Laboratory Chemicals (cont.)

- 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.

- **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.

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

2.1.2 Personal Hygiene

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

- **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.

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

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

2.1.3 Housekeeping

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

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

- **Work areas**, and especially work benches, should be kept clear of clutter and obstructions.

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

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

- **Hazardous wastes** should be kept in the appropriate containers and labeled properly.

- **Unlabeled containers** should be considered to contain hazardous wastes at the end of each working day, and handled accordingly.

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

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

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

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

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

2.3 HAZARD COMMUNICATION

2.3.1 Material Safety Data Sheets (MSDS)

- **General Description**

    - A Material Safety Data Sheet, often referred to by the acronym MSDS, 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).

    - A Glossary of Terms commonly found on MSDSs is available as Section 5.0 of this CHP.

- **Limitations**

    - **MSDSs are *highly* variable in their format, content and accuracy.** Statements are often generic, vague, legalistic and/or inaccurate.

    - Thus, MSDS should **NOT** be used as the **exclusive** source of safety information regarding laboratory chemicals.

- **Format of an MSDS**

    - The format of a MSDS may vary, but there is specific information that is required to be included in each document. Thus, it may prove useful to review the format provided below: **(Note- not all MSDS follow this, or any one, organizational format)**:

2.3.1 Material Safety Data Sheets (MSDS) Format (cont.)

Section I - Chemical/Manufacturer Identification. Examples of information include:

- Manufacturer's name, address and telephone number
- Number to call in case of emergency involving product
- Chemical name and synonyms
- Trade name and synonyms
- Chemical family and formula
- CAS # (Chemical Abstract Service) for pure materials

Section II - Constituents and percentages. Examples of information:

- All hazardous chemicals which comprise 1% or greater of the mixture will be identified. Carcinogens will be listed if their concentrations are ≥ 0.1%.
- If a component is not listed, it has been judged to be non-hazardous or is considered proprietary information by the manufacturer.
- Components listed include pigments, catalysts, vehicles, solvents, additives, base metals, alloys, metallic coatings, fillers, solids or gases.

Section III - Physical Properties. Examples of information include:

- Boiling point
- Vapor pressure
- Vapor density
- Solubility in water
- Specific gravity
- Percent volatile
- Evaporation rate
- Appearance and odor

Section IV - Fire and Explosion Hazards. Examples of information include:

- Flash point
- Lower and upper explosive limits (**LEL/UEL**)
- Extinguishing agent - water, dry chemical, foam, halon, etc.
- Unusual fire and explosion hazards, toxic fumes
- Special procedures may also be listed.

Section V - Health Hazards. Examples of information include:

- Threshold Limit Value
- Effects of overexposure: headache, nausea, narcosis, irritation, weakness
- Primary routes of exposure: inhalation, skin, ingestion
- Cancer or other special health hazards
- Emergency/first aid procedures for ingestion, inhalation and skin/eye contact

2.3.1 Material Safety Data Sheets (MSDS) Format (cont.)

Section VI - Reactivity data. Examples of information include:

- Stability: stable; unstable; conditions to avoid
- Incompatibility: materials to avoid
- Hazardous decomposition products
- Hazardous polymerizations: conditions to avoid

Section VII - Spill Response. Examples of information include:

- Containment procedures
- Evacuation procedures
- Proper waste disposal

Section VIII - Personal Protective Equipment. Examples of information include:

- Respiratory equipment: e.g. dust mask, chemical cartridge respirator etc.
- Ventilation: i.e., local, general, special
- Protective gloves: i.e., type, construction material etc.
- Eye protection: e.g. goggles, face shield etc.

Section IX - Handling and Storage Procedures. Examples of caution statements:

- Keep container closed.
- Store in a cool, dry, well ventilated area.
- Keep refrigerated.
- Avoid exposure to sunlight.

Section X - Special Precautions or Miscellaneous Information

- **Proprietary Exclusions from an MSDS**
  - Manufacturers may withhold certain information as "proprietary" (such as individual ingredients and/or percentages) on a Material Safety Data Sheet if the information is considered a trade secret.
  - However, users have a legal right to obtain this information from the manufacturer to evaluate the health risk if adverse health effects are suspected.

2.3.2. Labels

- **Basic Information Provided by Labels**
  - Containers of laboratory chemicals which pose a physical or health hazard to employees must have a hazard communication label attached. Labels on hazardous chemicals should include:

2.3.2. Labels - Basic Information Provided (cont.)

- Common name of the chemical.
- Name and contact information for the product's manufacturer or distributor.
- 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))

- **Additional Information Provided by Labels**

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

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

- **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.*

- **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.

- **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.

- **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.

2.4 PERSONAL PROTECTIVE EQUIPMENT

2.4.1 General Considerations

2.4.1.1 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:

2.4.1.1 Engineering and Administrative Controls (cont.)

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

- **Engineering Controls**
  - **Local ventilation** (e.g., fume hoods)

2.4.1.2. Selection Resources

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

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

2.4.2 Laboratory Clothing

- 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.**

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

- Laboratory coats should be laundered regularly and *separately* from street clothes.

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

- **Shoes** should always be worn in the lab. Sandals/perforated shoes are inappropriate.

- **Long hair** and **loose clothing** should be confined.

2.4.2.1 Additional Protective Clothing

- 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**).

2.4.2.1 Additional Protective Clothing (cont.)

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

- **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.

- **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.

2.4.2.2 Chemical Resistant Gloves

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

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

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

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

- 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. Since many chemicals will "break through" (i.e., penetrate) incompatible gloves in a short time, gloves should be carefully selected. General selection criteria is shown in **Table 2.4.2.2 below**:

Table 2.4.2.2 - GLOVE TYPE SELECTION GUIDE

CHEMICAL FAMILY	BUTYL RUBBER	NEOPRENE	PVC (VINYL)	NITRILE	LATEX
Acetates	G	NR	NR	NR	NR
Acids, inorganic	G	E	E	E	E
Acids, organic	E	E	E	E	E
Acetonitrile, Acrylonitrile	G	E	G	S	E
Alcohols	E	E	NR	E	E
Aldehydes	E	G	NR	S[2]	NR
Amines	S	NR	NR	F	NR
Bases, inorganic	E	E	E	E	E
Ethers	G	F	NR	E	NR
Halogens (liquids)	G	NR	F	E	NR
Inks	G	E	E	S	F
Ketones	E	G	NR	NR	G
Nitro compounds (Nitrobenzene, Nitromethane)	G	NR	NR	NR	NR
Oleic Acid	E	E	F	E	NR
Phenols	E	E	NR	NR	G
Quinones	NR	E	G	E	E
Solvents, Aliphatic	NR	NR	F	G	NR
Solvents, Aromatic	NR	NR	F	F	NR

[1] *S = Superior   E = Excellent   G = Good   F = Fair   NR = Not Recommended*

[2] *Nitrile gloves are superior for all aldehydes except for acetaldehyde, where butyl rubber is recommended.*

2.4.3 Protection of the Eyes

- **Policy**

  · **Eye protection is required** for <u>all</u> 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.

2.4.3 Protection of the Eyes (cont.)

- **Contact lenses**

  · Contact lenses can increase the risk of eye injury if worn in the laboratory (particularly if they are of the gas permeable variety), since gases and vapors can be concentrated under such lenses and cause permanent eye damage.

  · Chemical splashes to the eye can lodge behind all types of lenses, making it difficult to remove with a typical eye wash.

  · For these reasons, it is **recommended that contact lenses not be worn in labs**.

- **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.

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

  ➢ **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.

  ➢ **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 2.4.3** below

Table 2.4.3 - 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
Glasses (no shields)	Good	Poor	Excellent	Poor	Poor	Good to very good	Very good	Very good	Moderate
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

2.4.4 Protection Of The Respiratory System

2.4.4.1 Respiratory Warnings

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

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

2.4.4.2 Respirator Use

- Laboratories shall persistently attempt to minimize respiratory exposure to potentially hazardous chemical substances through **engineering methods** or **administrative controls** (see **Section 2.4.1.1).**

- 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.

- 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*.

- 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)

- Per the requirements of the OSHA Respiratory Protection Standard (29 CFR 1910.134), 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 Cleaning/Disinfection
  - Respirator Storage

- 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 should contact the Office of EH&S, ext. 4196.

2.5 LABORATORY SAFETY EQUIPMENT

2.5.1 Chemical Fume Hoods

- **Purposes**

  · 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.

  · 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.

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

- **Principles of Safe Fume Hood Operation**

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

  · **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.

  · Hood sashes should be maintained at a minimum height (4 to 6 inches) when **not manipulating** chemicals or adjusting apparatus within the hood, to maximize face velocity flows.

  · 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 (typically 14") will ensure an adequate air velocity through the face of the hood

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

  · The **chemical manufacturer's or supplier's specific instructions** (located on the products MSDS 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]*

2.5.1 Chemical Fume Hoods -Principle of Safe Operation (cont.)

· 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 2.5.1** below.

The guidelines provided in **Table 2.5.1** are based on the following information, which is readily available on MSDS 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 2.5.1 - 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.
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)

Note: 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.

2.5.2 Eye Washes and Safety Showers

- **Access**

    · 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.

    · **Passageways** to the eyewash and shower should be kept clear of any obstacle (even a temporarily parked chemical cart).

- **Measurements and Inspections**

    · **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 ≥ **.4 gallons per minute**.

    · **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**.

    · Eyewash and shower flow inspections shall be **recorded** and maintained in the EH&S copy and your department's "Reference Copy" of the CHP, as **Appendix E.**

2.5.3 Fire Safety Equipment

- Fire safety equipment easily accessible to the laboratory **<u>must</u>** include:

    · A **fire extinguisher (type ABC)**

- Fire safety equipment easily accessible to the laboratory **<u>should</u>** include:

    · **Fire hoses**
    · **Fire blankets (*<u>required</u>* 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.

2.6 CHEMICAL PROCUREMENT, DISTRIBUTION, AND STORAGE

2.6.1 Procurement

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

2.6.1 Chemical Procurement (cont.)

· 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.

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

- No container should be accepted without an adequate identifying **label** as outlined in **Section 1.5.4** of this CHP.

2.6.2 Distribution

- 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.

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

- 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.

2.6.3 Storage

2.6.3.1 General Chemical Storage Guidelines

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

- **Secondary containers** (one inside the other) and **spill trays** should be used for high hazardous chemicals (e.g., especially strong reagents etc.).

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

- 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.

- All containers containing **hazardous waste** must be properly labeled.

2.6.3.2 Chemical Storage Separation Guidelines

· Liquid chemicals which are stored in glass containers, and/or large volumes of chemicals (regardless of container) should be grouped first into major hazard groups, and THEN stored in alphabetical order. **Table 2.6.3.2** provides these Chemical Storage Guidelines:

Table 2.6.3.2 - 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 in alphabetical order:

Phase	Hazard Group	Common Chemical Examples
Solid	explosive	picric acid (dried), picrates
	oxidizer	chlorates, dichromates, nitrates, perchlorates, permanganates, peroxides
	very reactive (w/ water or other chemicals)	aluminum chloride (anhydrous), calcium, calcium carbide, lithium, phosphorus pentachloride, phosphorus pentoxide, potassium, sodium, white phosphorus
Liquid	strong acid	hydrogen fluoride, hydrochloric acid
	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 very reactive/explosive	NA chlorosulfuric acid, chlorates, organic peroxides
Gas	strong acid/caustic	ammonia, hydrogen chloride
	flammable	acetylene

	oxidizer	chlorine, nitrous oxide

2.6.3.3 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 ≥ 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 2.6.3.3, found on the next page (limits also provided as Table 3.1.4 in Section 3.0 of this CHP):

Table 2.6.3.3 - Flammable Liquid Storage Limits

STORAGE CONTAINER	MAXIMUM ALLOWABLE VOLUME 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 (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*

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

vinyl chloride vinylidene chloride	propylene dichloride diethylamine	methyl methacrylate methylal		

2.6.3.4 Chemical Storage of Unstable Chemicals

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

- **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.

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

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

  - 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 **Section 3.2,** "Highly Reactive Chemicals and High Energy Oxidizers", for additional information and examples of materials which may form explosive peroxides.

2.7 CHEMICAL SPILLS & ACCIDENTS

2.7.1 Chemical Spills Preparation

- 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.

- General guidelines are provided on the next pages to assist laboratory personnel to assess and subsequently respond to chemical spills. Another document, entitled ***The Oakland University Emergency Action Plan***, addresses chemical spills in greater detail and is available upon request from the Office of EH&S, ext. 4196.

2.7.2 Assessing the Type of Spill: Incidental or Emergency

- **Incidental Release.** Release of a material which meets ALL of the following criteria:
  - Identity of material is KNOWN; and
  - 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); and

2.7.2 Assessing the Type of Spill - Incidental Release (cont.)

- "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., MSDS) necessary to respond safely and effectively to the accidental and/or uncontrolled release of a hazardous material.

- **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).

2.7.3 General Spill Response Guidelines

2.7.3.1 Responding to "Incidental" Spills

- People in the immediate area of the spill should be **alerted.**

- 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. MSDS or other safety literature) necessary to respond safely and effectively to the accidental and/or uncontrolled release of a hazardous material.

- The laboratory employee should make certain that he/she has **adequate ventilation** (e.g., windows open) in addition to ensuring that the fume hoods in the room are on.

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

- **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.

- 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 **Section 2.10**).

2.7.3.2 Responding to "Emergency" Spills

- **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.

2.7.3.2 Responding to "Emergency" Spills (cont.)

- **Door(s) to affected room(s) should be closed**.

- **Call "911",** 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 MSDS, 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.

- 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 the information obtained thus far. The responding EH&S employee shall report to the site and begin preliminary assessment and mitigation procedure/recommendations.

- The **Office of Environmental Health and Safety** is available for guidance and advice for all chemical spills and accidents. **Other OU resources**, including Jerry Compton (Chemistry), William Bradford (RSO) Paul Tomboulian (Chemistry), Dorothy Duffy (Chemistry), Michael Sevilla (Chemistry), and/or Kathleen Moore (Chemistry) can also assist with the spill "assessment process" if EH&S is not immediately available.

2.7.3.2 Responding to "Emergency" Spills (cont.)

- 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.

2.7.4 Mercury (Hg) Spills

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

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

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

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

- Mercury residues should be placed in a labeled container and disposed of as hazardous chemical waste, through the Office of EH&S (see **Section 2.10**).

2.7.5 Alkali Metal Spills

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

2.7.6 White Phosphorus Spills

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

2.8 PERSONAL CONTAMINATION AND INJURY

2.8.1 General Information

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

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

- **Seriously injured persons should**:
  - ➢ **Obtain medical attention** promptly by dialing ext. 911.
  - ➢ **Not be moved** unless remaining in that location will place that individual in additional danger
  - ➢ **Be covered** immediately with a blanket to protect against shock.

2.8.2 Chemicals Spills onto the Body

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

- 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.

- Chemicals should be washed off with **water** **only**. *Neutralizing chemicals, unguents, creams, lotions or salves are NOT appropriate.*

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

- **Skin-absorbed chemicals**.

  - 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.

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

2.8.3 Chemical Splash in the Eye

- 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.

- **Contact lenses should be removed immediately**.

- **Medical attention** should be obtained promptly by calling OU Police at ext. 911.

2.8.4 Ingestion of Hazardous Chemicals

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

- **OU Police** should be notified by dialing ext. 911.

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

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

- The ambulance crew and attending physician(s) should be provided with the chemical name and any other information, including the **MSDS and/or label** if possible.

2.8.5 Inhalation of Smoke, Vapors or Fumes

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

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

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

- **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)

2.8.6 Chemical Fires Involving Clothing

- 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**).

- 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.

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

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

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

2.8.7 Actions to be Avoided During Emergencies

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

- Emergencies should never be handled alone

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

2.9 FIRE AND FIRE RELATED EMERGENCIES

2.9.1 Discovery or Suspicion of Fire

- **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:

  · **Notify OU Police** by dialing ext. 911.

  · **Activate the building alarm** (fire pull station).

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

  · **Shut down equipment** in the immediate area, <u>if possible</u> without personal risk.

  · 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.

- **Portable fire extinguisher** should ONLY be used to:

  · control **<u>small</u>** fires **OR**

  · assist oneself or others to **evacuate**

2.9.2 Fire Alarm Response

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

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

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

2.10 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 regular 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.*

2.10 CHEMICAL WASTE DISPOSAL PROGRAM (cont.)

- Hoods should not be used for disposing of volatile chemicals.

- 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.*

2.10.1 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:

- Drain disposal is NOT an option unless the generating department:
  - is aware of the **exact chemical composition** of the waste being considered for drain disposal; AND
  - has determined whether a general or specific **City of Detroit prohibition** exists regarding (any of) the chemical constituents in the waste; AND
  - is confident that the chemical does not pose a **fire/explosion hazard**.

- A copy of the City of Detroit Ordinance (No. 23-86) is located in the Appendices of the *OU Hazardous Waste Management Guidance Manual*.

- 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

CHEMICAL EMERGENCY
Telephone Reporting Format

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)* if you require additional information upon arrival

FOR CHEMICAL SPILLS:

- **Approximately ____________** *(amount)* **of chemical is spilled (or leaking).**

- **The name of the material _is/is not_ known.** *If known,* **It is _____________** *(spell for dispatcher if possible)*

  - *If the release is due to a leak*: **The material _does/does not_ continue to "flow"**

  - *If leak is still being released, at what rate:* **The material is __________ (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 MSDS, placards on the product's transport vehicle, hazard warning label(s) on its container or packaging, and so on).*

- **The material _is/is not_ known to be flammable.** *If flammable,* **there _are/are not_ 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)*

- **The release _has/has not_ been contained to prevent its spread. It _did/did not_ enter the __________ sewer** *(give location of sewer if material did enter it).*

-- DO NOT HANG UP UNTIL REQUESTED --

CHEMICAL INCIDENT REPORT FORM

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

Section 3.0
HEALTH AND SAFETY INFORMATION FOR HAZARD CLASSES

NOTE:
For your convenience, an alphabetical list of common laboratory chemicals and their corresponding hazard classes is provided in Appendix A of this Chemical Hygiene Plan. Additionally, a list of chemical examples in each of the following hazard classes are listed within their corresponding segments (below).

3.1 FLAMMABLE LIQUIDS

3.1.1 General Information

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

- 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.

- 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.

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

- 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).

- For vapors of a flammable liquid to ignite/burn, three conditions must exist simultaneously:
  - the **concentration of the vapor** 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.

3.1.2 General Control Strategies

- **The concentration of flammable vapors** should be maintained below the lower flammability limit by persistently using local exhaust ventilation (e.g., fume hoods).

- The number of **open containers** holding flammables should be kept to a minimum.

- **Ignition sources should be removed**, including open flames, hot surfaces, operating electrical equipment and static electricity, wherever possible.

3.1.3 Handling Flammable Liquids

- **Gloves, protective glasses, and long sleeved lab coats** should be worn.

- **Metal or plastic containers, or safety cans** (versus glass) should be used as small storage containers for flammable liquids.

- Free flowing liquids generate static electricity, which can produce a spark and ignite the solvent. Thus, lab workers should **properly ground** the metal surfaces or containers through which flammable substances are flowing, thereby discharging static electricity.

- **Flammable substances should never be heated via open flames or ovens**. Alternate heat sources include steam baths, water baths, oil baths, heating mantles or hot air baths.

3.1.3.1 Handling Large Quantities of Flammable Liquids

- Large quantities of flammable liquids should be handled in **chemical fume hoods**.

- **Five gallon containers** <u>**must be**</u> dispensed to smaller containers in a chemical fume hood

- **Large quantities** of flammable liquids must be handled in areas free of ignition sources (including spark emitting motors and equipment) using non-sparking tools.

3.1.4 Storing Flammable Liquids

- Every effort should be made to store flammable substances **away from ignition sources** and in safety cans.

- **Flammable liquids should never be stored on the floor.**

- If no flammable storage cabinet is available, flammable substances should be stored **in cabinets under hoods or benches** (when available)**,** or in **safety cans**.

- Flammable liquids stored **in the open** in the laboratory work area shall be kept to the minimum necessary for the work being performed.

3.1.4 Storing Flammable Liquids (cont.)

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

- 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 2.6.3.2 (Section 2.0 of this CHP**)

- Flammable liquids which require refrigeration should 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.**

- Flammable chemicals should be **stored per the limits** provided in Table 3.1.4 on the next page (limits also provided as Table 2.6.3.3 in Section 2.0 of this CHP):

Table 3.1.4 - Flammable Liquid Storage Limits

STORAGE CONTAINER	MAXIMUM ALLOWABLE VOLUME 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 (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*

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

vinyl chloride vinylidene chloride	propylene dichloride diethylamine	methyl methacrylate methylal		

3.2 HIGHLY REACTIVE CHEMICALS

3.2.1 General Description

- Highly reactive chemicals include those which:
  - Are **inherently unstable** and susceptible to rapid decomposition; **or**
  - React violently or form potentially explosive mixtures or generate toxic gases, vapors or fumes, when **mixed with water**; **or**
  - Are cyanide- or sulfide- bearing chemicals that **generate toxic vapors** at a pH < 4.0; **or**
  - **Are capable of detonation or explosive reaction** when subjected to a strong initiating source or if heated in confinement.
- **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.

3.2.2 "Classes" of Reactive Materials

- **Reactive to Light:** Hydrogen and chlorine react together explosively in presence of light.
- **Reactive to Water:** Alkali metals, such as sodium, potassium and lithium, react violently with water liberating hydrogen gas.
- **Shock Sensitive:** Acetylides, azides, organic nitrates, nitro compounds, and many peroxides are shock sensitive.
- **Organic peroxides**
  - Organic peroxides constitute a special class of compounds with instability characteristics that make them among the **most hazardous substances** normally handled in the laboratories.
  - As a class, organic peroxides are **low- to high-powered explosives.**
  - 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.
  - Organic peroxides are also **highly flammable.**
  - **"Peroxide formers"**
    - Can form peroxides during storage and after exposure to the air once opened.

3.2.2 "Classes" of Reactive Materials - Organic Peroxides (cont.)

- Peroxide Formers Include:
  - aldehydes
  - ethers (especially cyclic ether)
  - compounds containing benzylic hydrogen atoms
  - compounds containing the allylic structure (including most alkenes)
  - vinyl and vinylidene compounds
- 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 [**Tables 3.2(SS) and 3.2(PF)**].

3.2.3 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.

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

➢ 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.

· The following **personal protection equipment** should always be worn:

➢ lab coats
➢ gloves
➢ protective glasses/goggles.
➢ A **face shield long enough to give throat protection** during the reaction.

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

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

3.2.3 Handling Reactive Chemicals (cont.)

- Shock sensitive materials should be **dated upon receipt**.
  - Sealed containers should be **discarded after one year** of receipt;
  - Containers that have been opened should be discarded **within six months of opening,** unless an inhibitor was added by the manufacturer.
- Glass containers that have **screw-cap lids or glass stoppers should not be used** to contain reactive materials.
- **Water-sensitive** compounds should be handled away from water sources.
- Highly reactive chemicals should be **handled away from direct light, open flames, and other sources of heat.**
- Highly reactive compounds should not be purchased, synthesized, or stored in the laboratories in **quantities** beyond what is immediately needed.
- 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.
- 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.
- **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.

3.2.4 Storage of Reactive Chemicals

- Store **water-sensitive** compounds away from water sources.
- Storage of reactives should be in **closed cabinets segregated from the materials with**

which they react and, if possible, in secondary containers.

· 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 2.6.3.2 (Section 2.0 of this CHP)**

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

3.2.4.1 Storage of Peroxide Forming Substances

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

· 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.

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

· 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.

3.2.5 Examples of Reactive Chemicals

Table 3.2(PF) - List of Peroxide Formers

The following are common laboratory chemicals which may form explosive peroxides:		
Acetal	Dimethyl ether	Sodium amide
Cyclohexene	Dioxane	Tetrahydrofuran
Decahydronaphthalene	Divinyl acetylene	Tetrahydronaphthalene
Diacetylene	Ether (glyme)	Vinyl ethers
Dicyclopentadiene	Ethylene glycol dimethyl ether	Vinylidene chloride
Diethyl ether	Isopropyl ether	
Diethylene glycol	Methyl acetylene	

3.2.5 Examples of Reactive Chemicals (cont.)

Table 3.2(SS) - List of Shock Sensitive Chemicals

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

3.3 HIGH ENERGY OXIDIZERS

3.3.1 Definition

- High energy oxidizers are those chemicals which **readily support combustion or produce vigorous reactions**, e.g., by giving off oxygen.

3.3.2 Handling High Energy Oxidizers

- **Always....**

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

  - 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.

  - **Always review safety literature** and discuss proposed reactions with supervisors.

  - Always manipulate oxidizing chemicals **inside fume hoods**.

  - Always wear the following **personal protection equipment**:

    - lab coats
    - gloves
    - protective glasses/goggles.

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

- **Never....**

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

  - Never use a **metal spatula** with peroxides; metals can lead to explosive decompositions.

  - Never work **alone.**

3.3.3 Storage of Oxidizers

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

- 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 and/or reactive/explosive liquids), see **Table 2.6.3.2 (Section 2.0)**.

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

3.3.4 Examples of High Energy Oxidizers

Table 3.3 - List of High Energy Oxidizers

The following are examples of powerful oxidizing reagents:

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

3.4 COMPRESSED GASES

3.4.1 General Hazard Information

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

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

- **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.

- 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.

3.4.2 Handling Compressed Gases

- **Personal Protection**

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

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

  - **Flashback arresters** and compatible metal tubing are required for all compressed flammable gases.

3.4.2 Handling Compressed Gases (cont.)

- **Cylinder Size**

  - 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.

- **Content ID.** The contents of any compressed gas cylinder should be clearly identified.

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

  - **Color coding is not a reliable means of identification**.

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

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

- **Equipment/Parts/Supplies**

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

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

  - **A regulator adaptor should NEVER be used.**

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

  - **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</u> <u>supplier</u>** should be used to open valves. Under no circumstances should pliers, pipe wrenches, or monkey wrenches be used to open cylinder valve.

3.4.2 Handling Compressed Gases (cont.)

- **Leaks**
  - **Soapy water** should be used to detect leaks.
  - **After any maintenance** or modifications, the regulator, piping system and other couplings should be tested.
- **Empty Cylinders**
  - **Cylinders should never be bled completely empty**. A slight pressure is necessary to keep contaminants out (172 kPa or 25 psi).
  - Empty cylinders **should not be refilled in the labs** unless equipped to prevent overfilling.
  - Employees should **return** empty cylinders to the manufacturer/supplier.

3.4.2.1 Special Precautions for Hydrogen

- 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.
  - Hydrogen has an extremely **wide flammability range** (LEL 4%, UEL 74.5%), making it easier to ignite than most other flammable gases.
  - Hydrogen's **temperature increases as it is liberated from its cylinder**
  - Hydrogen burns with an **invisible flame.**
  - **A piece of paper** can be used to tell if the hydrogen is burning.

3.4.2.2 Special Precautions for Oxygen

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

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

3.4.3 Storage of Compressed Gases

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

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

3.4.3 Storage of Compressed Gases (cont.)

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

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

- Gas cylinders must be **separated from incompatible cylinders** (e.g. never store oxygen, or other oxidizing reagent, cylinders next to flammable gas cylinders).

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

- **Empty and full cylinders should not be stored in the same place.**

3.4.4 Highly Toxic Gases

- The pressurized gases identified in **Table 3.4** below are particularly hazardous. **Section 1.7** of this CHP describes what is **required** of OU employees who work with these gases.

Table 3.4 - Highly Toxic Gases

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

3.5 CORROSIVE CHEMICALS

3.5.1 General Information

- **Major classes** of corrosive chemicals.
  - Strong acids (e.g., hydrogen fluoride, hydrochloric acid)
  - Strong bases (e.g., potassium hydroxide, ammonia)
  - Dehydrating agents (e.g., sulfuric acid, sodium hydroxide, phosphorus pentoxide)
  - Oxidizing agents (e.g., acid dichromate, chromic acid, chromium trioxide, hydrogen peroxide>30%, nitric acid, sodium peroxide, sulfuric acid)

3.5 Corrosive Chemicals - General Information (cont.)

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

- **Inhalation** of vapors or mists of these substances can cause severe bronchial irritation.

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

3.5.2 Classes of Corrosives

3.5.2.1 Strong acids

- Many concentrated liquid acids can damage the skin and eyes and their **burns are very painful.**

- **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.

3.5.2.2 Strong alkalis

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

- 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.

- 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).

3.5.2.3 Dehydrating agents

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

- 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.

- 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.

3.5.2.4 Oxidizing Corrosive Agents

- 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.

- See **Sections 3.2 and 3.3** of this CHP for more information on reactives and high energy oxidizers.

3.5.3 Handling Corrosives

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

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

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

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

- 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.

3.5.4 Storage of Corrosives

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

- 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 2.6.3.2 (Section 2.0 of this CHP)**.

3.5.5 Examples of Corrosive Chemicals

- A list of corrosive laboratory agents (and their physical states) is presented in **Table 3.5** below.

Table 3.5 - List of Corrosive Chemicals

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

Corrosive Chemicals Chemical Name	Physical State	Type of Corrosive Hazard
thioglycolic acid	L	corrosive
trichloroacetic acid	S	corrosive
zinc chloride	S	corrosive

3.6 TOXIC CHEMICALS

3.6.1 General Information - Acute and Chronic Toxicity

3.6.1.1 Acute Toxicity

3.6.1.1.1 Definition

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

- Short-Term Effects Include:

  - General effects:
    - Headache
    - Dizziness
    - Nausea
    - Shortness of Breath
    - Vomiting

  - Eye, Pulmonary or Skin Irritation

3.6.1.1.2 The Oral-LD_{50} toxicity test

- 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

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

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

- 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}s and Skin-LD_{50}s are much more accurate indicators of laboratory chemical toxicity (*when* this toxicological data are available).

3.6.1.1.3 Irritants

3.6.1.1.3.1 Pulmonary Irritants

- Pulmonary irritants cause inflammation of mucous membranes

- Can result in cough, tightness in chest, shortness of breath

3.6.1.1.3.1 Pulmonary Irritants (cont.)

- 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 3.6(A)** below.

3.6.1.1.3.2 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 3.6(A)** below.

3.6.1.1.4 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 3.6(A)** below:

Table 3.6(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 dimethylacetamide 1,1-dimethylhydrazine	toxic toxic toxic	inhalation, contact inhalation, contact 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

Chemical Name	Toxicity	Route of Exposure
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

Chemical Name	Toxicity	Route of Exposure
trichloroacetic acid	toxic irritant, eye/skin	inhalation, contact
uranium compounds	toxic	inhalation
zinc chloride zinc sulfate	toxic irritant, eye/skin/pulmonary	inhalation, contact inhalation, contact

3.6.1.2 High Acute Toxicity

3.6.1.2.1 General Description

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

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

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

  - has an **LC_{50}** less than 2,000 ppm (for volatile liquids or gases) OR

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

3.6.1.2.2 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 3.6(HA)** below

Table 3.6(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

3.6.1.3 Chronic Toxicity

3.6.1.3.1 General Description

- 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).

- A substance considered to present **chronic toxicity**....
  - 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)
  - is a **carcinogen or suspected carcinogen**;
  - is a **reproductive toxin** (mutagen or teratogen)
  - is a **skin or pulmonary sensitizer**

- Specific chronic toxicity information on the substances used in the laboratory can be found on these substances' **MSDS**. See **Section 1.5.3** for information on how to obtain/locate MSDS. 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.

- Chemical questions can be directed to the OU Chemical Hygiene Officer.

3.6.1.3.2 Reproductive Toxins

3.6.1.3.2.1 Definition

- There are two types of toxins which can be toxic to future generations:
  - **Mutagens** can cause a change (or “mutate”) 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.

3.6.1.3.2.1 Definition of Reproductive Toxins (cont.)

- **Data Available**

  · Information regarding reproductive toxicity can be found on **MSDS**. See **Section 1.5.3** for information on how to obtain/locate MSDS.

  · 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.

3.6.1.3.3 Sensitizers

· 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 3.6(S)** below.

3.6.1.3.4 Examples of Chemicals which Exhibit High Chronic Toxicity

· A list of common laboratory chemicals which exhibit **high chronic toxicity** to organ systems and/or suspected **carcinogenicity** is provided as **Table 3.6(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.*

· A list of common laboratory chemicals which exhibit **reproductive toxicity** is provided as **Table 3.6(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 <u>chronic</u> basis in academic/research laboratories.*

· A list of common laboratory chemicals which are known sensitizers is provided as **Table 3.6(S)** below.

Table 3.6(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 dimethyl sulfate 1,1-dimethylhydrazine	toxic carcinogenic carcinogenic	inhalation inhalation contact, inhalation
1,2-dimethylhydrazine	carcinogenic	inhalation
dioxane	carcinogenic toxic	contact, inhalation

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
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 3.6(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 3.6(S) - List of Sensitizers

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

3.6.2 Handling Chemicals Which Present High Acute or Chronic Toxicity

3.6.2.1 General Work Practices

- **Skin surfaces** - hands, forearms, face and neck - should be **washed** immediately following completion of the procedure(s).
- Work surfaces should be **decontaminated** after completing work with these chemicals.
- 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.,≥ 1 liter)**; AND/OR**
  - on a **regular basis** (i.e., ≥ 3 separate handling sessions per week); **AND/OR**

- ➢ for **long periods of time** (i.e., 4-6 hours at a time)

3.6.2.1 General Practices for Working with Toxic Chemicals (cont.)

- **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.

3.6.2.2 Engineering Controls

- 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.

- These chemicals should be **transported** between laboratories in durable outer containers.

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

- 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.

3.6.2.3 Personal Protective Equipment

- **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.

- **Full body protection** (disposable coveralls) should be considered if the potential for extensive personal contamination exists.
- All protective equipment should be removed when leaving the designated area and **decontaminated** (washed) or, if disposable, placed in a plastic bag and secured.

3.6.2.4 Designated Work Areas

- All chemicals exhibiting high acute or high chronic toxicity should be used in **designated (posted) areas.** See **Section 1.7** for more information regarding this OSHA requirement.

- 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 **Section 1.7** for more information regarding this OSHA requirement.

3.6.3 Storage of Chemicals Which Present High Acute or Chronic Toxicity

- **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).

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

- All chemicals exhibiting high acute or chronic toxicity should be stored in **designated (posted) areas.** See **Section 1.7** for more information regarding this OSHA requirement.

Section 4.0
CHEMICAL TOXICOLOGY

4.1 CHEMICAL TOXICOLOGY OVERVIEW

4.1.1 Toxicology Definitions

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

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

- **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:

  - Absorption through the **respiratory tract** via inhalation.

  - Absorption through the **skin** via dermal contact.

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

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

4.1.2 Dose-Response Relationship

- **Toxicity** of a substance is exhibited only when:

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

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

- **Dose-Response Premise**

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

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

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

4.1.3 Occupational Exposure Standards

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

  · The **ACGIH** (American Conference of Governmental Industrial Hygienists) develops **TLVs** (Threshold Limit Values):

    - An organization devoted to the administrative and technical aspects of occupational and environmental health, the ACGIH is a **professional society**, 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.

  · **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.

- **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)**.

  · **"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.

4.1.4 Types of Toxic Effects

- **Acute Effects**
  - Toxic effects (symptoms) are experienced after a **short, single exposure**
- **Chronic Effects**
  - Toxic effects (symptoms) are experienced after **prolonged or repeated exposures** of a duration measured in days, months or years.
  - Symptoms are not apparent during, or immediately following, exposure.
- **Cumulative Effects**
  - Toxic effects which occur as a result of chemical "build up" in the body as a result of numerous chronic exposures.
  - Effects are not seen until a **"critical body burden"** is reached.
- **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.
- **Systemic Effects**
  - Adverse health effects that take place at a location distant from the body's initial point of contact.
- **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.

4.1.5 Factors Affecting Toxicity

- **Nature of the Chemical**
- **Route of exposure**, i.e., inhalation, skin contact and/or ingestion
- **Duration of exposure**, i.e., length of the TOTAL exposure (either at one time or over a series of repeated exposures)
- **Rate of entry**, or how fast the chemical dose is delivered
- **Concentration** of the chemical
- **Host factors**, including ***genetic predisposition***, ***gender*** and ***age*** of the exposed individual
- **Previous exposure** to the substance (can lead to tolerance, increased sensitivity or make no difference)
- **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.

4.1.6 Toxicity By Physical Classification

- **Aerosol Toxicity**
  - Aerosols are composed of solid or liquid microscopic particles dispersed in gaseous medium.
  - The **toxic potential** of an aerosol is only partially described by its airborne concentration.
  - 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.

4.1.6 Toxicity By Physical Classification (cont.)

- **Gas or Vapor Toxicity**
  - **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.

4.1.7 Physiological Classifications

4.1.7.1 Asphyxiants

- **Simple asphyxiants** are...
  - Inert gases that displace oxygen
  - **Examples** include:
    - ➢ Nitrogen
    - ➢ Helium
    - ➢ Nitrous oxide
    - ➢ Carbon dioxide
    - ➢ Hydrogen
- **Chemical asphyxiants...**
  - Reduce the body's ability to absorb, transport, or utilize inhaled oxygen
  - They are often active at very low concentrations (a few ppm)
  - **Examples** include:
    - ➢ carbon monoxide
    - ➢ cyanides

4.1.7.2 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 3.6(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.*

4.1.7.3 Irritants

- **Pulmonary Irritants**

  - Materials that cause **inflammation of mucous membranes** with which they come in contact.

  - Can result in **cough, tightness in chest, shortness of breath**

  - Inflammation of tissue results from exposure to **concentrations far below** those needed to cause corrosion.

  - Irritants can also cause changes in the **lung function.**

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

  - **Primary Pulmonary Irritants**

    - 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.

  - **Secondary Pulmonary irritants**

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

  - Examples of pulmonary irritants can be found in **Table 3.6(A),** Section 3.0 of this CHP.

- **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 can be found in **Table 3.6(A)**, Section 3.0 of this CHP.

4.1.7.4 Mutagens

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

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

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

4.1.7.5 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.

4.1.7.6 Primary Anesthetics =Neurotoxins (see Section 4.1.7.9 below)

4.1.7.7 Sensitizers

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

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

- A list of common laboratory chemicals which are known Sensitizers is provided as **Table 3.6(S)**, Section 3.0 of this CHP.

4.1.7.8 Teratogens = **embryotoxic or fetotoxic agents** (see Section 4.1.7.9 below)

4.1.7.9 Target-Organ Agents (chemical examples are in **Table 4.2)**

- **Embryotoxic or fetotoxic agents** interfere with normal embryonic development without causing a <u>lethal</u> effect to the fetus or damage to the mother. Effects are not inherited.

- **Hematopoietic Agents** act on the **blood** or **hematopoietic system**, including bone marrow

- **Hepatotoxic agents** cause damage to the liver

- **Nephrotoxic agents** damage the kidneys

- **Neurotoxic agents** depress or otherwise damage the brain and or central nervous system

4.2 EXAMPLES OF TARGET ORGAN EFFECTS

Table 4.2 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 4.2 - Target Organ Effects from Chemical Exposures

Toxins	Target Organ Effects	Signs & Symptoms	Example Chemicals	
Embryo- or Fetotoxins	Affect unborn fetus	fere with normal developmen s	nium on disulfide roform SO	thane chloride
Hematopoietic toxins	Decrease blood function	osis of consciousness	ne nic ene on monoxide	ides -benzene ene
Hepatotoxins	liver damage	dice enlargement	roform l thylsulfate	osamines hloro-ethylene ene
Nephrotoxins	kidney damage	na einuria	roform thylsulfate genated hydrocarbons	cury ium
Neurotoxins	Affect CNS	vior changes eased coordination osis	ene on disulfide on tetrachloride	 cury benzene

SECTION 5
GLOSSARY OF TERMS USED IN MSDS

ACGIH - See the AMERICAN CONFERENCE OF GOVERNMENTAL INDUSTRIAL HYGIENISTS

ACUTE EFFECTS - Short-term effects (generally reversible)

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

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 asphyxiants, 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.

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.

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.

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 100°F (37.8°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".

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.

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

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

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.

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 below 100°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 MSDS.

g - See GRAM

g/Kg - See GRAMS PER KILOGRAM.

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).

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

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.

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

NARCOSIS - Stupor or unconsciousness caused by exposure to a chemical

NFPA - The National Fire Protection Association is a voluntary membership organization whose aims are to promote and improve fire protection and prevention. NFPA has published 16 volumes of codes known as the National Fire Codes. 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.

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.

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. A hazardous polymerization is the above reaction with an uncontrolled release of energy.

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

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 MSDS.

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

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.

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.

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 - 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 - 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 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).