Chemical Hygiene Plan

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Chapter 1. Principles of Laboratory Safety

Section 1. OSHA Laboratory Standard

The Occupational Safety and Health Administration (OSHA) Laboratory Standard, OSHA 29 CFR 1910.1450, *Occupational Exposure to Hazardous Chemicals in Laboratories*, was created to minimize employee and student exposure to hazardous chemicals in the laboratory. The OSHA Laboratory Standard can be viewed on the OSHA Web site:
http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=10106

The OSHA Laboratory Standard definition of a Chemical Hygiene Plan is: A written program developed and implemented by the employer which sets forth procedures, equipment, personal protective equipment and work practices that are capable of protecting employees from the health hazards presented by hazardous chemicals used in that particular workplace..."

The Marshall University Chemical Hygiene Plan (CHP) was developed to outline the University's commitment to protecting the health and wellbeing of its faculty, staff, students, visitors, and the environment; as well as to meet the requirements of the OSHA Laboratory Standard. The CHP establishes general rules for the safe handling, storage, and disposal of hazardous chemicals and sets forth prudent work practices that are designed to protect employees and students from exposure to chemical hazards and unsafe work practices in the laboratory. To protect its students and employees from hazardous materials and unsafe work practices, the University has established safety rules and regulations for all academic laboratories, research laboratories, prep rooms, and other workplaces utilizing hazardous chemicals.

Section 2. Health Hazards

According to OSHA, a hazardous chemical is a chemical for which there is statistically significant evidence, based on at least one study conducted in accordance with established scientific principles, that acute or chronic health effects may occur in exposed persons. Acute exposure is defined as short durations of exposure to high concentrations of hazardous materials in the work place. Chronic exposure is defined as continuous exposure over a long period of time to low concentrations of hazardous materials in the work place.

Many of the chemicals and solutions that are routinely used in academic laboratories can present a significant health hazard when handled improperly. The Swiss physician and alchemist Theophrastus Phillippus Aureolus Bombastus von Hohenheim (1493-1541), who took the name Paracelsus later in life in homage to Celsus, a Roman physician, is known as "The Father of Toxicology." Paracelsus is famous for his quote, "What is it that is not poison? All things are poison and nothing is without poison. It is the dose alone that makes a thing not a poison."

Engineering controls (i.e., chemical fume hoods and glove boxes), administrative controls (i.e., safety rules, Chemical Hygiene Plans, and Standard Operating Procedures), work practices (prohibition of mouth pipetting, and substitution of non-hazardous or less hazardous chemicals when applicable), and use of personal protective equipment (PPE) (i.e., gloves, lab coats, and chemical splash goggles) are designed to protect laboratory workers from exposure to hazardous materials. Routes of exposure to hazardous materials include absorption, inhalation, ingestion, and injection.

Health hazards in the laboratory include toxic, flammable, corrosive, irritant, sensitizing, and carcinogenic chemical substances. The effect of an exposure to a hazardous material can be acute or

chronic, depending upon the hazardous material and the length of time that one was exposed to it. Acute health effects appear rapidly after only one exposure and can result in rashes, dizziness, coughing, and burns. Chronic health effects may take months or years before they are diagnosed. Symptoms of chronic exposure can include joint paint, neurological disorders, and tumors.

A chemical allergy is an adverse reaction (i.e., rash or hives) to a chemical. Some persons have developed chemical sensitivities to certain chemicals or types of chemicals, including ammonia, iodine, bromine, and sulfur. Such reactions are usually the result of a previous sensitization to that particular chemical, or one that is similar in nature. The protein in soft, flexible latex rubber gloves can cause mild or severe, life-threatening latex allergic reactions in some persons.

Chemicals may pose a potential health hazard to people with existing health problems, women of childbearing age and women who are pregnant or breastfeeding. Faculty, staff, and students who have existing medical conditions, are pregnant or nursing, or who learn of their pregnancy while working in a chemistry lab or while enrolled in a laboratory course should consult with their health care provider about possible health consequences from exposure to chemicals and biologic organisms. These persons are encouraged to discuss personal health matters with their health care provider prior to enrolling or continuing in the course.

Section 3. Physical Hazards

Examples of physical hazards in the laboratory include gas cylinders, cryogenic liquids, electrical equipment, lasers, magnetic fields, and reactions that involve high pressure or vacuum lines. Another type of physical hazard is the presence of spilled liquids or broken glassware on the floor or in the work space. Good housekeeping practices serve to eliminate these physical hazards. Laboratory workers must follow all departmental safety rules and policies to avoid injuries associated with physical hazards.

Section 4. Safety Data Sheets

Formerly known as an MSDS, or Material Safety Data Sheet, these documents provide important information about chemicals. With the OSHA adoption of the Globally Harmonized System (GHS) in 2012, MSDS was changed to SDS. An SDS is designed to provide employees and emergency personnel with the proper procedures for handling, storage, and disposal of the material. While the name was changed, the information provided remains the same and in a standardized 16-section format:

1. Identification of the substance or mixture and of the supplier
    - GHS Product Identifier
    - Other means of identification
    - Recommended use of the chemical and restrictions on use
    - Supplier’s details (including name, address, phone number etc.)
    - Emergency phone number

2. Hazard identification
    - GHS classification of the substance/mixture and any national or regional information
    - GHS label elements, including precautionary statements. (Hazard symbols may be by pictogram or by the name of the pictogram e.g. “flame”, “skull and crossbones”);
    - Other hazards which do not result in the classification (e.g. “dust explosion hazard”) or are not covered by the GHS.

3. Composition/information on ingredients:

Substance

- Chemical identity;
- Common name, synonyms, etc.;
- CAS number and other unique identifiers
- Impurities and stabilizing additives which are themselves classified and which contribute to the classification of a substance.

Mixture

- The chemical identity and concentration or concentration ranges of all ingredients.

4. First aid measures
   - Description of necessary measures, subdivided according to the different routes of exposure, i.e. inhalation, skin and eye contact and ingestion;
   - Most important symptoms/effects, acute and delayed.
   - Indication of immediate medical attention and special treatment needed, if necessary.

5. Fire-fighting measures
   - Suitable (and unsuitable) extinguishing media.
   - Specific hazards arising from the chemical (e.g. nature of hazardous combustion products).
   - Special protective equipment and precautions for fire-fighters.

6. Accidental release measures
   - Personal precautions, protective equipment and emergency procedures.
   - Environmental precautions.
   - Methods and materials for containment and cleaning up.

7. Handling and storage
   - Precautions for safe handling.
   - Conditions for safe storage, including any incompatibilities.

8. Exposure controls/personal protection
   - Control parameters e.g. occupational exposure limit values or biological limit values.
   - Appropriate engineering controls.
   - Individual protection measures, such as personal protective equipment.

9. Physical and chemical properties
   - Appearance (physical state, color etc.); Odor; Odor threshold; pH; Melting point/freezing point; Initial boiling point and boiling range; Flash point; Evaporation rate; Flammability (solid, gas); Upper/lower flammability or explosive limits; Vapor pressure; Vapor density; Relative density; Solubility; Auto-ignition temperature; Decomposition temperature; Viscosity.

10. Stability and reactivity
    - Reactivity;
    - Chemical stability;
    - Possibility of hazardous reactions;
    - Conditions to avoid (e.g. static discharge, shock or vibration);
    - Incompatible materials;
    - Hazardous decomposition products.

11. Toxicological information

- Information on the likely routes of exposure (inhalation, ingestion, skin and eye contact);
- Symptoms related to the physical, chemical and toxicological characteristics;
- Delayed and immediate effects and also chronic effects from short and long term exposure;
- Numerical measures of toxicity (such as acute toxicity estimates).

12. Ecological information

- Ecotoxicity (aquatic and terrestrial, where available);
- Persistence and degradability;
- Bioaccumulative potential;
- Mobility in the soil;

13. Disposal information

Description of waste residues and information on their safe handling and methods of disposal, including the disposal of any contaminated packaging.

14. Transport information

- UN number;
- UN proper shipping name:
- Transport hazard class / classes;
- Packing group, if applicable
- Environmental hazards (e.g.: Marine pollutant (Yes/No));
- Transport in bulk (according to Annex II of MARPOL 73/78 and the IBC Code);
- Special precautions which a user needs to be aware of, or needs to comply with, in connection with the transport or conveyance within or outside their premises.

15. Regulatory information

Safety, health and environmental regulations specific for the product in question.

16. Other information including information on preparation and revision of the SDS

A comprehensive file of Safety Data Sheets (SDS) must be kept on file in the laboratory / work area and be readily accessible to all employees during all work shifts. SDSs can be made available to employees via the Internet, but all personnel in the workplace must have access to a computer and be trained on how to access the correct SDS information. Helpful SDS search web sites are included in Appendix B. All departments/entities are required to maintain SDS information for their programs and ensure information is updated regularly, and that SDSs for materials no longer in use are maintained for 30 years.

Laboratory workers should always READ and HEED the label and the Safety Data Sheet before using a chemical for the first time. Know the types of PPE that you will be required to wear when handling the chemical. Ensure that the ventilation in the laboratory will be adequate for your needs. Be familiar with the departmental and lab Chemical Hygiene Plan and Emergency Action Plan in the event of a chemical spill, fire, or explosion.

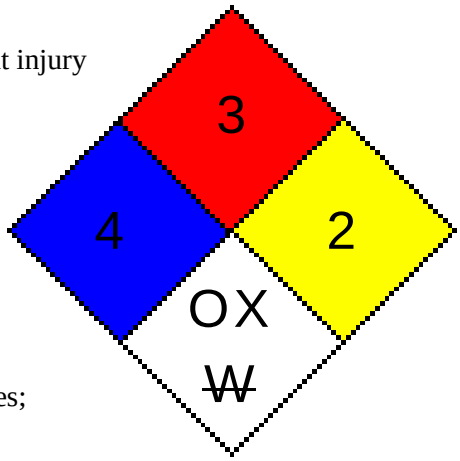
Section 5. NFPA Classification System

In the event of an emergency in a laboratory, the National Fire Protection Association (NFPA) 704 "fire diamond" is designed to provide information to emergency responders regarding the chemical contents of a laboratory. The fire diamond provides information on the degree of danger for health hazards, fire hazards, and instability hazards. This information is also useful for personnel working in or around laboratories that have hazardous materials.

The NFPA fire diamond is commonly displayed on chemical labels, secondary container labeling in the academic laboratories, and on the SDS. Additionally, it must be posted on entrance door(s) to each laboratory or area where hazardous materials are present. When posted on the laboratory door, the numerical ratings refer to the contents of the entire laboratory, not to a specific chemical within the laboratory. It is useful to conduct a chemical inventory to identify the hazards of all chemicals present and fill in the NFPA 704 diamond with this information, using the highest rating in each block from all of the chemicals present.

NFPA 704: Standard System for the Identification of the Hazards of Materials for Emergency Response, 2012 Edition

BLUE - HEALTH HAZARD
4 - Very short exposure can be lethal or cause major permanent injury
3 - Short exposure can cause serious temporary or moderate permanent injury
2 - Can cause temporary incapacitation or residual injury
1 - Can cause significant irritation
0 - Poses no health hazard, no precautions necessary



RED - FLAMMABILITY HAZARD
4 - Will rapidly vaporize, or is readily dispersed in air, and will readily burn; flash point below 73 °F
3 - Can be ignited under almost all ambient temperature conditions; flash point between 73 °F and 100 °F
2 - Must be moderately heated or exposed to high ambient temperatures; flash point between 100 °F and 200 °F
1 - Must be heated before ignition can occur; flash point over 200 °F
0 - Materials that will not burn

YELLOW - INSTABLITY HAZARD
4 - Readily capable of detonation or explosive decomposition at normal temperatures and pressures
3 - Capable of detonation or explosive decomposition but must be heated; reacts explosively with water, or will detonate if severely shocked
2 - Readily undergoes violent chemical change at elevated temperatures and pressures; reacts violently with water, or may form explosive mixtures with water
1 - Normally stable, but can become unstable at elevated temperatures and pressures
0 - Normally stable, even under fire conditions; not reactive with water

WHITE - SPECIAL HAZARD
Note: In accordance with the NFPA 704 Standard, only the following symbols are authorized in this block:
~~W~~ - Materials that violently or explosively with water (water reactivity rating of 2 or 3)
OX - Materials that possess oxidizing properties
SA – Materials that are simple asphyxiant gases, limited to: nitrogen, helium, neon, argon, krypton, and xenon

Chapter 2. Chemical Hygiene Responsibilities

Section 1. President of the Institution

1. Responsible for the implementation, enforcement, and support of all Environmental Health and Safety (EH&S) programs, in particular the Marshall University Chemical Hygiene Plan (CHP).

Section 2. Environmental Health and Safety

1. Provides general and specific laboratory safety training to employees upon request.
2. Provides technical assistance to laboratory employees regarding chemical handling, storage, use, and disposal.
3. Conducts exposure assessments upon request. Maintains environmental monitoring and employee exposure records. Submits monitoring results to the Chemical Hygiene Officer and the Dean/Director within five working days of receipt.
4. Audits the Chemical Hygiene Plan, chemical inventory, and SDS records in each department on an annual basis.
5. Conducts annual testing of chemical fume hoods and posts the testing results on each chemical fume hood in the department.
6. Provides annual laboratory inspections to ensure compliance with the University Chemical Hygiene Plan.
7. Provides technical assistance regarding personal protective equipment and safety equipment.
8. Provides technical assistance to employees to ensure code compliance.

Section 3. Dean of the College

1. Assumes responsibility for all departments engaged in the use of hazardous chemicals, and. ensures that each department remains in compliance with federal, state, local, and university regulations and policies.
2. Appoints a Safety Coordinator for the College and provides the support necessary to implement and maintain health and safety programs.
3. Provides budgetary arrangements to ensure the health and safety of the employees of the college.

Section 4. College Safety Coordinator

1. Serves as the Dean's liaison with Department Chairpersons, directors, faculty, staff, and students regarding health and safety issues.
2. Oversees the development and revisions of departmental Chemical Hygiene Plans, chemical inventories, emergency plans, and chemical waste disposal plans.
3. Serves as the College liaison with Environmental Health and Safety to ensure that all departments are in compliance with federal, state, local, and university regulations and policies regarding chemical storage and waste disposal.
4. Writes, designs, oversees production, and serves as the editor of the College safety documents.
5. Keeps current of legal requirements concerning regulated substances.

Section 5. Department Chairperson

1. Assumes responsibility for departmental personnel engaged in the use of hazardous chemicals.
2. Appoints a departmental Chemical Hygiene Officer and provides the support necessary to implement and maintain the departmental Chemical Hygiene Plan.

3. Meets with supervisors to discuss cited violations and ensure timely actions to protect employees, students, and facilities and to ensure that the department remains in compliance after receipt of inspection report from the Chemical Hygiene Officer.
4. Provides budgetary arrangements to ensure the health and safety of departmental employees, students, and visitors.
5. Serves as Chair of the Departmental Safety Committee, and appoints a faculty member and a graduate student member to serve on the Committee.

Section 6. Chemical Hygiene Officer (CHO)

1. Establishes and maintains a departmental Chemical Hygiene Plan that will serve to promote a safe and healthy environment in which to teach, learn, and conduct research.
2. Revises departmental safety policies and Chemical Hygiene Plan as needed. Revisions of safety documents are reviewed and approved by the Department Chair.
3. Serves on the Departmental Safety Committee
4. Monitors procurement, use, storage, and disposal of chemicals.
5. Conducts regular inspections of the laboratories and prep rooms. Submits detailed laboratory inspection reports to the Department Chair and to the College Dean.
6. Maintains inspection, personnel training, and inventory records.
7. Assists laboratory supervisors in developing and maintaining adequate facilities.
8. Keeps current of legal requirements concerning regulated substances and hazardous materials.
9. Notifies employees of the availability of medical attention under the following circumstances:
    - Whenever an employee develops signs or symptoms associated with a hazardous chemical to which the employee may have been exposed in the laboratory.
    - Where exposure monitoring reveals an exposure level routinely above the action level for an OSHA regulated substance for which there are exposure monitoring and medical surveillance requirements.
    - Whenever a spill, leak, explosion, or other occurrence resulting in the likelihood of a hazardous exposure occurs.

10. If medical attention is necessary, the CHO provides the attending physician the identity of the hazardous substance to which the employee may have been exposed; a description of the conditions under which the exposure occurred.
11. The CHO will notify affected employees in writing of any monitoring results either individually or by posting results in an appropriate location accessible to employees. This information shall be distributed within five working days upon receipt of the results from Environmental Health and Safety.
12. Encourages laboratory employees to attend specialized training (i.e., first-aid training, fire extinguisher training, and compressed gas cylinder training).

Section 7. Departmental Safety Committee

1. Review accident reports and make appropriate recommendations to the Department Chairperson regarding proposed changes in established procedures.
2. Perform inspections on an annual basis, or as needed, with the Chemical Hygiene Officer. Prepare a detailed inspection report to be submitted to each faculty member/laboratory supervisor and the Department Chairperson.

Section 8. Laboratory Supervisor

1. Ensures that laboratory workers comply with the departmental Chemical Hygiene Plan and do not operate equipment or handle hazardous chemicals without proper training and authorization.

2. Always wears personal protective equipment that is compatible to the degree of hazard of the chemical.
3. Follows all pertinent safety rules when working in the laboratory to set an example for his or her supervisees.
4. Reviews laboratory procedures for potential safety problems before assigning to other laboratory workers.
5. Ensures that visitors follow the laboratory rules, and assumes responsibility for all laboratory visitors.
6. Ensures that personal protective equipment is available and properly used by each laboratory employee and visitor.
7. Maintains and implements safe laboratory practices.
8. Monitors the facilities and the chemical fume hoods to ensure that they are maintained and function properly. Contacts Environmental Health and Safety to report problems with the facilities or the chemical fume hoods.

Section 9. Laboratory Worker

1. Reads, understands, and follows all safety rules and regulations that apply to the work area.
2. Plans and conducts each operation, laboratory class, or research project in accordance with the departmental and University Chemical Hygiene Plan.
3. Promotes good housekeeping practices in the laboratory or work area.
4. Communicates appropriate portions of the CHP to students in the work area.
5. Notifies the supervisor of any hazardous conditions or unsafe work practices in the work area.
6. Uses personal protective equipment as appropriate for each procedure that involves hazardous chemicals.
7. Immediately reports any job-related illness or injury to the supervisor.

Chapter 3. Personal Apparel and Personal Protective Equipment (PPE)

Section 1. Personal Apparel

1. Clothing that provides protection from chemical spills must be worn. Clothing must sufficiently cover the upper and lower body, including long pants (or long skirt) and the equivalent of a t-shirt. Shorts and short skirts are inappropriate apparel.
2. Closed-toed shoes must be worn at all times. Perforated, open-toed, open-backed, or high-heeled shoes, clogs, or sandals are not appropriate.
3. For your protection, jewelry (i.e., rings, bracelets, necklaces, and watches) should not be worn. Chemicals can seep under the jewelry and cause injuries to the skin, and can damage it. Jewelry can also become caught in machinery and can conduct electricity.
4. Hair longer than shoulder length and loose sleeves must be confined.

Section 2. Personal Protective Equipment (PPE)

1. Always review new procedures and refer to the SDS to determine the proper PPE required for each chemical to be used.
2. Wear chemical splash goggles that conform to ANSI Z87.1-2003, *Occupational and Educational Personal Eye and Face Protection Devices*, at all times (and over eyeglasses).

Safety glasses — **do not protect the face and eyes from chemical splashes. Not approved for use in chemistry laboratories.**

Impact goggles — **are for use where flying debris is a hazard. Vents and holes around seal will not stop fluids. Not approved for use in chemistry laboratories.**

Chemical splash goggles — **protect the face and eyes in the event of a chemical splash. Approved for use in chemistry laboratories.**

3. A face shield (in addition to chemical splash goggles) should be used when there exists a possibility of splashes to the face, fire, explosion, or implosion.
4. Protective safety glasses with UV-absorbing lenses should be worn when working with radiation of wavelengths shorter than 250 nm (welding glasses).
5. Gloves that are appropriate to the degree of hazard must be worn at all times. Consult the SDS and review glove manufacturer specifications to ensure protection is provided, particularly for highly toxic materials. Inspect gloves for defects before wearing. Remove gloves before handling pens, notebooks, doorknobs, radios, computer keyboards, and telephones. Remove gloves before exiting the laboratory.
6. Lab coats must be worn at all times in laboratories. Rubber aprons are recommended when working with highly corrosive or caustic materials.

Chapter 4. Facilities

Section 1. Laboratory Design

1. The laboratory facility will have an appropriate ventilation system to avoid intake of contaminated air.
2. The stockrooms and storerooms must be well ventilated.
3. The laboratory will include proper storage cabinets and storage areas for chemicals.
4. The laboratory will have available properly functioning chemical fume hoods and laboratory sinks.
5. Other safety equipment in the laboratory will include fire extinguishers, safety showers, fire blankets, and eyewash stations.
6. Experimental work should be appropriate to facilities available.
7. Modifications to the laboratory facility cannot be undertaken without consultation with the Department Chair, the Chemical Hygiene Officer, and Environmental Health and Safety.

Section 2. Laboratory Ventilation

1. Laboratory procedures involving hazardous chemicals must not be started if there is a possibility that the ventilation system cannot handle the gas or vapor emissions from the procedure.
2. General ventilation provides a source of breathing air and a source for make-up air for local ventilation devices. The laboratory ventilation should have a performance level of 10-20 room changes per hour. An inadequate ventilation system can cause an increased risk by creating a false sense of security in the laboratory. Laboratory air must not be recirculated within the building.
3. There should be 2.5 linear feet of hood space for each worker who spends the majority of his or her time working with hazardous chemicals.
4. Hood face velocity should be 60-120 linear feet per minute.
5. All chemical fume hoods will be tested on an annual basis by Environmental Health and Safety and inspection results will be posted on the fume hood.
6. To ensure their safety and health, all personnel must properly use and maintain the chemical fume hoods.

- When using the hood, the sash opening should be kept at a minimum to ensure the efficiency of the operation.
- All chemicals and equipment should be placed at least six inches from the hood face to ensure proper air flow.
- Use the hood when there is a possibility of release of toxic chemical vapors, dusts, or gases, particularly when working with any volatile substance.
- Keep hoods closed when not in use.
- Do not store chemicals or equipment in the hood.
- All persons should be discouraged from walking in front of a hood that is in use. Such behavior disrupts the air flow in front of the hood.
- Keep your head and body outside of the hood face, and listen for changes in the air flow.
- Do not rely on the hood for protection against explosions. Plan your experiments wisely.
- Keep the sash glass clean and to not obstruct the view of the hood with posters, decals, or other items.

Section 3. Building Security

1. All laboratory doors must be closed and locked when workers or students are not present.
2. If you are working in a laboratory or office and leave for any reason or any length of time, you must close and lock the door.

3. Do not loan your building keys to anyone else.
4. Immediately report the loss or theft of your keys to the Chemical Hygiene Officer.
5. Do not permit unauthorized persons to enter laboratories or offices.
6. Do not prop open doors or leave doors ajar in laboratory facilities.
7. If an employee should discover that criminal activity has occurred in either building, he or she should immediately notify the Marshall University Police Department, 696-HELP (4357).

Chapter 5. General Protocols

Section 1. Avoiding Routine Exposure to Hazardous Chemicals

1. Thoroughly review all proposed laboratory procedures to determine the potential health and safety hazards before beginning work. Refer to the SDS for guidance on chemical storage, handling, and disposal. Avoid underestimation of risk when handling hazardous materials.
2. Minimize all chemical exposure. Avoid ingestion, injection, inhalation, eye contact, and skin contact with hazardous materials.
3. Observe the PEL (Permissible Exposure Limit) and TLV (Threshold Limit Value) of each hazardous material in the laboratory. These limits are listed in the SDS.
4. The choice of chemicals to be used should be appropriate to the facilities available and should not exceed the capacity of the exhaust system.
5. Do not smell or taste chemicals. When instructed to smell a chemical, gently waft the vapors toward your nose. Do not directly inhale the vapors.
6. Vent apparatuses which may discharge chemicals (vacuum pumps, distillation columns, etc) into chemical fume hoods.
7. Inspect gloves and glove boxes before use.
8. Do not allow release of hazardous substances into environmentally controlled rooms since these rooms recirculate the air.
9. Always wash exposed areas of skin after chemical usage and before exiting the work area.
10. Never wear gloves or lab coats outside of the laboratory. Laboratory workers should wash laboratory apparel separately from personal clothing.
11. Eating, smoking, using smoke-less tobacco products, drinking, chewing gum, or applying cosmetics in laboratories is prohibited.
12. Food and beverages are not to be stored in chemical storage areas or refrigerators.
13. Do not use glassware or utensils used for laboratory work for any other purpose (i.e., drinking from beakers).
14. Keep chemical containers closed when not in use. Do not leave funnels in chemical waste collection containers.

Section 2. General Housekeeping Practices in the Laboratory

1. Access to exits, emergency equipment, and utilities must never be blocked. Coats, bags, and other personal items must be stored in the proper area, not on the bench tops or in the aisle ways.
2. Properly label chemicals and equipment for use and storage. Repair or replace any damaged labels immediately. Secondary containers must be labeled with the chemical name, manufacturer's name, hazard information, and any other special warnings listed on the original label.
3. Floors should be cleaned on a regular basis. Promptly wipe up all liquid spills and ice on the floor.
4. Keep work areas clean and uncluttered. Bench tops and hoods should remain free of broken glass, spilled chemicals, paper litter, etc.
5. Chemical hazards should be maintained at least two inches from the edge of the bench tops.
6. Hallways and stairways should not be used as storage areas.
7. Do not conduct unattended experiments without the authorization and prior approval of the Laboratory Supervisor.
8. Do not store materials or chemicals on the floor.
9. Do not block sink drains. Place rubber matting in the bottom of the sinks to prevent breakage of glassware and avoid injuries.

10. Wear appropriate gloves to clean glassware. Do not pile up dirty glassware in the laboratory. Wash glassware carefully. Dirty water can mask broken glass fragments. Handle and store laboratory glassware with care. Promptly discard cracked or chipped glassware.
11. Clean up work areas at the end of the operation or day.
12. Properly dispose of broken glass and sharps (i.e., needles and razor blades). Broken glass should be collected in heavy cardboard boxes or plastic buckets with lids. Broken glass boxes/buckets should be disposed in the regular trash. If broken glassware is contaminated with a hazardous substance, the glassware must be treated as a hazardous substance.
13. To avoid accidents, drawers and cabinets must be kept closed.
14. Properly dispose of all waste chemicals. Never pour waste chemicals down the drains.
15. To avoid the presence of noxious fumes arising from the sewer lines, the Laboratory Supervisor should ensure that water is poured down each laboratory floor drain on at least a monthly basis to ensure that the drain trap is functional.
16. Formal housekeeping and laboratory inspections will be conducted on a regular basis by the Chemical Hygiene Officer and/or the Departmental Safety Committee.

Section 3. General Safety Rules

1. Employees are not permitted to deviate from the assigned work schedule without prior authorization from the Laboratory Supervisor. Unauthorized experiments are strictly forbidden.
2. Plan appropriate protective procedures and plan the positioning of all equipment before beginning any operation. Follow the appropriate Standard Operating Procedures (SOP) at all times in the laboratory.
3. Read the SDS and the label before using a hazardous chemical.
4. Report all injuries, accidents, incidents, and near-misses to the Chemical Hygiene Officer.
5. Know the location and proper use of the safety equipment, (i.e., eyewash station, safety shower, fire extinguisher, first-aid kit, and fire blanket) emergency telephone, and fire alarm in the area in which you are working.
6. Appropriate personal protective equipment must be worn at all times.
7. Appropriate eye protection (chemical splash goggles and/or a face shield) must be worn by all persons (including visitors) where hazardous chemicals are used or stored.
8. Wear appropriate gloves when handling toxic materials. Inspect all gloves for holes and defects before using.
9. The use of contact lenses in the laboratory is strongly discouraged. If an employee must wear contact lenses when working with hazardous substances, the employee must notify his or her supervisor so that all special precautions can be taken.
10. Do not wear synthetic finger nails, which are made of extremely flammable polymers that burn to completion and are not easily extinguished.
11. Notify your supervisor if you experience sensitivities to any chemicals.
12. When heating a test tube or other apparatus, never point the apparatus toward yourself or other persons in the area.
13. Always protect your hands when cutting glass tubing. Do not attempt to dry glassware by inserting a glass rod wrapped with paper towels. Always lubricate glassware with soap or glycerin before inserting rods, tubing, or thermometers. Hot glass looks just like cold glass, be sure that your glassware has cooled before you touch it.
14. Dilute concentrated acids and bases by slowly pouring the acid or base into water while stirring.
15. Secure all water, gas, air, and electrical connections in a safe manner.
16. Do not pipette any substance by mouth in the laboratory; use a mechanical pipette.
17. Properly dispose of all chemical wastes. Do not pour chemicals down the drains.
18. Report any unsafe conditions to the Laboratory Supervisor or Chemical Hygiene Officer.
19. Children and other unauthorized persons are not permitted in areas with hazardous chemicals in use.
20. Hair longer than shoulder length and loose sleeves must be confined.

Section 4. Unattended Operations

1. Obtain permission from the supervisor prior to conducting any unattended operations.
2. Leave lights on and post a sign on the door announcing an unattended operation.
3. Return periodically to check on the unattended operation.
4. Provide for the containment of toxic substances in the event of equipment or utility failure.
5. Water hoses must be securely fastened to faucets and apparatus to avoid floods.
6. The laboratory door should be posted with emergency contact names and telephone numbers.

Section 5. Signs and Labels

1. Emergency signs shall be posted on all laboratory and prep room doors. The signs must contain the names and telephone numbers of all emergency contact personnel.
2. The NFPA 704 "fire diamond" must also be posted on the exterior of all doors for areas where hazardous chemicals are stored. The sign must be filled out completely, based on the overall hazard of the materials present. A template is available on the EH&S web site: www.marshall.edu/safety/chemical/storage.asp
3. All unwanted chemicals and chemical waste containers must be properly labeled. A label template is available on the EH&S web site, link above. Date, contents, and hazards must be indicated.
4. Signs must be provided at all designated location(s) for safety shower, eye wash, fire extinguisher, first-aid station, fire blanket, and emergency telephone.
5. Areas with special or unusual hazards must have signage reflecting these hazards.

Section 6. Laboratory Equipment

1. Electrical equipment should be maintained only by trained individuals. Properly ground all electrical equipment. Report any electrical failure or suspicious heating of equipment to the Laboratory Supervisor immediately. Periodically inspect electrical equipment. Ensure quick access to electrical equipment shut-offs in the event of an emergency. Ensure that all electrical hand tools are double insulated or grounded.
2. Centrifuges should be anchored securely to the bench top. Close the lid before operating and remain with the centrifuge until full operating speed is attained. If vibration occurs, stop the centrifuge and check the counter-balance load. Periodically clean the buckets and rotors to avoid contamination.
3. Take extra precautions when using Dewar flasks; shield or wrap them with tape to contain implosions.
4. Use laboratory equipment for the intended purpose only.
5. Regularly clean and examine all laboratory equipment.
6. Extension cords must only be used for periods of 24 hours or less. Power strips are the preferred alternative to extension cords. Do not block walkways or aisles with extension cords or power strips. Periodically inspect extension cords and power strips for visible defects.
7. When using lasers, always wear appropriate eye protection and do not look directly at the source of the beam. Do not aim the laser by sighting along the beam. Keep the laser beam at or below chest height. Reflective materials should not be allowed near the beam. Hang warning signs when lasers are in use.
8. When using UV lamps, wear UV-absorbing eye protection, as described in the operating procedures for the instrument. Cover exposed skin.

Section 7. Environmental Monitoring

1. Regular employee exposure monitoring will be provided by EH&S upon request.
2. Regular monitoring for airborne substances may be appropriate when testing a new ventilation system or when redesigning laboratory hoods.

3. Regular monitoring may be appropriate if a hazardous substance is stored in the laboratory or if the substance is used routinely (three times a week or more.)

Section 8. Medical Monitoring Program

The institution has established an Employee Medical Monitoring Program. In compliance with OSHA 29 CFR 1920.20, employee records will be maintained for the length of employment plus 30 years. The employee will be monitored:

- if the employee develops signs and symptoms of exposure associated with a hazardous chemical.
- when exposure monitoring routinely exceeds the action level for an OSHA regulated substance.
- in the event of a spill, leak, explosion, or other occurrence resulting in the likelihood of exposure.

Section 9. Records Maintenance

1. Accident report forms will be submitted to the Chemical Hygiene Officer.
2. Medical records are to be retained by EH&S.
3. The Chemical Hygiene Officer and the EH&S will retain copies of all personnel training records.
4. The Chemical Hygiene Officer will retain an up-to-date copy of the chemical inventory; a copy will be forwarded to EH&S.
5. The Chemical Hygiene Officer will maintain the departmental Chemical Hygiene Plan.

Chapter 6. Chemical Management

Section 1. Introduction

The prudent management of hazardous materials, from their procurement to their disposal, is a critical element of a successful laboratory safety program. Chemical management includes the following processes:

1. Chemical Procurement
2. Chemical Storage
3. Chemical Handling
4. Chemical Inventory
5. Transportation of Chemicals
6. Chemical Waste Collection and Disposal

Section 2. Chemical Procurement

When preparing to order a chemical for an experiment, there are several questions that one should ask, including:

- Do I really need to order this chemical?
- How much do I really need to order to perform my experiment?
  REMEMBER THAT WHEN ORDERING CHEMICALS, LESS IS ALWAYS BEST
  Order the least amount of chemicals that will be needed to save storage space, money, and disposal costs.
- What personal protective equipment (PPE) is required when handling this chemical?
- Is the proper PPE available in the laboratory?
- What is the level of training that is required to use this chemical?
- Are there special handling precautions?
- Does the laboratory have the proper storage facilities?
- Does the laboratory chemical fume hood provide proper ventilation?
- Are there special containment considerations in the event of a spill, fire, or flood?
- Will the institution provide disposal of this chemical? Are there additional costs related to the disposal of this chemical?

According to the OSHA Lab Standard, Appendix A, Section D.2.a (Chemical Procurement, Distribution, and Storage; Procurement), "Before a substance is received, information on proper handling, storage, and disposal should be known to those who will be involved." Additionally, Section D.2.a (Chemical Procurement, Distribution, and Storage; Procurement) states, "No container should be accepted without an adequate identifying label. Preferably, all substances should be received in a central location."

Only authorized personnel should purchase chemicals and other hazardous materials, such as gas cylinders. The Chemical Hygiene Officer should review all hazardous material requisitions. If you or your group should receive a gratis shipment of chemicals from any source, submit a copy of the bill of lading or packing slip to the Chemical Hygiene Officer. Ultimately, the purchaser of the chemical accepts responsibility for the ownership of the chemical. All chemical shipments in the Chemistry Department are received and processed by the chemical stockroom staff in Room 455, Science Building.

Section 3. Chemical Storage

In the event of a chemical spill or fire, incompatible chemicals that are stored in close proximity can mix to produce fires, toxic fumes, and explosions. To protect the laboratory worker, chemicals must be separated and stored according to hazard category and compatibility. Read the SDS and heed the precautions regarding the storage requirements of the chemicals in your laboratory. Chemical compatibility resources are available on the Environmental Health and Safety web site: http://www.marshall.edu/safety/chemical, as well as in *Prudent Practices in the Laboratory: Handling and Disposal of Chemicals*.

All chemical containers must be properly labeled. To avoid accidents and potentially costly fines from federal regulatory agencies, all secondary container labels should contain:

- Chemical name
- Hazard warnings and/or pictograms
- Name of manufacturer
- Name of researcher in charge
- Date of transfer to the vessel

Promptly date all incoming chemical shipments and rotate stock to ensure use of older chemicals. Peroxide-formers should be dated upon receipt and dated again when the container is opened so that the user can dispose of the material according to the recommendations on the Safety Data Sheet. Store peroxide-formers away from heat and light in sealed, airtight containers with tight-fitting, non-metal lids. Test regularly for peroxides and discard before expiration dates. See *Management of Peroxide-Forming Chemicals* on the Environmental Health and Safety web site for specific information: http://www.marshall.edu/safety/chemical-safety/hazardous-materials/.

When storing chemicals on open shelves, always use sturdy shelves that are secured to the wall and contain ¾" lips. To avoid accidents, do not store liquid chemicals over five feet in height on the open shelves. Do not store anything, especially chemicals, within 18 inches of the sprinkler heads in the laboratory. Use secondary containment devices (i.e., chemical resistant trays) where appropriate. Do not store chemicals in the laboratory fume hood; on the floor; in aisle ways, hallways, areas of egress; or on the bench top. Store chemicals away from heat and direct sunlight.

Only laboratory-grade explosion-proof refrigerators and freezers may be used to store chemicals that require cool storage in the laboratory. Chemicals that are stored in a refrigerator must be in sealed and properly labeled containers. Periodically clean and defrost the refrigerator/freezer to ensure maximum efficiency. Never use domestic refrigerators and freezers to store chemicals since they possess ignition sources and can cause dangerous and costly laboratory fires and explosions. Do not store food or beverages in any laboratory refrigerator. Label all refrigerators that contain biological or radioactive materials with the appropriate symbols and warnings. Conduct regular testing and inspections of the refrigerators to ensure that they are not contaminated with radioactive materials.

Highly toxic chemicals must be stored in a well-ventilated, secure area that is designated for this purpose. Cyanides must be stored in a tightly closed container and securely locked in a cool, dry, cabinet. Access to the cabinet must be restricted. Protect cyanide containers against physical damage and separate them from incompatibles. Follow good hygiene practices and regularly inspect your PPE. Use proper disposal techniques.

Hydrofluoric acid (HF) quantities in the laboratory must be kept at a minimum for the planned usage. Personnel must be trained on the proper techniques to handle HF. Calcium gluconate gel (2.5%)

must be present in the laboratory for treatment purposes in the event of an exposure. Standard first-aid treatments for acid burns do not apply to an HF exposure. Rinse with cool water for five minutes only, apply the calcium gluconate gel, and immediately seek medical attention.

Tax-free ethanol (managed through the Chemistry Department stockroom) must be stored in a securely locked cabinet within the laboratory. Minimize quantities and restrict access.
All flammable liquids must be stored in approved flammable liquid containers and storage cabinets. National Fire Protection Association (NFPA) regulations limit the quantity of flammables per cabinet, lab space, and building. See *Management of Flammable and Combustible Materials* on the EH&S web site for specific information:
http://www.marshall.edu/safety/files/2013/03/Management_of_Flammable_and_Combustible_Materials.pdf

Chemical storage cabinets may be used for long-term storage of limited amounts of chemicals. Rooms that are used specifically for chemical storage and handling (i.e., prep rooms, storerooms, waste collection rooms, and laboratories) are controlled-access areas. Chemical storage rooms should be professionally designed and must provide proper ventilation, two means of access/egress, vents and intakes at both ceiling and floor levels, a diked floor, and automatic water sprinklers (with the exception of water-reactive chemical storage). The chemical storage room must be a spark-free environment and one must use only spark-free tools within the room. Special grounding must be installed to prevent static charge while dispensing solvents.

Section 4. Chemical Handling

Important information about handling chemicals can be found in the Safety Data Sheets (SDS). A comprehensive file of SDSs must be kept in the work area, and must be available to all employees during all work shifts. If a department elects to us online access rather than hardcopies of the SDSs, all personnel must have computer access during the work shift, and must be trained on how to find the SDSs for the chemicals used or stored in their area.

All personnel should READ and HEED the container label and the Safety Data Sheet before using a chemical for the first time.

It is important to know the types of PPE that are required to when handling chemicals. Ensure that the ventilation in the laboratory will be adequate for your needs. Be familiar with the departmental Chemical Hygiene Plan and Emergency Action Plan in the event of a chemical spill, fire, or explosion.

Section 5. Chemical Inventory

Why do we maintain chemical inventories in our labs? The OSHA Lab Standard, Appendix A, Section D.2.b states, *"Stored chemicals should be examined periodically (at least annually) for replacement, deterioration, and container integrity"* and Section D.2.d states, *"Periodic inventories should be conducted, with unneeded items being discarded or returned to the storeroom/stockroom."*

What are the benefits of performing annual chemical inventory updates?

- Ensure that chemicals are stored according to compatibility tables.
- Eliminate unneeded or outdated chemicals.
- Ability to share chemicals in emergency situations.
- Update the NFPA 704 hazard diamond posted on the laboratory door.
- Promote more efficient use of lab space.

- Check expiration dates of peroxide-formers.
- Check the integrity of the shelving and storage cabinets.
- Force lab supervisors to make "Executive Decisions" about dusty bottles of chemicals.
- Repair/replace labels and caps.
- Ensure compliance with all federal, state, and local record keeping regulations.
- Promote good relations and a sense of trust with the community and your emergency responders.
- Reduce the risk of exposure to hazardous materials and ensure a clean and healthy laboratory environment.

The amounts of hazardous materials should be carefully monitored in the laboratory. A physical chemical inventory should be performed at least annually, or as requested by the Chemical Hygiene Officer. A thorough inventory will eliminate unneeded or outdated chemicals and will ultimately result in more efficient use of laboratory storage space. A *Chemical Inventory Form* is available on the EH&S web site in Excel format: http://www.marshall.edu/safety/files/2013/03/Chemical_Inventory_Form.xls

Safety Issues Related to the Chemical Inventory Process include:

- Wear appropriate PPE and have extra gloves available.
- Use a chemical cart with side rails and secondary containment.
- Use a laboratory step stool.
- Read the Emergency Action Plan and be familiar with departmental safety equipment.
- If necessary, conduct a work stand down while you perform the inventory.

Section 6. Transportation of Chemicals

Always use a secondary containment device (i.e., rubber pail) when transporting chemicals from the storeroom to the laboratory or even short distances within the laboratory. Use carts with attached side rails and trays of single piece construction at least two inches deep to contain a spill that may occur. Bottles of liquids should be separated to avoid breakage and spills. Never transport liquid chemicals in basket-type carts. Do not overfill carts. Avoid high traffic areas when moving chemicals within the building.

Plan your work to avoid class changing times and other times when students are in the hallways. When possible, use freight elevators when transporting chemicals and do not allow other passengers. If you must use a general traffic elevator, ask other passengers to wait until you have delivered your chemicals. When transferring flammable liquids from a drum, always ground the drum and the receiving vessel to prevent a static charge buildup.

To protect faculty, staff, and students, all planned demonstrations and chemistry magic shows that will be performed that are not a part of normal instructional activities must be pre-approved and authorized by the Chemical Hygiene Officer. Faculty who are interested in participating in such activities and plan to use departmental chemicals and apparatus must submit the following information, in writing and two weeks in advance of the planned event, to the Chemical Hygiene Officer:

The location of the demonstration
The date of the event
The age of the intended audience
The number of persons who will attend the event
The degree of audience participation
The demonstrations that will be performed
A list of chemicals that will be transported to the demonstration site
The personal protective equipment that will be worn and by whom

All chemicals that are transported to the demonstration site must be handled in a prudent manner, packaged appropriately, properly labeled, and transported back to Chemistry Department stockroom for disposal via the university chemical waste disposal system. Under no circumstances should any chemicals that originated at the Chemistry Department be left at the demonstration site or disposed of at the demonstration site. Prior to the planned event, event organizers should ensure that, in the event of an accident involving chemicals in their personal vehicles, they will be covered under their personal insurance policies. Many insurance policies forbid the transport of any chemicals from the workplace in personal vehicles.

The American Chemical Society (ACS) publication, "National Chemistry Week (NCW) and Community Activity - Safety Guidelines" provides an excellent resource for personnel who perform demonstrations and magic shows and can be found at the ACS Web site: http://www.acs.org/content/dam/acsorg/education/policies/safety/safety-guidelines-for-ncw-and-community-activities.pdf

Submit all chemicals to be shipped outside the department, either domestically or internationally, to the stockroom manager, room 455, Science Building. The U.S. Department of Transportation oversees the shipment of hazardous materials and will impose significant fines and citations in the event of non-compliance.

Section 7. Chemical Waste

Chemical waste must be processed according to the policies of the institution. The *Unwanted Chemical Pickup Request Form* is available on the EH&S web site: http://www.marshall.edu/safety/files/2013/04/Unwanted-Chemical-Pickup-Request-Form.doc. Hazardous waste will be collected on an as-requested basis by institutional personnel. Please do not leave waste at the Chemistry Department Stockroom for disposal.

Waste containers should be the minimum size that is required. Leave at least one inch of headspace in the liquid container to allow for expansion.

It is the policy of Marshall University that all waste chemicals must be placed into appropriate waste containers in the laboratories.

Do not pour chemicals down the drains or dispose in the trash.

Chapter 7. Compressed Gas Safety

Section 1. General

All laboratory workers must know and understand the properties, uses, and safety precautions of the gas before using the gas and/or associated equipment. Consult the supplier and the Safety Data Sheets for the particular gases being used. The Laboratory Supervisor should provide proper training and instruction for all personnel handling compressed gases. Chemical splash goggles and leather gloves are recommended for handling compressed gas cylinders.

Section 2. Gas Cylinder Handling

Never drag or slide a gas cylinder, even for short distances. Cylinders should be moved by using a suitable hand cart. Securely fasten the cylinder cap prior to transporting a gas cylinder. Never drop cylinders or permit them to strike each other violently. The valve protection cap must be left in place until the cylinder has been secured against a wall or bench, placed in a cylinder stand, or on a cylinder cart and is ready to be used.

Cylinders must be secured at all times. Do not tamper with safety devices in valves or cylinders and never permit oil, grease, or other readily combustible substances to come in contact with cylinders, valves, or regulators for oxidizing gases. Do not remove or deface the product identification labels or decals, or change the cylinder color. Never lift a cylinder by the cap. Promptly return empty or unneeded cylinders to the appropriate gas cylinder storage area.

Section 3. Storage of Gas Cylinders

Cylinders should be stored in an upright position. Cylinders should be assigned to a definite, isolated area for storage and the area posted with the names of the gases stored. Separate cylinders of gases belonging to various categories, taking into account the nature of the gases. Segregate full and empty cylinders. The area should be dry, cool, and well-ventilated, and preferably fire-resistant. Keep cylinders protected from excessive temperatures by storing them away from radiators or other sources of heat. Cylinders must be secured while in storage.

Open flames are prohibited in oxidant or flammable gas cylinder storage areas. Cylinders containing oxidizers must be separated from flammable gas storage areas or combustible materials by at least 20 feet (6 meters) or by a noncombustible wall. Store only the amount of flammable or toxic gas required for a specific application. Store cylinders containing flammable gases away from other combustible materials. Cylinders containing flammable gases and mixtures should be properly grounded. Store empty and full cylinders separately and arrange full cylinders so that old stock is used first. Ensure that an adequate supply of water is available for first-aid, fire action, or dilution of corrosive material in the event of a spill.

Section 4. Use of Gas Cylinders

The cylinder decal or label is the only positive way to identify the gas contained in a cylinder. Color coding of cylinders is an identification method used for the convenience of the cylinder supplier only. Do not use cylinders as rollers for moving material or other equipment. Never attempt to mix gases in a cylinder. Never transfer gases from one cylinder to another. Never use oxygen as a substitute for compressed air. No part of a cylinder should be subjected to temperatures above 130°F (54°C). Prevent

sparks or flames from welding or cutting torches or any other source from coming in contact with cylinders. Do not permit cylinders to come in contact with electrical apparatus or circuits.

Use regulators and pressure relief devices when connecting cylinders to systems of lower pressure service ratings. Only regulators approved for the specific gas should be used. Open the cylinder valve before adjusting the pressure on the regulator. Always open the cylinder valve slowly. Valves should be closed on cylinders and all pressure released from equipment connected to the cylinder at the end of a task or any time an extended nonuse period is anticipated. If a cylinder protective cap is extremely difficult to remove, do not apply excessive force or pry the cap loose with a bar inserted into the ventilation openings.

Attach a label or tag to the cylinder identifying the problem and return the cylinder to the supplier. Wrenches should not be used on valves equipped with a hand-wheel. If the valve is faulty, attach a label or tag to the cylinder identifying the problem and return the cylinder to the supplier. Use only oxygen-compatible threading compounds such as Teflon tape on valve threads for oxygen service.

Section 5. Gas Regulators

1. General

Most regulators are similar in appearance; however, a principle difference occurs at the inlet connection. Inlet connection standards are established by the Compressed Gas Association (CGA). It is important that the inlet connection of the regulator is properly mated with the supply valve connection, as specified by the established standards for the service intended. Checking proper mating will avoid putting the regulator into the wrong service.

2. Selecting a Regulator

Select a regulator which is suited for the particular gas service. CGA valve outlets are noted for each gas and gas mixture and the CGA inlet for the regulator must correspond. Never use regulators with gases other than those for which they were intended.

3. Using a regulator

Identify the regulator. Check the label and the inlet and outlet gauges. Ascertain that the high pressure gauge is suitable for the pressure of the cylinder or source system. Inspect the regulator for evidence of damage or contamination. If there is evidence of physical damage or foreign material inside the regulator, return it to the supplier. Inspect the cylinder valve for evidence of damage. Attach the regulator to the cylinder and tighten the inlet nut securely. Close the regulator by turning the adjusting knob to the full counterclockwise position. The regulator must be closed before opening the cylinder valve.

4. Safety Check the System

Make sure that the regulator adjusting knob is turned fully counterclockwise. Standing with the cylinder valve between yourself and the regulator, place both hands on the cylinder valve and open it slowly, allowing the pressure to rise gradually in the regulator. When the high pressure gauge indicates maximum pressure, open the cylinder valve fully. Always close the cylinder valve when it is no longer necessary to have it open. Do not leave it open when the equipment is unattended or not in operation.

5. Adjusting the Pressure

Turning the adjusting knob clockwise, establish the required use pressure by referring to the low pressure gauge. Make sure that the cylinder valve is easily accessible. Never exchange the discharge (low pressure) gauge for one of lower pressure. The gauge may rupture if the adjusting knob is unintentionally turned too far.

6. Precautionary Measures

Check diaphragm regulators for creep (leakage of gas from the high pressure side when the low pressure side is turned off). Provide check valves. Gas from a high pressure system may back up, so backpressure protection is needed to prevent damage to a regulator.

7. Removing the Regulator from Service

Close the cylinder valve. Vent the gases in the regulator and/or system, or isolate the system and vent the gases in the regulator by turning the adjusting knob clockwise to make certain that no pressure is trapped inside the regulator. If the gas is flammable, an oxidant, corrosive, or toxic, take appropriate measures to render it innocuous by employing a suitable disposable system before venting the gas to the atmosphere. After relieving all the gas pressure, turn the adjusting knob counterclockwise as far as possible.

All low pressure equipment connected to sources of high pressure should be disconnected entirely or, if not, independently vented to the atmosphere as soon as the operation is completed or shut down for an extended period of time. Disconnect the regulator. If the regulator is to remain out of service, protect the inlet and outlet fittings from dirt, contamination, or mechanical damage. Replace the cylinder valve cap.

Section 6. Basic Emergency Action Procedures Involving Gas Cylinders

1. Pre - Emergency Planning

Be prepared. Dealing with compressed gas emergencies begins with planning. An emergency response plan should be developed for the laboratory. As a minimum, the plan should include:

- •Emergency telephone numbers
- •Emergency response organizational charts
- •Emergency procedures
- •Listing of key personnel
- •Training schedules and documentation
- •Hazardous materials lists (including storage locations, quantities, etc.)
- •Emergency response equipment lists
- •Facility maps

2. Fire Extinguishing Methods

Before working with any flammable material, first notify the Chemical Hygiene Officer about the type of material being handled and the best method to use in fighting that particular kind of fire. If an emergency should occur in which gas is burning, **stop the flow of gas before extinguishing the fire**. If the fire is extinguished before the gas is turned off, an explosive mixture with air may be formed, which could result in more extensive damage. However, if the fire must be extinguished before an immediate shutoff of the gas supply can be accomplished, use carbon dioxide or dry chemical extinguishers.

Cool the surrounding area with water spray to prevent ignition of other combustible materials. The possibility of oxidizing gases, nonflammable toxic gases, or nonflammable corrosive gases being present in the area or being involved in a fire is another important safety consideration. Develop procedures to eliminate or minimize the hazards associated with these products.

3. Handling of Leaking Cylinders

Most leaks occur at the valve used in the top of the cylinder. Areas that may be involved are:
•Valve threads
•Safety device
•Valve stem
•Valve outlet

If a leak develops, immediately notify the Chemical Hygiene Office and effect emergency action procedures. Never attempt to repair a leak at the valve threads or safety device. Consult the supplier for instructions if the leak is located at the valve stem or valve outlet.

The following general procedures are for leaks of minimum size where the indicated action can be taken without serious exposure to personnel.

- If a leak develops in a cylinder containing flammables, inerts, or oxidants, ensure that there is adequate ventilation to dissipate the gas. Move the cylinder to an isolated area (away from combustible material if it is a flammable or oxidizing gas) and post signs that describe the hazards and state warnings.
- Some corrosives are also oxidants or flammables, adding to the seriousness of the leak. If the product is corrosive, the leak may increase in size as the gas is released. Move the cylinder to an isolated, well-ventilated area and use suitable means to direct the gas into an appropriate chemical neutralizer. Post signs that describe the hazards and state warnings.
- Follow the same procedure for toxic gases as for corrosive gases. Move the cylinder to an isolated, well-ventilated area and use suitable means to direct the gas into an appropriate chemical neutralizer. Post signs that describe the hazards and state warnings.
- If it is necessary to move a leaking cylinder through populated portions of the building, place a plastic bag, rubber shroud, or similar protection over the top and tape it (preferably with duct tape) to the cylinder to confine the leaking gas.
- Basic action for large or uncontrollable leaks should include the following steps:
  - Notify the Chemical Hygiene Officer
  - Evacuation of personnel
  - Rescue of injured personnel by crews equipped with adequate protective clothing and breathing apparatus
  - Fire-fighting action
  - Emergency repair
  - Decontamination

Section 7. Cryogenics

The temperature used to distinguish between cryogenics and refrigeration depends on the source to which one is referring. Temperatures as low as -150°C (-238°F) are used as the upper limit for defining a fluid as cryogenic. The most commonly used temperature is -73°C (-100°F).

1. General Safety Precautions

As stated above, the potential hazards in handling all cryogenic liquids stem from their two main properties:

Because they are all extremely cold, cryogenic liquids and their cold "boil-off" vapor can rapidly freeze human tissue, and can cause many common materials such as carbon steel, plastics, and rubber to become brittle or even fracture under stress. Care must also be given to the method of joining (welding, etc.) the materials. Cryogenic liquids in containers and piping at temperatures at or below the boiling point of liquefied air (-194°C or -318°F) can actually condense the surrounding air to a liquid. The extremely cold cryogenic fluids (liquid hydrogen and liquid helium) can solidify air or other gases.

All cryogenic liquids produce large volumes of gas when they vaporize. If these liquids are vaporized in a sealed container, they can produce enormous pressures which could rupture the vessel. For this reason, pressurized cryogenic containers are usually protected with multiple devices for pressure relief. Common protective devices are pressure relief valves for primary protection and frangible discs for secondary protection. Vaporization of all liquid cryogenics, except oxygen, in an enclosed work area can create an oxygen-poor atmosphere. Vaporization of liquid hydrogen in an enclosed work area can create a flammable mixture with air.

Personnel should be thoroughly instructed and trained in the nature of cryogenic hazards and the proper steps to avoid them. This should include emergency procedures, operation of equipment, safety devices, knowledge of the properties of materials used, and personal protective equipment required.

Equipment and systems should be kept scrupulously clean and contaminating materials (oil, grease, etc.) avoided as these may create a hazardous condition upon contact with cryogenic fluids or gases used in the system.

Mixing of gases or liquids should be strictly controlled to prevent the formation of flammable or explosive mixtures. As the primary defense against fire or explosion, extreme care should be taken to avoid contamination of a fuel with an oxidant or contamination of an oxidant with a fuel. When flammable gases are being used, potential ignition sources must be carefully controlled.

2. Handling

Always handle cryogenic liquids carefully. At their extremely low temperatures, they can produce cryogenic burns on the skin and freeze tissues. When spilled on a surface they tend to cover it completely and therefore cool a large area. The vapors from these liquids are also extremely cold and can produce burns. Use both hands when handling cryogenics. Do not use a cell phone when handling cryogenics or allow yourself to be distracted in any other manner.

Exposure to these cold gases which is too brief to affect the skin of the face or hands can affect delicate tissues, such as those of the eyes. Stand clear of boiling or splashing liquid and its issuing cold gas. Boiling and splashing always occur when charging a warm container or when inserting objects into the liquid. Always perform these operations slowly to minimize boiling and splashing. Never allow any unprotected part of your body to touch uninsulated pipes or vessels containing cryogenic liquids; the extremely cold material may stick fast and tear the flesh when you attempt to withdraw it.

Even nonmetallic materials are dangerous to touch at low temperatures. Use tongs to withdraw objects immersed in a cryogenic liquid. In addition to the hazards of frostbite or flesh sticking to cold materials, objects that are soft or pliable at room temperature, such as rubber or plastics, are easily broken because they become hard and brittle at these extremely low temperatures. Carbon steels become brittle at low temperatures and may easily fracture when stressed.

3. Protective Clothing

Chemical splash goggles must be worn during the transfer process and during normal handling of cryogenic liquids. If severe spraying or splashing may occur, a face shield should be worn for additional protection. Dry leather gloves or fiberglass gloves should always be worn when handling anything that comes in contact with cold liquids or vapor. Gloves should be loose fitting so that they can be removed quickly if cryogenic liquids are spilled into them. Depending on the application, special clothing may be advisable. Wear trousers on the outside of shoes. Personnel working with cryogenic fluids should not wear watches, rings, bracelets, and other jewelry.

4. Containers

Cryogenic liquids are stored, shipped, and handled in several types of containers, depending upon the quantity required by the user. The most common containers for laboratory use are the Dewar or the liquid cylinder. Since heat leak is always present, vaporization takes place continuously. Rates of vaporization may be as low as 0.4% and as high as 3% of container content per day, depending upon the design of the container and the volume of the stored product. Customized containers must be designed and constructed to withstand the weights and pressures that will be encountered, and adequately ventilated to permit the escape of evaporated gas. They should also be equipped with rupture disks on both inner and outer vessels to release pressure if the safety relief valves should fail. As there is always some gas present when using liquefied gases, container capacity should be designed to include an allowance for that portion which will be in the gaseous state.

Dewar

This type of container is considered a non-pressurized container. The unit measure of capacity of the Dewar is the liter, and they come in sizes ranging from 5 to 200 liters. Product may be removed by pouring from a small Dewar. Product should be removed from a 50-liter or larger capacity Dewar by means of low pressurization and a transfer tube. A dust cap over the outlet of the neck tube prevents atmospheric moisture from plugging the neck tube. These containers cannot be used for liquid helium or liquid hydrogen.

Chapter 8. Emergency Preparedness

Section 1. Fire Alarm Policy

When a fire alarm sounds in the facility, you must evacuate the laboratory immediately via the nearest exit. Extinguish all flames and turn off all equipment, as appropriate, before exiting. Faculty and teaching assistants must ensure the orderly and expeditious evacuation of the students from the classrooms and laboratories. Personnel who violate this fire alarm policy will be subject to citations and/or arrest by the responding university and city officials.

Section 2. Emergency Safety Equipment

A written emergency action plan should be developed and communicated to all personnel in the unit. The plan should include procedures for evacuation, ventilation failure, first-aid, and incident reporting.

Fire extinguishers will be made available in the laboratory and will be tested on a regular basis by Facilities Management personnel. If you activate a fire extinguisher for any reason, immediately report the activity to the Chemical Hygiene Officer so that the fire extinguisher will be replaced in a timely manner.

Fire blankets will be made available in the laboratory, as required. Fire blankets are used to wrap a burn victim to douse the flames. They are also useful to cover a shock victim and for warmth and to provide a privacy shield when treating a victim under a safety shower in the event of a chemical spill.

Access to fire alarms and telephones will be made available for emergency use.

Eye wash stations will be made available and inspected on a regular basis by departmental personnel. Safety showers will be made available and tested routinely by departmental personnel.

Maintain clear pathways to fire extinguishers, fire blankets, first-aid kits, eye wash stations and safety showers.

Section 3. Chemical Spill Policy

Laboratory personnel should be familiar with the chemical, physical, and toxicological properties of each hazardous substance in the laboratory. Consult the label and the Safety Data Sheet prior to the initial use of each hazardous substance. Personal protective equipment should be used that is appropriate to the degree of hazard of the chemical in use. Always use the minimal amount of the chemical and use caution when transporting the chemical. In the event of an accidental chemical release or spill, personnel should refer to the following general guidelines. Consult Environmental Health and Safety if you should have any questions regarding the following guidelines.

Low flammability and low toxicity materials that are not volatile (e.g., inorganic acids and caustic bases)

1. Decontaminate any victims with the nearest safety shower, eyewash, or other appropriate action as described in the Safety Data Sheet.
2. Immediately notify the Chemical Hygiene Officer and Principle Investigator.
3. Wear personal protective equipment that is appropriate to the degree of hazard of the spilled substance.

4. Using chemical spill kits that contain an inert absorbent, clean up the affected area if this action can be accomplished without risk of additional injury or contamination to personnel. If the spill is located on the laboratory floor, be aware that some absorbents can create a slipping hazard. Contact EH&S if assistance is necessary.
5. Dispose of contaminated materials according to departmental policy. Coordinate with EH&S.
6. Complete an incident report and submit it to the Chemical Hygiene Officer.

Flammable solvents of low toxicity (e.g., diethyl ether and tetrahydrofuran)

1. Decontaminate any victims with the nearest safety shower, eyewash, or other appropriate action as described in the Safety Data Sheet.
2. Alert all other workers in the laboratory and the general vicinity of the spill.
3. Extinguish all flames and turn off any spark-producing equipment. If necessary, turn off the power to the laboratory at the circuit breaker. However, the ventilation system must remain operational.
4. Immediately notify Chemical Hygiene Officer, Environmental Health and Safety, and MU Police Dept.
5. Wear personal protective equipment that is appropriate to the degree of hazard of the spilled substance.
6. Using spill pillows or spill absorbent and non-sparking tools, soak up the solvent as quickly as possible. Be sure to soak up chemicals that have seeped under equipment and other objects in the laboratory. If the spill is located on the laboratory floor, be aware that some absorbents can create a slipping hazard.
7. Dispose of contaminated materials according to departmental policy. Coordinate with EH&S.
8. Complete an incident report and submit it to the Chemical Hygiene Officer.

Highly toxic materials (e.g., dimethylmercury and hydrofluoric acid)

1. Alert all other workers in the laboratory and the general vicinity of the spill and immediately evacuate the area.
2. Decontaminate any victims with a safety shower or eyewash in a safe location. Take other appropriate decontamination action as described in the Safety Data Sheet.
3. Immediately notify Chemical Hygiene Officer, Environmental Health and Safety, and MU Police Dept.
4. Do not attempt to clean up the spill. EH&S personnel will evaluate the hazards that are involved with the spill and will take the appropriate actions.
5. Only Hazardous Waste Operations and Emergency Response (HAZWOPER) trained personnel are authorized to decontaminate the area and package contaminated waste for disposal.
6. Complete an incident report and submit it to the Chemical Hygiene Officer.

Section 4. Accident Procedures

Immediately notify the Chemical Hygiene Officer and/or the Environmental Health and Safety office. Following the incident, the employee must complete an Injury/Illness Report and submit it to EH&S. Provide a copy of the appropriate SDS to the attending physician, as needed.

Cuts: If the injured person has experienced a minor cut, flush the wound with cool running water to remove any possible chemical contaminants. If there is a cut on a gloved hand, remove the glove after thoroughly washing the affected area to avoid contamination of the cut with chemicals. Apply a bandage and advise the victim that he or she should report any signs of infection to a physician. If there is a possibility that the wound is contaminated by broken glass or chemicals, the victim should seek immediate medical attention.

If the injured person has experienced a more serious injury (if sutures will be necessary) call 911 and apply sterile gauze pads to the wound. If necessary, apply direct pressure to the wound to stop the bleeding. Apply additional pads if the blood soaks through the first sterile pad. If bleeding continues, encourage the victim to lie down and elevate the wound area to a position

above the victim's heart. If you are unable to stop the bleeding, remain calm and carefully explain the situation to the dispatcher at 911. The dispatcher will advise you on further action.

Thermal Burns: Do not apply ointments or ice to the wound. For first-degree wounds, flush with copious amounts of tepid running water. Apply a moist dressing and bandage loosely. For second degree (with open blisters) and third degree burns, do not flush with water. Apply a dry dressing and bandage loosely. Immediately seek medical attention.

Cold / Cryogenic Burns: Do not apply heat or rub the affected area. Tissue contact with cryogenic liquids produces damage similar to that associated with thermal burns and causes severe deep freezing with extensive destruction of tissue. Remove any clothing that is not frozen to the skin and flush the affected area with warm water (around 104°F [40°C]) to reduce freezing. Do not apply heat or use hot water. Loosen any tight clothing which may restrict circulation to the affected area. Cover the affected area with a sterile protective dressing or with clean cloth, and protect the area from further injury. Seek medical attention promptly.

Note that frozen tissues are painless and appear waxy with a pallid yellow color. Tissues become painful and edematous upon thawing and the pale color turns to pink or red as circulation of blood is restored. Tissues which have been frozen show severe, widespread cellular injury and are highly susceptible to infections and additional trauma. Therefore, rapid rewarming of tissues is not recommended if transportation to a medical facility will be delayed.

Hydrofluoric Acid Exposure: Hydrofluoric acid (HF) is an extremely corrosive liquid that can cause severe injury via skin and eye contact, inhalation, and ingestion. HF readily penetrates the skin and causes decalcification of bone. Laboratory workers should be familiar with first-aid procedures for HF exposure before beginning work with HF. Calcium gluconate gel (2.5% w/w) must be readily accessible in work areas where any potential HF exposure exists.

In the event of contact with HF, first-aid must be started right away. For exposure on skin, remove contaminated clothing and immediately wash the area well with water. Generously apply the calcium gluconate gel. If the calcium gluconate gel is unavailable, continue flushing the exposed areas with water for 15 minutes. Seek immediate medical attention upon completion of these first aid measures.

If HF is splashed in the eyes, immediately flush for 15 minutes, holding the eyelids apart. Do not apply 2.5% calcium gluconate to eyes, a 1% solution is recommended. If ingested, call 911 immediately. If the vapor is inhaled, move the victim to fresh air and call 911.

Chemical Burns: Immediately flush the area with tepid running water for 15 minutes. Place the victim in the safety shower, if necessary, before removing any jewelry, contaminated clothing, and shoes. **Do not apply ointments, baking soda, ice, or gauze coverings to the wound.** Seek immediate medical attention at the nearest Emergency Room and request a workers compensation claim be initiated.

Eye Contact: Flush eyes with tepid water for 15 minutes and seek immediate medical attention.

Ingestion: DO NOT WASTE TIME. Call 911. Do not encourage vomiting except under the advice of a physician. **Call the Poison Control Center immediately and consult the SDS for the appropriate action. POISON CONTROL CENTER: 1-800-222-1222**

Save all chemical containers and a small amount of vomitus, if possible, for analysis. Stay with the victim until emergency medical assistance arrives.

Unconsciousness: Call 911. If it is safe for you to enter the area, place the victim on his or her back and cover with a blanket. Do not attempt to remove the victim from the area unless there exists an immediate danger. Clear the area of any chemical spill or broken glassware. If the victim begins to vomit, turn the head so that the stomach contents are not aspirated into the lungs.

Convulsions: Call 911. If it is safe for you to enter the area, remove anything that might cause harm to the victim. Clear the area of any chemical spills or broken glassware. If the victim begins to vomit, turn the head so that the stomach contents are not aspirated into the lungs. Try to protect the victim from further danger with as little interference as possible.

Appendix A - References

ANSI Z87.1-2003; American National Standard, *Occupational and Educational Personal Eye and Face Protection Devices*; American Society of Safety Engineers: Des Plaines, IL, 2003.

ANSI Z358.1-2004; *Standard for Emergency Eyewash and Shower Equipment*; American National Standards Institute: New York, NY, 2004.

National Fire Protection Association, NFPA 30: *Flammable and Combustible Liquids Code*; Quincy, MA, 2012 edition.

National Fire Protection Association, NFPA 45: *Standard on Fire Protection for Laboratories Using Chemicals*; Quincy, MA, 2011 edition.

National Fire Protection Association, NFPA 704: *Standard System for the Identification of the Hazards of Materials for Emergency Response*; Quincy, MA, 2012 edition.

Occupational Safety and Health Administration, *Laboratory Safety Guidance*; OSHA 3404-9N 2011

Occupational Safety and Health Administration, *Occupational Exposure to Hazardous Chemicals in Laboratories*; 29 CFR; Part 1910.1450, 2006.

Prudent Practices in the Laboratory, Handling and Management of Chemical Hazards; National Research Council; The National Academy Press: Washington, D.C., 2011.

Safety in Academic Chemistry Laboratories; 7th edition, American Chemical Society; Washington, D.C., 2003.

Appendix B - SDS Search Sites

- Acros Organics - search for Acros, Maybridge, and Fisher Scientific products
- Airgas - search on pure & mixed gases
- Avantor Performance Materials - search for J.T. Baker and Macron Chemicals
- Canadian Center for Occupational Health & Safety - search by manufacturer/supplier
- Fisher Scientific - search SDS for Fisher products
- ILPI – where to find SDSs on the Internet - search Government & Non-Profit, and Chemical Manufacturers and Suppliers
- MSDS Search.com - links to a variety of SDS databases, including foreign languages
- MSDS Xchange - offering a free online binder, and product and manufacturer searches
- NIH National Library of Medicine: Hazardous Substances Data Bank
- NIOSH Pocket Guide to Chemical Hazards - info on chemical safety and compatibility
- NJ Department of Health, Right to Know Program: Hazardous Substance Fact Sheets
- NOAA CAMEO Chemicals - online database of hazardous materials
- Praxair – search by product name or P-number to learn about the composition, hazards, storage recommendations, and other critical facts for different gases
- Safety Information Resources Inc. - manufacturer listings, SDS search, safety info
- Science Lab - search by CAS, chemical name, or chemical formula
- Sigma-Aldrich - search SDS for Sigma products, registration required
- SIRI MSDS Index - manufacturer/supplier links; and chemical name, CAS, NSN search
- VWR - search by chemical name, manufacturer, catalog number or SDS text

- Marshall University Environmental Health & Safety – SDS search link
- Marshall University Chemistry Department - more SDS search links

Appendix C - Glossary of Terms

Section 1. Acronyms

ACGIH	American Conference of Governmental Industrial Hygienists
ANSI	American National Standards Institute
ASTM	American Society for Testing and Materials
ATSDR	Agency for Toxic Substances and Disease Registry
BEI	Biological Exposure Indexes
CAA	Clean Air Act
CAS	Chemical Abstracts Service
CDC	Centers for Disease Control and Prevention
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CGA	Compressed Gas Association
CHEMTREC	Chemical Transportation Emergency Center
CHO	Chemical Hygiene Officer
CHP	Chemical Hygiene Plan
CMA	Chemical Manufacturer's Association
CPSC	Consumer Product Safety Commission
CWA	Clean Water Act
DOE	Department of Energy
DOL	Department of Labor
DOT	Department of Transportation
EPA	Environmental Protection Agency
FDA	Food and Drug Administration
FR	Federal Register
HAZWOPER	Hazardous Waste Operations and Emergency Response
HEPA	High Efficiency Particulate Air
HMIS	Hazardous Materials Identification System
IARC	International Agency for Research on Cancer
IDLH	Immediately Dangerous to Life and Health
NAS	National Academy of Sciences
NEC	National Electrical Code
NFPA	National Fire Protection Association
NIEHS	National Institute of Environmental Health Sciences
NIH	National Institutes of Health
NIOSH	National Institute for Occupational Safety and Health
NSF	National Science Foundation
NTP	National Toxicology Program
OEL	Occupational Exposure Limit
OSHA	Occupational Safety and Health Administration
PEL	Permissible Exposure Limit
PPE	Personal Protective Equipment
RCRA	Resource Conservation and Recovery Act
SARA	Superfund Amendments and Reauthorization Act
SCUBA	Self-Contained Breathing Apparatus
SDS	Data Safety Sheets
SOP	Standard Operating Procedures
TLV	Threshold Limit Value

TWA	Time Weighted Average
VOC	Volatile Organic Compounds
WHO	World Health Organization

Section 2. Definitions

Acute Exposure - Short durations of exposure to high concentrations of hazardous materials in the work place.

Allergen - A chemical substance that induces an immediate or delayed adverse reaction by the immune system.

Asphyxiant - A substance that can cause suffocation.

Carcinogen - A substance that causes the development of cancerous growths in humans or is considered capable of causing cancer in humans. A substance is considered a carcinogen if:

1) It has been evaluated by the International Agency for Research on Cancer (IARC) and has been found to be a carcinogen or potential carcinogen;
2) It is listed in the National Toxicology Program's (NTP) *Annual Report on Carcinogens* as a carcinogen or potential carcinogen;
3) It is an OSHA-regulated carcinogen;

Caustic Material - A material that has a pH greater than 12 and has a corrosive or irritating effect on living tissue at the point of contact.

Chemical Abstracts Service (CAS) Registration Number - A unique number that is assigned to a chemical as a means to identify the material.

Chemical Hygiene Officer - An employee who is qualified, through training, education, and experience, to oversee the implementation of and subsequent reviews of the Chemical Hygiene Plan, per OSHA 29 CFR 1910.1450, *Occupational Exposure to Hazardous Chemicals in Laboratories.*

Chemical Hygiene Plan - A written plan that is designed to protect laboratory workers from occupational exposure to hazardous chemicals, per OSHA 29 CFR 1910.1450, *Occupational Exposure to Hazardous Chemicals in Laboratories.*

Chronic Exposure - Continuous exposure over a long period of time to low concentrations of hazardous materials in the work place.

Chronic Toxicity - Adverse health effects that can be a result of long-term exposure to hazardous materials.

Combustible Material - A substance (solid, liquid, or gas) that must be moderately heated or exposed to relatively high ambient temperatures before ignition can occur. Flash point between 100°F – 200°F.

Corrosive Material - A substance that has a pH less than 2 or greater than 11.5 which can cause visible destruction of or irreversible alteration on physical contact with living tissue.

Embryotoxin - A material that is harmful to a developing embryo at a concentration that does not have adverse effects on the pregnant female.

Explosive Material - A material that will exhibit a rapid chemical change when subjected to a suitable ignition source (i.e., detonation, heat, friction, or impact).

Flammable - A term commonly used to describe a gas, solid, vapor, or liquid that easily ignites and rapidly burns. Flash point below 100°F.

Flash Point - The lowest temperature at which a flammable liquid produces sufficient vapor to form a readily ignitable mixture with air, either at its surface or in a container.

Hazardous Chemical - A chemical for which there is statistically significant evidence, based on at least one study conducted in accordance with established scientific principles, that acute or chronic health effects may occur in exposed persons.

Hazard Warning - A label on a chemical container that includes text and/or symbols to convey the hazards of the material.

High Efficiency Particulate Air (HEPA) filter - An air filter that has a 99.97% removal efficiency for 0.03 micron particles.

Immediately Dangerous to Life and Health (IDLH) - The maximum concentration of a hazardous substance from which a worker can escape within 30 minutes without irreversible health effects. IDLH is used to determine respirator selection.

Incompatible Materials - Materials which, when mixed, could result in the formation of toxic gases or hazardous conditions (i.e., an explosion).

Irritant - A substance that produces an inflammatory effect on contact with living tissue.

Lachrymator - A substance that has an irritating or burning effect on skin, eyes, and respiratory tract.

LD_{50} - The single dose (lethal dose) of a substance that will cause the death of 50% of a population of animals. Exposure to the substance is via all routes except inhalation.

Mutagen - A material that produces a gene-change, genetic mutations in chromosomal DNA.

Oxidizing Agent - A substance that may react violently upon contact with reducing materials.

Nonflammable - A material that is not easily ignited; a DOT hazard class for compressed gases that are not classed as flammable gases.

Permissible Exposure Limit (PEL) - The maximum acceptable concentration of a chemical in the work place air. Commonly used exposure limits include TLV-TWA (Threshold Limit Value-Time Weighted Average), STEL (Short-Term Exposure Limit), and C (Ceiling Value).

Personal Protective Equipment (PPE) - Protective equipment (gloves, chemical splash goggles, laboratory coat or apron, respirator, etc.) worn by laboratory workers to protect them from direct exposure to hazardous materials.

Physical Hazard - A substance that is a hazard of physical origin (i.e., a burn); a material that is flammable, explosive, water reactive, pyrophoric, or unstable; a combustible liquid, a compressed gas, an organic peroxide, or an oxidizer.

Poison - A substance that may injure or kill an organism, even in relatively low doses.

Pyrophoric Material - Any liquid or solid which will ignite spontaneously in air below 54°C (130°F).

Reactive Material - An explosive material, organic peroxide, pressure-generating material, or water reactive material that vigorously polymerizes, decomposes, condenses, or becomes self-reactive when subjected to pressure, shock, or temperature changes.

Safety Data Sheet - A document which contains relevant information about a material, as referenced by OSHA 29 CFR, Part 1910.1200. Formerly called MSDS or Material SDS.

Select Carcinogen - Defined in OSHA 29 CFR 1910.1450, *Occupational Exposure to Hazardous Chemicals in Laboratories*, as a substance that:

1) Is regulated by OSHA as a carcinogen;
2) Is listed by the NTP as "known to be carcinogen";
3) Is listed on IARC lists as Group 1, "carcinogenic to humans"; or
4) Is included on the IARC lists as Group 2A or 2B, "reasonably anticipated to be carcinogen" because it causes statistically significant tumor incidence in animals according to the criteria that are listed in Section 2, Paragraph b.

Teratogen - A substance that can disturb the development of an embryo or fetus. Teratogens may cause a birth defect in the child, or halt the pregnancy outright. The classes of teratogens include chemicals, drugs maternal infections, and radiation.

Threshold Limit Value - The ACGIH term that is used to express the maximum airborne concentration of a substance to which most workers can be exposed during a normal eight-hour work day or normal 40-hour work week with no adverse health effects.

TLV-Ceiling Limit - The exposure concentration that must not be exceeded at any time.

TLV-Short Term Exposure Limit (STEL) - The maximum concentration of an airborne substance for a continuous exposure period of 15 minutes, with the following guidelines:

1) There will be a maximum of four 15-minute periods per day.
2) There will be at least 60 minutes between exposure periods.
3) The daily TLV-TWA will not be exceeded.

TLV-Time Weighted Average - The ACGIH term that is used to express the maximum allowable time weighted average concentration of an airborne substance for a normal eight-hour work day or 40-hour work week.

Toxic Material - A poisonous substance which has the ability to cause adverse health effects upon exposure.