CHEMICAL HYGIENE AND LAB SAFETY MANUAL

SOUTH DAKOTA SCHOOL OF MINES & TECHNOLOGY

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Created: 01/12/05
Revision Date: 11/29/2018

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Special Thanks to Ohio State University, Environmental Health and Safety Department for the foundation of this Chemical Hygiene Plan.

Cornell University Chemical Hygiene and Lab Safety Manual has been used as the basis for sections 14, 15, and 19.

1. PURPOSE

The purpose of this Chemical Hygiene and Lab Safety Plan is to provide handling practices and procedures to be followed by employees, students, visitors, and other personnel working in each laboratory to protect them from potential health and physical hazards. While the Plan establishes work practices to promote safety in the laboratory, each individual has the first responsibility for ensuring that good health and safety practices are implemented in the laboratory. Not only does this individual responsibility promote personal well-being and the well-being of others, it also advances SDSM&T's commitment to excellence in research. The facilities and precautions in this Chemical Hygiene and Lab Safety Plan are compatible with current knowledge and regulations.

2. SCOPE

The Chemical Hygiene and Lab Safety Plan applies to all employees, students, visitors, and other personnel working in each laboratory and small pilot plant scale operations involving hazards, in facilities on and off the main campus.

3. DEFINITIONS (As excerpted from 29 CFR 1910.1450)

Action Level -- A concentration designated in 29 CFR part 1910.1450 for a specific substance, calculated as an 8-hour time weighted average (TWA), that initiates certain required activities. The Action Level is generally considered to be one half of the Permissible Exposure Limit (PEL).

Bloodborne Pathogen -- Pathogenic micro-organisms that are present in human blood and can cause disease in humans. These pathogens include, but are not limited to, Hepatitis B Virus (HBV) and Human Immune Deficiency Virus (HIV).

Chemical Hygiene Officer-- An employee who is qualified by training or experience to provide technical guidance in the development and implementation of the provisions of the Chemical Hygiene Plan (CHP). At SDSM&T, this is the Campus Environmental Health and Safety Director.

Chemical Hygiene Plan-- A written program developed and implemented that 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 the laboratory. This plan should be reviewed and updated at least annually by the Risk Management Committee and the Campus EHS Manager.

Combustible-- A material that has a Flash Point at or above 140^0 F.

Designated Area-- An area that may be used for work with select carcinogens, reproductive toxins or substances that have a high degree of acute toxicity. A designated area may be the entire laboratory, an area of a laboratory or a device such as a laboratory hood.

Flammable Liquid-- A material that has a flash point below 140^0 F and a vapor pressure not exceeding 40 pounds per square inch, absolute (psia) at 100^0 F.

Hazardous Chemical-- A chemical for which there is statistically significant evidence, based on at least one study conducted in accordance with established scientific principles, which acute or chronic health effects may occur in exposed employees. The term "health hazard" includes chemicals that are carcinogens, toxic or highly toxic agents, reproductive toxins, irritants, corrosives, sensitizers, hepatotoxins, nephrotoxins, neurotoxins, agents that act on the hematopoietic systems and agents that damage the lungs, skin, eyes or mucous membranes.

Laboratory -- A workplace where any quantity of hazardous and non-hazardous chemicals are used on a regular basis.

Laboratory Scale -- Work with substances in which the containers used for reactions, transfers, and other handling of substances are designed to be easily and safely manipulated by one person. Also may be called Bench Scale.

Laboratory Standard -- The procedures and standards encompassed by 29 Code of Federal Regulations (CFR) 1910.1450; also known as the Occupational Exposure to Hazardous Chemicals in the Laboratory

Chemical Hygiene Plan.

Laboratory Use of Hazardous Chemicals -- Handling or use of such chemicals in which all of the following conditions are met.

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

Laboratory Employee -- An individual **paid** by SDSM&T or a Principal Investigator who is a laboratory worker; this may include faculty, staff, post-doctoral students, graduate students, and student employees.

Laboratory Student – An individual **unpaid** by SDSM&T or a Principal Investigator who is a laboratory worker; this may include faculty, staff, students (post-doctoral, graduate, and undergraduates).

Laboratory Worker -- An individual (either paid or unpaid) employed in a laboratory workplace who may be exposed to hazardous chemicals in the course of his or her assignments.

Permissible Exposure Limit (PEL) – For laboratory uses of OSHA regulated substances, the employer shall assure that laboratory employees' exposures to such substances do no exceed the permissible exposure limits specified in 29 CFR 1910, Subpart Z.

Principal Investigator – For research laboratories, the professor or director in charge is the Principal Investigator. For academic laboratories, the chair or designee of the department is the Principal Investigator.

Reproductive Toxins -- Chemicals that affect the reproductive capabilities including chromosomal damage (mutations) and effects on fetuses (teratogens).

Select Carcinogen -- Any substance that meets one of the following criteria:

1. It is regulated by OSHA as a carcinogen; or
2. It is listed under the category, known to be carcinogens, in the Annual Report on Carcinogens published by the National Toxicology Program (NTP) (latest edition); or
3. It is listed under Group 1 (carcinogenic to humans) by the International Agency for Research on Cancer Monographs (IARC) (latest editions); or
4. It is listed in either Group 2A or 2B by IARC or under the category, reasonably anticipated to be carcinogens by NTP, and causes statistically significant tumor incidence in experimental animals in accordance with any of the following criteria:
    a. After inhalation exposure of 6-7 hours per day, 5 days per week, for a significant portion of a lifetime, to dosages of less then 10 mg/m^3.
    b. After repeated skin application of less than 300 mg/kg of body weight per week; or
    c. After oral dosages of less that 50 mg/kg of body weight per day.
5. See Select Carcinogens and Reproductive Toxins.

Shall / Should -- In this document, "shall" indicates a required condition or action; "should" indicates a preferred laboratory practice.

Common Acronyms

ACGIH	American Conference of Governmental Industrial Hygienists
ANSI	American National Standards Institute
CFR	Code of Federal Regulations
CHMO	Chemical and Hazardous Materials Officer
DOT	Department of Transportation
EPA	Environmental Protection Agency
IARC	International Agency for Research on Cancer
IUPAC	International Union of Pure and Applied Chemistry
LD_{50}	Lethal Dose for 50% Mortality
SDS	Safety Data Sheets
NFPA	National Fire Protection Association
NIOSH	National Institute of Occupational Safety and Health
NTP	National Toxicology Program

OSHA	Occupational Safety and Health Administration
SOP	Standard Operating Procedure
TLV	Threshold Limit Value

4. EMPLOYEE RIGHTS and RESPONSIBILITIES

4.1 EMPLOYEE RIGHTS

The University is required to advise laboratory employees of their rights regarding the Chemical Hygiene Plan. It is to your advantage to understand your rights.

1. Employees shall receive training on the hazards associated with chemicals and on the measures they can take to protect themselves from those hazards.
2. Employees, who may be exposed to hazardous chemicals, shall have access to the following information:
   - Chemical exposure information
   - Workplace chemical inventory
   - Safety Data Sheets
3. The employer must provide employees with appropriate personal protective equipment free of charge.
4. Employees who have been exposed to hazardous chemicals shall have access to:
   - Medical Consultation and Examinations
   - Records of their Medical Consultations and Examinations
   - Results of Environmental Monitoring

   This shall be provided upon request through the Campus EHS Manager.
5. Employees have a right to file a complaint against the University regarding alleged violations of the Laboratory Standard without fear of retribution.

Questions about employee rights under the Laboratory Standard or about the contents of any part of the Chemical Hygiene and Lab Safety Manual should be directed to the Laboratory Supervisor or the Campus EHS Manager for clarification or more information.

4.1 EMPLOYEE RESPONSIBILITIES

President of the South Dakota School of Mines and Technology
The President of the South Dakota School of Mines and Technology has ultimate responsibility for the University Chemical Hygiene and Lab Safety Manual and shall provide endorsement and budgetary support through the appropriate Vice Presidents and University Offices for its implementation at the Departmental level.

Campus EHS Manager
The Campus EHS Manager is responsible for the development and implementation of chemical hygiene policies and practices in the laboratory and determining the minimum requirements of the CHP that all laboratories must follow. The Campus EHS Manager is responsible for working with the faculty, staff, student, and others to develop and implement appropriate chemical hygiene practices and procedures. To accomplish this, the Campus EHS Manager shall:

1. Establish procedures to monitor the procurement, use, and disposal of chemicals used in the laboratory.
2. Establish procedures to perform annual inspections of laboratories to insure that appropriate laboratory chemical hygiene and housekeeping are conducted and that adequate records are maintained.
3. Help Departments and Principal Investigators to develop adequate precautions and facilities.
4. Know and communicate the current legal requirements for regulated substances.
5. Develop, implement, and seek ways to improve the Chemical Hygiene and Lab Safety Manual.
6. Communicate standards, changes in standard operating procedures (SOPs) and CHP status to the Department and Principal Investigators affected.
7. Monitor the procurement and use and disposal of chemicals used in the laboratories.

Provost and VP of Academic Affairs
The Provost and VP of Academic Affairs shall provide endorsement and budgetary support for the implementation of the Chemical Hygiene and Lab Safety Manual.

Department Chairman/Head
The Department Chairman and the Campus EHS Manager have responsibility for implementing the Chemical Hygiene and Lab Safety Manual at the department level and shall provide continuing support for chemical

hygiene.

Campus Chemical Materials Coordinator/Environmental Health and Safety Officer
1. Monitor the procurement of chemicals and instruments containing chemicals used in the laboratories.
2. Monitor chemical quantities to ensure compliance with Superfund Amendments and Reauthorization Act (SARA) Title III.
3. Practice appropriate labeling schemes.
4. Keep accurate Safety Data Sheet (SDS) records.
5. Accept chemicals from campus for disposal.
6. Use proper methods for disposal with in all applicable legal requirements.
7. Document waste activity for campus.

Principal Investigator -- The Principal Investigator is responsible for chemical hygiene in the laboratory. The Principal Investigator shall ensure:
1. He/she has a working knowledge of this Chemical Hygiene and Lab Safety Manual and applicable laws including 29 CFR 1950.1450.
2. Laboratory workers know and follow the Chemical Hygiene and Lab Safety Manual rules and relevant SOPs.
3. Record safety meetings with personnel.
4. To provide protective equipment in working order.
5. To train personnel in the safety precautions for chemicals being used.
6. To follow chemical disposal procedures properly.
7. To inspect emergency equipment, chemical hygiene, and housekeeping and maintain record of inspections.
8. To report any deficiencies that require departmental or higher level action to the Department Chair, Director, and/ or Campus EHS Manager.

Laboratory worker -- Each laboratory worker is responsible for planning and conducting all operations in accordance with the chemical hygiene and lab safety manual procedures, developing good personal chemical hygiene habits, reporting safety deficiencies to the Principal Investigator, and taking advantage of appropriate training opportunities.

Laboratory Inspection Teams -- Each Principal Investigator will appoint individuals to conduct periodic laboratory self-inspections. The Campus EHS Manager will conduct annual inspections of all laboratories. Laboratories will be inspected for compliance of the Chemical Hygiene and Lab Safety Manual, safety policies, procedures, regulatory requirements, and applicable laws.

5. ENFORCEMENT

The SDSM&T Environmental, Health, Safety, and Risk (EHS&R) Committee will assume responsibility for the implementation, validation, control and enforcement of the Chemical Hygiene and Lab Safety Manual, on and off the main campus. Any violations will result in the following actions:
1. A formal written warning of violation(s) with a specific date at which the infraction must be resolved. This may be included in the formal annual audit reports.
2. If violation(s) continues after date, the EHS&R Committee will review the violation and try to resolve.
3. If the violation still continues, the proper chain of command will be followed which could lead the laboratory closing until violation is corrected.

6. MEDICAL PROGRAM

1. An opportunity for medical surveillance, including medical consultation and follow-up, shall be provided under the following circumstances:
    a. Where exposure monitoring is over the action level for an OSHA regulated substance that has medical surveillance requirements.
    b. Whenever a laboratory employee develops signs or symptoms that may be associated with a hazardous chemical to which the employee may have been exposed to in the laboratory.
    c. Whenever a spill, leak, or explosion results in the likelihood of a hazardous exposure, as determined by the Campus EHS Manager or designee.
    d. To all employees required to wear a respirator.
    e. To all emergency response team members.
2. All examinations shall be provided by or under the supervision of a licensed physician, at no cost to the employee, without loss of pay, and at a reasonable time and place. A physician experienced in

occupational medicine shall be used whenever possible.
3. First aid kits (see Section 12.7) will be maintained and checked periodically for expired or missing items.
4. Where medical consultations or examinations are provided, the examining physician shall be provided with the following information:
   a. The identity of the hazardous chemical(s) to which the employees may have been exposed.
   b. A description of the conditions under which the exposure occurred including quantitative exposure data, if available.
   c. A description of the signs and symptoms of exposure that the employee is experiencing, if any.
5. For examinations or consultations provided to employees, a written opinion from the examining physician shall be obtained by the Principal Investigator and the Campus EHS Manager. It shall include:
   a. Recommendations for further medical follow-up.
   b. Results of the examination and associated tests.
   c. Any medical condition revealed that places the employee at an increased risk of exposure to a hazardous substance found in the workplace.
   d. A statement that the employee has been informed of the results of the examination or consultation.

7. ACCIDENTS OR INCIDENTS

1. Laboratory accidents that involve a personal injury that appears to require medical assistance should be immediately reported to Emergency Services (call 9-911), Facilities Services (x2251, normal business hours; x6100 after hours and weekends). Facility Services will notify the Campus EHS Manager.
2. Personnel responding to any injury that appears to require emergency first aid shall notify the Laboratory Supervisor at the first, safe opportunity.
3. An incident report form must be filed with Campus Safety (Facilities Services), Campus Chemical Materials Coordinator, Surbeck Front Desk, or the Campus EHS Manager for any laboratory accident involving personal injury as described in the Campus policy V-E-03. An incident report may also be filled out electronically at the following web site: http://www.sdsmt.edu/Campus-Services/Environmental-Health-and-Safety/Incident-Reporting/.
4. If a spill or incident represents a hazard to other building occupants, the fire alarm should be pulled to evacuate the building, and Campus Safety (x6100) should be called.
5. Serious and reported accidents and near-accidents shall be investigated by the Campus EHS Manager or designee.

8. ADMINISTRATIVE PROCEDURES

8.1 SAFETY REGULATIONS

Departments offering laboratories which contain potential chemical, mechanical, or electrical hazards should provide safety information listing the safety rules and procedures required of all students using the laboratory facilities. The information must be supplied in the laboratory course syllabus or student sign-offs. An overview of general and experiment specific safety procedures should be performed for each lab session.

8.2 BEHAVIOR IN THE LABORATORY OR SHOP

1. Workers should act in a professional manner at all times.
2. Horseplay and practical jokes are expressly forbidden.
3. No undergraduates are allowed to work in a lab containing hazards alone. The institution also highly discourages graduate student work alone in laboratories, especially after business hours.
4. Any visitor to the laboratory is to be escorted by a worker and is the responsibility of that worker. Appropriate safety rules must be observed. Refer to Section 14.
5. Contact information should be posted on all laboratory doors. If an experiment is being run unattended, this information must cover the proper contact information in case of a catastrophic failure.
6. Workers shall be aware of the location and proper operation of laboratory safety equipment.
7. The Nuclear Regulatory Commission strictly regulates the use of radioactive sources and radiation producing equipment. Before any radioactive source or radiation producing equipment is brought into the laboratory, the Campus EHS Manager and/ or the campus Radiation Officer must be consulted for appropriate permits, training and standard operating procedures. (See section 20.0 – Radionuclides, for other relevant information.)

8.3 AVOIDANCE OF ROUTINE EXPOSURES

1. Skin contact with chemicals should be avoided.
2. Use standard wafting practices if there is a need to smell chemicals. Never smell or taste chemicals.
3. Do not pipette by mouth; use a vacuum or pipette bulb.
4. Vent any experiment that may discharge toxic or noxious chemicals into a local exhaust device, (i.e., a chemical fume hood).
5. Flammable, corrosive or toxic volatile materials must be trapped when they are evaporated, for example with rotary evaporators or similar devices.

8.4 PERSONAL HABITS IN THE LABORATORY

1. Eating, drinking, gum chewing and cosmetic application are not permitted in the laboratory.
2. Smoking is not allowed on campus except for in designated parking lots inside of vehicles.
3. Food may not be stored in a refrigerator that has been or is being used to store chemicals. Alternatives should be discussed with the Department Chair/Supervisor.
4. Ice produced by ice machines for laboratory use shall not be used for beverages, food or food storage.
5. No glassware or utensils that are used for laboratory operations shall be used for storage, handling, or consumption of food or beverages.
6. Hands should be washed before using the restrooms and before eating or smoking. Areas of exposed skin, i.e. forearms, should be washed frequently if there is potential of contact with chemicals.
7. Long hair and loose clothing shall be confined.
8. Shoes that cover the entire foot must be worn in laboratories at all times. Sandals are not allowed to be worn in any laboratory.
9. Appropriate clothing must be worn at all times. It is determined by the Principal Investigator what is appropriate for his/ her lab. Shorts, capris, skirts (that do not cover the entire leg), sleeveless shirts, must not be worn where chemicals are present.
10. Proper eye protection must be worn at all times in a laboratory. Proper protection necessary for a laboratory is determined by the Principal Investigator for that laboratory. Proper protection includes, but not limited to, chemical splash safety goggles, face shields, and safety glasses. Employees wearing contact lenses must be informed of the special hazards associated with their use, (i.e., absorption of chemicals from the air) and must inform their supervisors so that appropriate measures can be taken in an emergency. For increased safety, contacts should not be worn when working with chemicals.
11. Be alert to unsafe conditions. It is the responsibility of each individual to assure a safe working environment for themselves and other workers in the laboratory and to bring them to immediate attention.
12. Any spills or accumulations of chemicals on work surfaces must be removed as soon as possible using techniques that minimize residual surface contamination. Refer to SDS for safety precautions. Do not attempt to clean up a spill, if you have not received proper training. Call Campus Safety at 6100. It will be assessed by trained personnel who will ensure that proper clean-up techniques are employed.

8.5 HOUSEKEEPING

1. Lab areas are to be kept clean and uncluttered. This will help prevent spillage, breakage, personal injuries and unnecessary contact with chemicals.
2. Contaminated glassware should be cleaned daily.
3. Spills shall be cleaned up immediately from work areas and floors.
4. Doorways and walkways within the lab shall not be blocked or used for storage.
5. Floors must be maintained dry at all times.
6. Access to exits, hallways, emergency equipment, and utility controls shall never be blocked.
7. Chemical containers shall be properly emptied and cleaned prior to disposal. Glass bottles will be uncapped, washed out with an appropriate solvent, triple rinsed with water and placed in the glass container for disposal.
8. Equipment and instrumentation shall be cleaned to remove spillage and contamination before repair or calibration service is requested and service personnel will be informed of any hazardous contamination prior to servicing.

9. ENGINEERING CONTROLS

Engineering controls are considered the first line of defense in the laboratory for the reduction or elimination of the potential exposure to hazardous chemicals. Examples of engineering controls used in laboratories at SDSM&T may include dilution ventilation, local exhaust ventilation, chemical fume hoods, glove boxes, safety shields, and proper storage facilities.

The OSHA Laboratory Standard requires that "fume hoods and other protective equipment function properly and that specific measures are taken to ensure proper and adequate performance of such equipment." General laboratory room ventilation is not adequate to provide proper protection against bench top use of hazardous chemicals. Laboratory personnel need to consider available engineering controls to protect themselves against chemical exposures before beginning any new experiment(s) involving the use of hazardous chemicals.

The proper functioning and maintenance of fume hoods and other protective equipment used in the laboratory is the responsibility Facilities Services and EHS. Other protective equipment includes equipment such as fire extinguishers, emergency eyewash and showers, and mechanical ventilation. Periodic inspections and maintenance by these groups ensure proper functioning and adequate performance of these important pieces of protective equipment.

However, it is the responsibility of laboratory personnel to immediately report malfunctioning protective equipment, such as fume hoods, or mechanical problems to their supervisor as soon as any malfunctions are discovered. EHS can be contacted, if it involves any EHS device.

See APPENDIX A for detailed information on fume hood and other capture device use.

10. PERSONAL PROTECTIVE EQUIPMENT

The Principal Investigator will be responsible (with technical assistance from the Campus EHS Manager or Campus Chemical Storeroom) for selecting personal protective equipment, acquiring approved equipment, maintaining availability, and establishing equipment cleaning and disposal procedures as defined in appropriate Standard Operating Procedures (SOPs) and the Job Hazard Assessment (See Section 22 of this document). Laboratory workers should be advised on the proper selection, use and limitations of personal protective equipment before they are required to use the equipment. Personal protective equipment, excluding safety glasses and shoes, should be removed before leaving work areas.

10.1 EYE PROTECTION

1. Safety goggles, glasses and/or face shields and shall be worn at all times in a laboratory where chemicals and/ or potential eye impact hazards are present. EHS reserves the right for approval.
2. Employees wearing contact lenses must be informed of the special hazards associated with their use, (i.e., absorption of chemicals from the air) and must inform their supervisors so that appropriate measures can be taken in an emergency. For increased safety, contacts should not be worn when working with chemicals.
3. Before each use, eye and face protection equipment is to be inspected for damage, (i.e. cracks, severe scratches, debris). If deficiencies are noted, the equipment should be cleaned, repaired or replaced before use.

10.2 GLOVES

1. Chemical resistant gloves shall be worn whenever the potential for hazardous skin contact exists. The Safety Data Sheet for the substance or glove selection charts should be referenced. Standard operating procedures should specify glove requirements, if any.
2. Here are several links to several glove manufacturer selection charts: http://www.microflex.com/ChemChartLatexNitrile.pdf
3. http://www.ansellpro.com/download/Ansell_7thEditionChemicalResistanceGuide.pdf
4. http://www.deltagloves.com/chemchart.htm
5. Contaminated gloves shall be removed before touching surfaces outside the work area (i.e., doorknobs, faucet handles).
6. Before each use, gloves are to be inspected for damage and contamination, i.e., tears, punctures, discoloration. If deficiencies are noted, the gloves should be cleaned, repaired, or replaced before use.
7. Heat resistant gloves shall be used for handling hot objects. Asbestos containing gloves should not be used.
8. Abrasion resistant gloves (e.g. leather) should be worn for handling broken glass and other similar materials, but should not be used to handle chemicals.
9. Cryogen gloves shall be used for handling cold objects.

10.3 SHOES

1. Shoes that cover the entire foot must be worn in laboratories at all times. No sandals or open-toed shoes

shall be worn in the laboratory. Shoes worn should have non-skid soles and should have reasonable heel heights.
2. Safety shoes, toe guards or the equivalent should be worn if there is potential for injury from heavy objects. Safety shoes must meet the requirements of ANSI Z41 (Current).
3. Before each use, shoes are to be inspected for damage, deterioration, contamination, (i.e., tears, punctures, discoloration). If deficiencies are noted, the shoes should be cleaned, repaired or replaced before use.
4. Any special shoe requirements or restrictions shall be specified in the standard operating procedures.

10.4 CLOTHING

1. Laboratory coats shall be worn by laboratory employees whenever a reasonable risk of chemical exposure to skin or street clothing exists or when specified by standard operating procedures. They should be kept in an appropriate clean storage area. Disposable laboratory coats are recommended when working with highly toxic materials such as select carcinogens, mutagens or teratogens.
2. Clothing should be cleaned regularly. Clothing contaminated with hazardous materials must be either decontaminated before reuse or disposed.
3. The commercial launderer of any contaminated work clothing shall be notified of potentially contaminating substances.
4. Before each use, clothing is to be inspected for damage, deterioration, contamination, (i.e. tears, punctures, or discoloration). If deficiencies are noted, the clothing should be cleaned, repaired or replaced before use.
5. Chemical protective clothing must be removed before leaving the work area.

10.5 HEARING PROTECTION

1. Hearing protection (noise attenuating ear muffs or plugs) are required whenever employees are exposed to 85 dBA or greater as an eight hour time weighted average.
2. Hearing protection is to be inspected before each use for tears and contamination. If deficiencies are noted, the hearing protector should be cleaned, repaired or replaced before use.

10.6 RESPIRATORS

All employees issued respirators for any reason must be trained, have a medical exam, and be fit-tested prior use. Contact the Campus EHS Manager for more information.

11. EMERGENCY EQUIPMENT

11.1 GENERAL

Emergency equipment for each department on campus must be indicated on the floor plans. Each laboratory employee should be familiar with the location, application and correct use, where applicable, of the following equipment:
1. Fire extinguishers,
2. Fire alarms,
3. Safety showers,
4. Eye wash units,
5. First aid kits,

11.2 SAFETY SHOWERS AND EYE WASHES

1. Safety showers and eye washes should be easily accessible and available at all times when workers are in the work area.
2. Inspections
3. Adequate flow should be tested and documented annually for safety showers by the Campus EHS Manager, or designee. Eyewashes will be flushed bi-monthly.
4. Scissors must be immediately available for the removal of contaminated clothing. A privacy screen or blanket must be readily available if clothing needs to be removed. An extra clean blanket should be available for the victim post shower.

11.3 FIRE EXTINGUISHERS

1. Fire extinguishers should be provided within 30 feet of a work area and located along normal paths of travel.

2. Access must be maintained and the location should be conspicuously marked in an appropriate manner.
3. Facilities Services will complete/document monthly inspections.
4. Annual servicing of the fire extinguishers shall be completed by qualified personnel and documented.
5. Discharged fire extinguishers must be immediately reported to Facilities Services (x2251).

11.4 FIRE ALARMS

1. Fire alarms must be provided along normal paths of travel and along exit routes.
2. Inspections will be conducted periodically by qualified personnel and documented.
    a. Fire alarms should be conspicuously marked.
    b. Fire alarms in classroom buildings will be activated periodically by Facilities Services to insure proper operation per manufacturer's instructions and/or fire insurer's instructions.
    c. FIRE ALARMS ARE NOT TO BE TESTED BY LABORATORY PERSONNEL!
    d. The inspections will be documented.

11.5 SMOKE OR HEAT DETECTORS

1. Should be installed and selected for the appropriate hazards per building codes, fire codes and fire insurer's requirements.
2. Inspections will be performed periodically by Facilities Services.
3. The detection system should be tested to assure proper working order per manufacturer's and/or fire insurer's instructions.
4. SMOKE DETECTORS ARE NOT TO BE TESTED BY LABORATORY PERSONNEL!

11.6 FIRST AID KITS

1. First aid kits will be available and maintained for treatment of minor injuries or for short term emergency treatment until medical assistance arrives.
2. First aid kits will be kept in accessible and marked locations.
3. The first aid kits should be kept adequately stocked and maintained.

11.7 FIRE DOORS

1. Fire doors should be provided as required per building codes, fire codes and fire insurer's requirements. Fire doors must not be blocked open, and must be able to close properly.
2. Inspections will be conducted periodically by Campus EHS Manager or Facilities Services.
3. Fire doors with heat activated closures should be tested to assure proper working order.
4. FIRE DOORS ARE NOT TO BE TESTED BY LABORATORY PERSONNEL!

11.8 FIRE SUPPRESSION SYSTEMS

1. The fire suppression system must be selected based on the hazards.
2. Inspections--Periodically by qualified personnel.
    a. All system components must be checked for physical condition.
    b. The system should be activated and checked as appropriate for the type of system.
    c. FIRE SUPPRESSION SYSTEMS ARE NOT TO BE TESTED BY LABORATORY PERSONNEL!
    d. The inspections must be documented.

11.9 EMERGENCY LIGHTING

1. Emergency lighting must be adequate to provide lighting for egress during an emergency situation or power failure.
2. Inspections—Semi-annually **by Facilities Services**
    a. Emergency lighting must be activated to assure it is operational.
    b. Inspections should be documented.

11.10 SPILL KITS

Each area in which hazardous chemicals are used will maintain an appropriate spill control kit. Consult the Campus EHS Manager for instructions on how to use the kit.

12. EMERGENCY PROCEDURES

Refer to the emergency procedures found at the following web address: http://www.sdsmt.edu/Campus-Services/Emergency/

13. EMPLOYEE TRAINING

13.1 TRAINING

1. All laboratory employees shall be trained on the chemical and physical hazards present in their work area.
2. The aim of the training program is to assure that all individuals at risk are adequately informed about the work in the laboratory, its risks, and what to do if an accident occurs.
3. This training shall be provided at the time of an employee's initial assignment to a work area where physical or chemical hazards are present. It shall also be provided prior to assignments involving new exposure situations. The training shall be coordinated through the Principal Investigator/ Laboratory Supervisor, Campus EHS Manager, as appropriate.
4. The training should include, but not limited to:
   a. Handling hazardous chemicals,
   b. Exposure signs and symptoms,
   c. Fire training--prevention and response,
   d. Emergency response and evacuation,
   e. Interpretation of SDS's,
   f. Engineering controls,
   g. First aid,
   h. Personal hygiene,
   i. Protective clothing,
   j. Chemical or infectious waste disposal,
   k. Contents and availability of the CHP
   l. Review of PELs
   m. Laboratory hazards specific to work area, and if necessary,
   n. Respirator protection and fit testing program.
5. Training will be documented with the following information
   a. Trainer and/or media used,
   b. Content of Training,
   c. Attendees by signature,
   d. Date, and
   e. Location

13.2 TRAINING RESOURCES

The Campus EHS Manager provides the following training:

Laboratory Standard	Bloodborne Pathogens
Respirator Training and Fit Testing	Compressed Gases
Fume Hoods	Personal Protective Equipment
Safety Cabinets	Chemical Storage
Chemical Management (Waste)	Fire Extinguisher
Chemical Classifications	Hazardous Communication

13.3 REFERENCE MATERIALS

1. Reference materials on the hazards, safe handling, storage and disposal of hazardous chemicals can be found in Devereaux Library, Chemistry Storeroom, the "Chemical Management Guidebook" or the Campus EHS Manager.
2. The following reference texts are available through the State University Libraries:
   a. Prudent Practices for Handling Hazardous Chemicals in Laboratories, National Research Council, National Academy Press, Washington, DC, 2011.
   b. Young, J.A., ed., Improving Safety in the Chemical Laboratory: A Practical Guide, John Wiley & Sons, New York, NY, 1987. QD51 I48 1987
   c. Code of Federal Regulations, 29 CFR Part 1910 JK416.A3 A5 1966

3. Safety Data Sheets (SDS) shall be maintained by the Campus Chemical Storeroom as they are received.

14. VISITOR AND CONTRACTOR TRAINING

14.1 DEFINITIONS

1. Visitor - individual who is on site by invitation and who is not involved in the operations or processes of the laboratory and is not present in a contractual capacity.
2. Contractor - individual who is on site to complete a contracted responsibility and whose direct compensation is not being paid by the South Dakota School of Mines & Technology.

14.2 TRAINING

1. Visitor and contractor training will be the responsibility of the individual issuing the invitation, the agency awarding the contract or the Campus EHS Manager, as appropriate.

15. CHEMICAL HANDLING

Safe chemical use includes minimizing exposure to chemicals, proper training, understanding chemical hazards, proper labeling, proper storage and segregation, and proper transport. See Appendix C for more information on understanding chemical hazards, chemical hazard information, toxicity, and chemical exposure limits.

15.1 ROUTES OF ENTRY

The potential health effects that may result from exposure to chemicals depends on a number of factors. These factors include the properties of the specific chemical (including toxicity), the dose and concentration of the chemical, the route of exposure, duration of exposure, individual susceptibility, and any other effects resulting from mixtures with other chemicals.

In order to understand how chemical hazards can affect you, it is important to first understand how chemicals can get into your body and do damage. The four main routes of entry are inhalation, ingestion, injection, and absorption through the skin and eyes. See Appendix B for additional information on the routes of entry

15.2 CHEMICAL LABELING

The simple rule for chemical labeling is - if a container looks like it contains a chemical (even a clear liquid), then it must be labeled with the contents. Proper labeling of chemicals is one way of informing people who work in laboratories of potential hazards that exist, preventing the generation of unknowns, and facilitating emergency responses such as cleaning up spills and obtaining the proper medical treatment.

New chemical containers have the proper labeling information on the chemical label. The OSHA Laboratory Standard requires that labels on all incoming containers must be maintained and not defaced. As part of laboratory good housekeeping and self-inspections, if any chemical labels appear to be falling off, then laboratory personnel should tape the label back on the container or relabel with a permanent label.

Non-Original Containers

1. Non-original containers (secondary use containers) such as wash bottles, squirt bottles, temporary storage containers, beakers, flasks, bottles, vials, etc. or any container that a chemical from an original container is transferred into, must be properly labeled. In general, EH&S recommends writing out the full chemical name and any hazards associated with that chemical. Laboratory personnel are strongly encouraged to use commercially available pre-labeled containers (such as squirt bottles) for chemicals that get used frequently. However, labs can also choose to label chemical containers in other ways such as: Abbreviations – Structures and Formulas

   Use of abbreviations such as structures, formulas, or acronyms is acceptable. However, if you use any abbreviations, you must hang up a “key” to the abbreviations in a visible location (preferably close to the chemicals and/or by the door). The “key” must contain the abbreviation and the name of the chemical. Including the hazards of the chemical on the “key” is also useful information. Small Containers and Sample Storage

For small containers, such as vials and eppendorf tubes, which may be too small to write out a chemical name, structure, or formula, laboratories can implement other systems to identify the chemicals such as:

- Placing the vial or small container in a Ziploc bag or other type of overpack container (beaker, plastic bottle, etc.) and labeling the overpack container with the chemical name.
- Laboratories can use "price tag" style labels in which the chemical name is written out on a tag, and the tag is then attached to the small container with string or a rubber band.
- For vials in a test tube rack – laboratory personnel can simply label the rack with the chemical name, and then label the vials with an abbreviation, color, number, or letter code that corresponds to the label on the test tube rack. For example, if a lab had 10 small vials of ethanol in one rack, the rack could be labeled a 1-E = Ethanol. All of the vials would then be labeled as 1-E. Be sure that the number or letter code is clearly identifiable and would not be confused with other chemicals in the lab.
- For preserved specimens, bottles should be labeled with the preservative (i.e. ethanol or formaldehyde).
- For sample storage in refrigerators, laboratory personnel should label sample containers with one of the above methods, including labeling boxes that hold the small vials or chemical containers. Laboratories should include a key to any abbreviations on the outside of the refrigerator and label the key as "Sample Storage abbreviation = chemical name".

2. Number, Letter, and Color Codes

For vials and other small containers, laboratory personnel can make use of number, letter, and color-coded systems as long as a "key" is hung up which clearly identifies the chemical name that the number, letter, or color code represents. While this type of system is available for laboratory personnel to use, EH&S does not recommend using such a system for hazardous chemicals. Such a system would be more appropriate for non-hazardous compounds such as agar and buffer solutions.

***Please keep in mind that some laboratory workers may be color-blind - red-green and blue-yellow. This fact needs to be taken into consideration, BEFORE a color-coding system is used.

Labeling Requirements

In all cases, regardless of the labeling system used, the following labeling requirements must be followed:

- All chemical containers (both hazardous and non-hazardous) MUST be labeled. Chemical names must be written out in English. If a label is starting to fall off a chemical container or is becoming degraded, then the container needs to be relabeled or the chemical needs to be transferred to another properly labeled container.
- If abbreviations such as formulas, structures, or acronyms are used, then a "key" to the abbreviations must be hung up in a conspicuous location.
- All personnel working in the laboratory must be fully trained on how to label chemicals using the system and how to understand the labeling system. Training must occur when a new person begins working in the laboratory, when new chemicals are introduced, and should occur on a regular basis or annually.

15.3 CHEMIAL STORAGE

Chemical storage areas in the academic laboratory setting include central stockrooms, storerooms, laboratory work areas, storage cabinets, refrigerators, and freezers. There are established legal requirements as well as recommended practices for proper storage of chemicals. Proper storage of chemicals promotes safer and healthier working conditions, extends the usefulness of chemicals, and can help prevent contamination. Chemicals that are stored improperly can result in:

- Degraded containers that can release hazardous vapors that are detrimental to the health of laboratory personnel.
- Degraded containers that allow chemicals to become contaminated, which can have an adverse effect on experiments.
- Degraded containers that can release vapors, which in turn can affect the integrity of nearby containers.
- Degraded labels that can result in the generation of unknowns.
- Chemicals becoming unstable and/or potentially explosive.
- Citation and/or fines from state and federal regulatory agencies.

General Storage Guidelines

Laboratories should adhere to the following storage guidelines for the proper and safe storage of chemicals. By implementing these guidelines, laboratories can ensure safer storage of chemicals and enhance the general housekeeping and organization of the lab. Proper storage of chemicals also helps utilize limited laboratory space in a more efficient manner.

- All chemical containers MUST be labeled. Labels should include the name of the chemical constituent(s) and any hazards present. Be sure to check chemical containers regularly and replace any labels that are deteriorating or falling off and/or relabel with another label before the chemical becomes an unknown.
- Keep all containers of chemicals closed when not in use.
- Every chemical should have an identifiable storage place and should be returned to that location after use.
- The storage of chemicals on bench tops should be kept to a minimum to help prevent clutter and spills, and to allow for adequate working space.
- Chemical storage in fume hoods should be kept to a minimum - limited to the experiment being conducted. Excess storage of chemical containers in hoods can interfere with airflow, reduce working space, and increase the risk of a spill, fire, or explosion.
- For chemical storage cabinets, larger chemical bottles should be stored towards the back and smaller bottles should be stored up front where they are visible. Chemical bottles should be turned with the labels facing out so they can be easily read.
- Chemicals should not be stored on the floor due to the potential for bottles to be knocked over and result in a spill. If it is necessary to store bottles on the floor, then the bottles should be placed in secondary containment, such as trays, and the bottles should be placed away from aisle spaces.
- For multiples of the same chemical, older containers should be stored in front of newer chemicals and containers with the least amount of chemical should be stored in front of full containers. This allows for older chemicals to get used up first and helps to minimize the number of chemical containers in the storage area.
- Do not store chemicals in direct sunlight or next to heat sources.
- Laboratories should strive to keep only the minimum quantity of chemicals necessary. When ordering new chemicals, laboratories should only order enough stock needed for the experiment or the quantity that will get used up within 1 or 2 years at most.
- Liquid chemical containers should be stored in secondary containment, such as trays, to minimize the potential for bottle breakage and minimize the potential for spills.
- Always segregate and store chemicals according to compatibility and hazard classes.

- Chemical containers should be dated when they arrive and should be checked regularly and disposed of when they get past their expiration date. Please Note: Due to the potential explosion hazard, peroxide forming chemicals are required to be tested and dated.

- Flammable liquids in excess of quantities for specific flammability classes must be stored in approved flammable liquid storage cabinets.

- Do not store acids in flammable liquid storage cabinets. This can result in serious degradation of the storage cabinet and the containers inside. Corrosive chemicals should be stored in corrosion resistant cabinets. The exceptions to this rule are organic acids, such as Acetic acid, Lactic acid, and Formic acid, which are considered flammable/combustible and corrosive and can be stored in flammable or corrosive storage cabinets.

- Do not store corrosive or other chemicals that can be injurious to the eyes above eye level. In general and where practical, no chemicals should be stored above eye level.

- Do not store flammable liquids in standard (non-explosion proof) refrigerators or freezers. Due to the potential explosion hazard, only store flammables in refrigerators or freezers approved by the manufacturer for storage of flammables.

- Highly toxic chemicals such as inorganic cyanides should be stored in locked storage cabinets. Always keep the quantities of highly toxic chemicals to an absolute minimum. See Particularly Hazardous Substances section.

- Be aware of any special antidotes or medical treatment that may be required for some chemicals (such as cyanides and Hydrofluoric acid).

- Always keep spill kits and other spill control equipment on hand in areas where chemicals are used. Ensure all personnel working in the lab have been properly trained on the location and use of the spill kit.

- For reagent shelves, it is recommended to use shelves with anti-roll lips, to prevent bottles from falling off. This can also be accomplished using heavy gauge twine or wire to create a lip on the shelf.

15.4 CHEMICAL PROCUREMENT AND DISTRIBUTION

1. All chemicals in the laboratory must have approval of the Principal Investigator prior to purchase. Before purchasing any new chemical, the following information must be considered by the Principal Investigator:
   a. Proper storage and handling procedures
   b. Proper disposal procedures
   c. Presence of adequate facilities to handle and store the material safely,
   d. Adequate training for personnel handling the material
2. According to SDSM&T policy VI-A-04, all chemicals or instruments containing chemicals for laboratory and research areas. If the order is not glassware, plastic containers, or brushes, verify with Campus Chemical Materials Coordinator before ordering. In addition, if the Campus Chemical Storeroom has the appropriate grade or quality of chemical, it will be dispensed instead of purchased to prevent waste. A processing fee will be added to each purchase.
3. Before a chemical is received, information on proper handling, storage and disposal should be given to the workers involved. All original Materials Safety Data Sheets (SDS) that are received with shipments shall be maintained on file in the Campus Chemical Storeroom. **All laboratories will have a copy of the SDS available for each chemical in that laboratory on SDSOnline (http://www.sdsmt.edu/Campus-Services/Environmental-Health-and-Safety/). Laboratories can also keep hard copies.**
   1. No container should be accepted without an adequate identifying label. The label should include, at a minimum, the chemical name, date, and appropriate hazard warning. All chemicals from the storeroom will be labeled with a barcode label with the appropriate chemical name, date, and hazards.

15.5 CHEMICAL INVENTORY

Chemical inventories are required by SDSM&T policy VI-A-04. The Campus Chemical Storeroom maintains inventories using the campus inventory system. Unused or unwanted chemicals should be submitted for disposal. Contact the Campus EHS Manager for disposal procedures or use the following web address http://www.sdsmt.edu/Campus-Services/Environmental-Health-and-Safety/University-Chemical-Storeroom/

Any laboratory that houses a chemical with a health, flammability, or reactivity rating of 4, as designated by NFPA 49, should post the appropriate rating on the door with a contact name and number. For security purposes, the name of the chemical and the quantity on hand must be placed on the inside of the door of the lab.

15.6 TRANSPORTING CHEMICALS

When transporting chemicals between laboratories or other buildings on campus, the following guidelines should be implemented for protection of people and the environment, and to minimize the potential for spills to occur.

- Whenever transporting chemicals by hand, always use a secondary container such as a rubber acid carrying bucket, plastic bucket, or a 5-gallon pail). If necessary, a small amount of packing material (shipping peanuts, vermiculite, or cardboard inserts), that is compatible with the chemical(s), should be used to prevent bottles from tipping over or breaking during transport. You should have proper PPE accessible in the event of a spill.

- Wheeled carts with lipped surfaces (such as Rubbermaid carts) should be used whenever feasible.

- Whenever possible, do not use passenger elevators when transporting chemicals, only freight elevators should be used. If it is necessary to use a passenger elevator, use should be restricted to low-use times such as early in the morning or late in the afternoon. If this is not possible, be sure to warn passengers, or prohibit passengers from riding with you.

- When transporting compressed gas cylinders, always use a proper gas cylinder hand truck with the cylinder strapped to the cart and keep the cap in place. NEVER roll or drag a compressed gas cylinder.

- Avoid riding in elevators with cryogenic liquids or compressed gas cylinders. If this is necessary, consider using a buddy system to have one person send the properly secured dewars or cylinders on the elevator, while the other person waits at the floor by the elevator doors where the dewars or cylinders will arrive.

- Do not transport chemicals in your personal vehicle. Contact EH&S for assistance.

Please note: If you plan on transporting or shipping any hazardous chemicals off the main campus, be aware there are specific procedures, training and other legal requirements that must be followed. For more information, refer to the Shipping Hazardous Materials section.

15.7 CHEMICAL SEGREGATION

Chemicals should be stored according to compatibility and hazard classes. Rather than store chemicals alphabetically, or by carbon number, or by physical state, etc., EH&S recommends that you use the following scheme for organizing chemicals

Chemicals should be organized according to the hazard classes provided below. No reactive or corrosive chemicals should be stored above five (5) feet from the ground. Chemical container size should be limited to 4-L bottles. Any 20-L containers should be reviewed with EHS to ensure space requirements are met. No 200-L drums should be used or stored in any labs.

- RED NFPA 3 or 4 : Flammables. Preferably store in flammable cabinets, in small bottles in wall cabinets, and larger bottles in bench cabinets.

- BLUE NFPA 3 and 4: Health Hazard. Toxic if inhaled, ingested or absorbed through skin. Store in secure area, and not on open shelves.

- YELLOW NFPA 3 and 4: Reactive and oxidizing reagent. May react violently with air, water or other substances. Store away from flammables in secure area, and not on open shelves

- Corrosive: May harm skin, eyes, mucous membranes. Store away from red-, yellow-, and blue-coded reagents. Store in corrosive cabinets, separating acids and bases.

- GENERAL: No more than moderate hazard (many time marked in gray, green, or orange). These chemicals can be stored on open shelves within the laboratories. Basically, these will be NFPA RED 0-2, NFPA Blue 0-2, and NFPA Yellow 0-2.

15.8 CHEMICAL HAZARDS

Chemicals can be broken down into hazard classes and exhibit both physical and health hazards. It is important to keep in mind, that chemicals can exhibit more than one hazard or combinations of several hazards. Several factors factors can influence how a chemical will behave and the hazards the chemical presents, including the severity of the response:

- Concentration of the chemical.
- Physical state of the chemical (solid, liquid, gas).
- Physical processes involved in using the chemical (cutting, grinding, heating, cooling, etc.).
- Chemical processes involved in using the chemical (mixing with other chemicals, purification, distillation, etc.).
- Other processes (improper storage, addition of moisture, storage in sunlight, refrigeration, etc.).
- The following sections describe general information and safety precautions about specific hazard classes. The chemical hazards listed are based on the Department of Transportation (DOT) hazard class system.
- It is important to note that the following sections are general guidelines. Laboratory personnel should always review SDSs and other resources FIRST, before working with any chemical.

See Appendix D for definitions of each hazard.

15.9 WORK WITH PARTICULARLY HAZARDOUS MATERIALS

1. The following safeguards must be used for all work with "Select Carcinogens" and reproductive toxins (See Select Carcinogens and Reproductive Toxins), and substances that have a high degree of acute toxicity.
   a. The establishment of a "designated area", unless the Risk Management Committee and/ or the Campus EHS Manager decides after a case-by-case review that it is not necessary. The designated area may be an entire laboratory, an area of a laboratory or a device in the lab, such as a hood. This area must be clearly marked.
   b. Control equipment (glove box, hood, etc.) required.
   c. Proper storage procedures utilized.
   d. Personal protective equipment required.
   e. Procedures for retention of records on amounts of these materials on hand and used, and the names of the workers involved.
   f. Procedures for the prevention of spills and accidents, and emergency response.
   g. Procedures for decontamination and /or the disposal of wastes.
   h. Procedures for decontamination of the designated area.
2. Standard Operating Procedure's must exist for all laboratory operations that involve substances that require designated areas for use. The SOPs must include provisions for appropriate signs and labels and approvals for use.
3. A partial list of acutely toxic compounds can be found at Acutely Toxic Compounds.

16. WASTE DISPOSAL PROCEDURES

Waste Disposal procedures for chemical, infectious and other wastes are available from the Campus EHS Manager and the Campus Chemical Storeroom or at the following website http://business.sdsmt.edu/ehs/storeroom/. A general rule, **nothing but water goes down the sink – everything else needs to be treated as waste in laboratories.**

17. SAFETY DATA SHEETS

Safety Data Sheets (SDSs) are an important part of any laboratory safety program in communicating information to chemical users. Under the Globally Harmonization system (GHS) SDSs have been standardized to provide the following information:

- Section 1, Identification;
- Section 2, Hazard(s) identification;
- Section 3, Composition/information on ingredients;
- Section 4, First-aid measures;
- Section 5, Fire-fighting measures;
- Section 6, Accidental release measures;
- Section 7, Handling and storage;
- Section 8, Exposure controls/personal protection;
- Section 9, Physical and chemical properties;
- Section 10, Stability and reactivity;
- Section 11, Toxicological information; and
- Section 16, Other information, including date of preparation or last revision.

The Campus Chemical Storeroom verifies the SDS can be found on MSDSOnline for each chemical that enters campus. MSDSOnline is available through the following web address: http://www.sdsmt.edu/Campus-Services/Environmental-Health-and-Safety/. Back-up of the database are available, in the event that the database becomes unavailable. SDSs must be accessible at all times. It is the responsibility of Principal Investigators and laboratory supervisors to ensure that staff and students working in laboratories under their supervision have obtained required health and safety training and have access to SDSs (and other sources of information) for all hazardous chemicals used in laboratories under their supervision.

Please note: any accidents involving a chemical will require an SDS being provided to emergency response personnel and to the attending physician so proper treatment can be administered.

The EH&S "rule of thumb" is that a person working in a laboratory should be able to produce an SDS for any hazardous chemical found in the lab within five minutes.

SDSs and Newly Synthesized Chemicals

Principal Investigators will be responsible for ensuring that newly synthesized chemicals are used exclusively within their laboratories and are properly labeled. If the hazards of a chemical synthesized in the laboratory are unknown, then the chemical must be assumed to be hazardous and the label should indicate the potential hazards of that substance have not been tested and are unknown.

The Principal Investigator must ensure a SDS is prepared for newly synthesized chemicals if:

- The chemical is hazardous according to the OSHA definition of hazardous (if the hazards are not known, then the chemical must be assumed to be hazardous).

AND

- The newly created chemical or intermediate compound is going to be transferred to a different researcher or testing lab on or off of the University campus.

OR

- The newly created chemical or intermediate compound is going to be kept in the lab for an on-going basis for use by current and/or future researchers in the lab where it was originally made.

OR

- The newly created chemical or intermediate compound is going to be provided to another research group at the School of Mines.

18. HAZARDOUS MATERIAL SHIPPING

Training is required prior to shipping any hazardous materials. Please contact EHS for help.

19. PHYSICAL HAZARDS

In addition to the chemical hazards found in laboratories, there are also numerous physical hazards encountered by laboratory staff on a day-to-day basis. As with chemical hazards, having good awareness of these hazards, good preplanning, use of personal protective equipment and following basic safety rules can go a long way in preventing accidents involving physical hazards.

It is the responsibility of the Principal Investigator and laboratory supervisor to ensure that staff and students in laboratories under their supervision are provided with adequate training and information specific to the physical hazards found within their laboratories. See Appendix E for more information on physical hazards which may include:

A. ELECTRICAL SAFETY
B. MACHINE GUARDING
C. LIGHTING
D. COMPRESSED GASES
E. BATTERY CHARGING
F. HEAT AND HEATING DEVICES
G. HEAT STRESS
H. COLD TRAPS
I. AUTOCLAVES
J. CENTRIFUGES
K. CRYOGENIC SAFETY
L. EXTRACTIONS AND DISTILLATIONS
M. GLASS UNDER VACUUM PRESSURE
N. GLASSWARE WASHING
O. GENERAL EQUIPMENT SETUP
P. ERGONOMICS

20. BIOSAFETY

South Dakota School of Mines and Technology has a biosafety plan. BSL2 work is the current level of work being completed.

21. LASER SAFETY

South Dakota School of Mines and Technology has a laser safety plan.

22. RADIATION SAFETY

Contact the Campus EHS Manager for procedures for the procurement, handling, storage, use and disposal of radioactive materials. These procedures shall be followed by anyone using radionuclides. South Dakota School of Mines does not have a general license. Each PI must be added to the license in order to complete work with radioactive materials.

23. OPERATIONS REQUIRING PRIOR APPROVAL

Using and storing certain chemicals will require prior approval. Please contact Campus EHS Manager for approval. Some of these compounds include, but are not limited to: toxic or corrosive gases such as: Fluorine, Chlorine, Phosgene, Arsine, Anhydrous Hydrofluoric Acid, Carbon Monoxide, Hydrogen Sulfide, unstable Boron Hydrides; highly reactive or explosive chemicals such as: Polynitrated Compounds, unstable Organic Peroxides, Heavy Metal Azides or Acetylides; or highly toxic materials such as: Cholinesterase Inhibitors, some Pesticides or Magic Methyl and related chemicals.

24. STANDARD OPERATING PROCEDURE AND JOB HAZARD ASSESSMENT GUIDELINES

In addition to the following generic laboratory procedures, each laboratory should develop standard operating procedures specific to its operation. SOPs should be included for all commonly repeated procedures used by more than one student and for procedures in which sufficient protection for an employee is not provided by the general practices described in the CHP.

LABORATORY AND GENERIC SOP INFORMATION

1. A specific SOP is required when the general requirements cited in the following sections of the CHP are insufficient to direct and protect a new laboratory worker in a commonly required and repeated laboratory procedure.

Section	Content
5.0	General Laboratory Procedures

6.3	Chemical Storage
11.0	Personal Protection Equipment
17.0	Waste Disposal Procedures
18.0	Hood Safety and Ventilation

2. Contact the Campus EHS Manager for model SOP's. The SOP's must be modified or created for use within the specific laboratories. The EHS&R Committee may request Principal Investigators to prepare a SOP when the need is evident.
3. SOPs should be based on the following outline:

25. RECORD KEEPING

1. Accident /Incident reports shall be retained by Campus EHS Manager for five years.
2. Medical records shall be retained by the University for the duration of employment plus thirty years.
3. Industrial hygiene monitoring records shall be maintained by the University for thirty years.
4. Annual EHS audits completed by the Campus Environmental Health and Safety Director shall be maintained for five years.

26. REVIEW AND REVISION OF CHEMICAL HYGIENE AND LAB SAFETY MANUAL

The South Dakota School of Mines and Technology General Chemical Hygiene and Lab Safety Manual will be reviewed biennially by the EHS&R Committee. Requests for changes to the document may be made at any time during the year. Any request for changes that are more than editorial in nature will be reviewed by the EHS&R Committee. If the EHS&R Committee agrees that the requested change can be made, then an amendment to the Chemical Hygiene and Lab Safety Plan will be drafted and brought for approval. If the EHS&R Committee cannot find a means of accommodating the request, the individual will be notified. If the individual wants to pursue the requested modification further, the issues will be documented and presented to the committee for discussion.

APPENDIX A – ENGINEERING CONTROLS

A. FUME HOODS

a. General laboratory ventilation shall provide air flow into the laboratory from non-laboratory areas and out to the exterior of the building.
b. Laboratory doors should remain closed, except for egress and entrance.

1. HOOD USE

a. All reactions that produce unpleasant and/or potentially hazardous fumes, vapors and gases must be performed within a fume hood.
b. The hood sash should remain at or below the 18" mark. When adjustments are needed to laboratory equipment or operations within the hood while chemical emissions are being produced the hood sash should not be raised past the 100 linear feet per minute (lfm) indicator.

2. HOOD MAINTENANCE AND INSPECTIONS

a. User hood function inspections

Upon use (or "before each use") inspections by operators should be conducted.

i. Visually inspect the hood area for storage of materials and other visible blockages.
ii. If hood function indicating devices are not a part of the hood, verify the directional flow within the hood. This can be completed by place a 1 inch by 6 inch piece of soft tissue or ribbon at the hood opening and observe it for appropriate directional flow into the hood. Or, a ribbon can be permanently attached to show the directional flow.

b. Periodic hood function inspections

The quality and quantity of ventilation should be evaluated upon installation, biennually, and whenever a change in local ventilation devices is made. These evaluations are the responsibility of Facilities Services, or designee.

i. Capture or face velocity will be measured with a velometer or anemometer. Hoods for most common chemicals must have an average face velocity of 100 linear feet per minute at sash opening of 18 inches or higher. Face velocity readings should not vary by more than 20%.
ii. Local exhaust devices should be smoke tested to determine if the contaminants they are designed to remove are being adequately captured by the hood.

c. Annual maintenance

Overall maintenance of the local exhaust ventilation should be performed annually by Facilities Services, or designee.

i. Exhaust fan maintenance, (i.e., lubrication, belt tension, fan blade deterioration and rpm), shall be in accordance with the manufacturer's recommendation or as adjusted for appropriate hood function.
ii. Ductwork should be inspected for corrosion, buildup of condensate or particulate, and dampers checked and lubricated for appropriate operation.
iii. Air cleaning equipment such as charcoal or HEPA filters should be monitored for contaminant buildup. If not supplied with differential pressure gauges or audible alarms, the filters should be leak tested.

3. VENTILATION FAILURE

a. Questionable ventilation or requests to evaluate ventilation throughput or efficiency should be made to the Campus EHS Manager or Facilities Services.
b. Ventilation problems or fume hood alarms that are sounding should be reported to the Campus EHS Manager, who should submit repair requests to Facilities Services.
c. In the event of a total or catastrophic ventilation failure, take steps to cease operations (if doing so will not cause harm). This may include stabilizing the experiment, shutting off utilities, closing the sash, and closing the laboratory door.
    a. If appropriate, pull the fire alarm to evacuate the building. Otherwise, keep people from entering the lab.
    b. Notify Facilities Services/Campus Safety of the problem.

4. PERCHORLIC ACID USE

Be aware that use of heated Perchloric acid requires a special Perchloric acid fume hood with a wash down function. DO NOT use heated Perchloric acid in a regular fume hood. If heated

Perchloric acid is used in a regular fume hood (without a wash down function), shock sensitive metallic perchlorate crystals can form inside the duct work, and could result in causing an explosion during maintenance work on the ventilation system. If you suspect your fume hood has perchlorate contamination or would like more information on Perchloric acid fume hoods, then contact EH&S.

5. INSTALLATION OF NEW FUME HOODS

Installation of a new fume hood requires careful planning and knowledge of the existing building ventilation systems and capabilities. Improperly installed fume hoods or other capture devices can seriously disrupt the existing ventilation system and have a negative impact in the immediate room, other fume hoods, and the ventilation system throughout the building.

All fume hoods and other capture devices must be installed in consultation with Facilities Services and EH&S. All new installations of fume hoods must comply with PDC Design Standard 15020 – Laboratories.

In addition to ensuring proper installation of your new fume hood, by consulting with EH&S on new installations, your new fume hood or capture device will be added to our inventory and included in the annual fume hood inspection and testing program.

Please remember that all fume hood purchase requests need prior review and approval through EH&S. EH&S can provide information regarding the selection, purchase, and inspection requirements for laminar flow clean benches, biosafety cabinets, and portable fume hoods.

6. REMOVAL OF EXISTING FUME HOODS

Any removal of fume hoods and capture devices requires prior consultation with Facilities Services and EH&S. This is necessary to ensure building ventilation systems are not affected by removal of fume hoods and capture devices, and so utility services such as electrical lines, plumbing systems, and water and gas supply lines are properly disconnected.

There is an additional concern for the presence of asbestos within the fume hood itself, and potentially in any pipe insulation associated with the ductwork and/or Mercury in cup sinks. Any asbestos must be properly removed and disposed of by a certified asbestos removal company. EH&S can assist laboratories with the cleanup of any Mercury contamination. Contact EH&S for more information or questions about potential asbestos or Mercury contamination.

B. OTHER CAPTURE DEVICES

Other engineering controls for proper ventilation include glove boxes, compressed gas cabinets, vented storage cabinets, canopy hoods, and snorkels. These pieces of equipment are designed to capture hazardous chemical vapors, fumes, and dusts at the source of potential contamination. Examples where these capture devices would be appropriate include welding operations, atomic absorption units, vacuum pumps, and other operations.

Please note, when other laboratory apparatus (such as vacuum pumps and storage cabinets) are vented into the face or side of a fume hood, disruptions can occur in the design flow of the hood and result in lower capture efficiency. When such venting is deemed necessary, the connection should be further along the exhaust ducts of the hood system rather than into the face of the hood. To avoid the possibility of disrupting the efficiency and operation of the fume hood, any additional installations or adjustments should not be undertaken without first consulting with Facilities Services, EH&S, and the appropriate campus service shops.

1. Glove Boxes

Glove boxes (or glove boxes) are sealed enclosures designed to protect the user, the process or both. They are usually equipped with at least one pair of gloves attached to the enclosure. The user manipulates the materials inside using the gloves. Typically, a glove box has an antechamber that is used to take materials in and out of the box.

The topic of glove boxes can be confusing because their configuration depends on the application. Glove boxes can be under negative or positive pressure. Glove boxes under negative pressure are designed to protect the operator and ambient environment from the materials or processes; glove boxes under positive pressure are intended to protect the materials or processes from the operator and/or the ambient environment. The atmosphere in the glove box may be inert (e.g. nitrogen, argon, helium), sterile, dry, or otherwise controlled. Some glove boxes are equipped with filters (e.g. HEPA) while others vent to a fume hood duct or a dedicated duct. Glove boxes can have various controls, sensors and equipment such as pressure gauges, oxygen sensors, temperature controllers and purifiers.

The term “glove box” is most often applied to enclosures used in chemical and electronic laboratories. Similar apparatus exists in pharmaceutical and biological applications. In the pharmaceutical industry, “glove boxes” are called Compounding Isolators. Compounding Aseptic Isolators are used for compounding sterile preparations while Compounding Aseptic Containment Isolators are used for compounding sterile hazardous drug preparations. In biological applications, Class III biological safety cabinets are akin to glove boxes. A Class III cabinet is totally enclosed with a non-opening window, gas tight, and manipulation is achieved through the use of attached gloves. This cabinet is designed for work with high risk agents and provides maximum protection for the operator and the environment. Room air is HEPA-filtered and the exhaust air must pass through two HEPA filters. An independent, dedicated exhaust system maintains airflow to the cabinet that keeps the cabinet under negative pressure.

Regular maintenance and inspection is essential to ensure that a glove box is adequately protecting the user, the environment and/or the product/process. Routine maintenance procedures and the frequency of inspection (or certification) should follow the manufacturers and regulatory recommendations. SDSM&T requires that biological safety cabinets on campus be inspected annually by a certified company. Compounding Isolators require recertification every 6 months or less, in accordance with USP 797. Glove boxes used for work with hazardous chemicals or processes currently do not have a required frequency of inspection but annual certification by the manufacturer or an industrial hygienist is strongly encouraged.
The integrity of the glove box is key to successful containment. The gloves of a glove box are particularly vulnerable. Gloves should be regularly inspected for cuts, tears, cracking and pin hole leaks. If defects are found, the gloves should be replaced. Note that there are many different types of glove box gloves that vary in thickness, material, size, etc … Chose the correct one for the glove box and application.

There are various tests that can be performed on glove boxes, the suitability of which depends on the glove box and the application. Tests may include pressure decay (for positive pressure), rate of rise (for negative pressure), oxygen analysis, containment integrity, ventilation flow characterization, and cleanliness. The source of a leak can be identified using a Mass Spectrometer Leak Detector, ultrasound, the soap bubble method or use of an oxygen analyzer. For an in-depth discussion of glove boxes and testing, see: AGS (American Glove Box Society) 2007 Guide for gloveboxes – Third Edition. AGS-G001-2007. This guide is offered for sale.

APPENDIX B – ROUTES OF ENTRY

A. ROUTES OF ENTRY

1. Inhalation

Inhalation of chemicals occurs by absorption of chemicals via the respiratory tract (lungs). Once chemicals have entered into the respiratory tract, the chemicals can then be absorbed into the bloodstream for distribution throughout the body. Chemicals can be inhaled in the form of vapors, fumes, mists, aerosols and fine dust.

Symptoms of exposure to chemicals through inhalation include eye, nose, and throat irritation, coughing, difficulty in breathing, headache, dizziness, confusion, and collapse. If any of these symptoms are noted, leave the area immediately and get fresh air. Seek medical attention if symptoms persist and complete and Incident Report.

Laboratory workers can protect themselves from chemical exposure via inhalation through proper use of a functioning fume hood, use of dust masks and respirators when a fume hood is not available, avoiding bench top use of hazardous chemicals, ensuring chemical containers are kept tightly capped, and ensuring all chemical spills are promptly cleaned up.

2. Ingestion

Chemical exposure through ingestion occurs by absorption of chemicals through the digestive tract. Ingestion of chemicals can occur directly and indirectly. Direct ingestion can occur by accidently eating or drinking a chemical; with proper housekeeping and labeling, this is less likely to occur. A higher probability of receiving a chemical exposure can occur by way of indirect ingestion. This can occur when food or drink is brought into a chemical laboratory. The food or drink can then absorb chemical contaminants (vapors or dusts) in the air and result in a chemical exposure when the food or drink is consumed. This can also occur when food or drink is stored with chemicals, such as in a refrigerator. Ingestion can occur when a laboratory worker who handles chemicals does not wear gloves or practice good personal hygiene, such as frequent hand washing, and then leaves the laboratory to eat, drink, or smoke. In all cases, a chemical exposure can result, although the effects of chronic exposure may not manifest itself until years later.

Symptoms of chemical exposure through ingestion include metallic or other strange tastes in the mouth, stomach discomfort, vomiting, problems swallowing, and a general ill feeling. If you think you may have accidentally ingested a chemical, seek medical attention immediately and/or call the Poison Control Center at 1-(800)-222-1222 followed by Campus Safety at 605-394-6100. After seeking medical attention, complete an Incident Report.

The best protection against ingestion of chemicals is to properly label all chemical containers, never consume food or drink or chew gum in laboratories, always wear PPE (such as gloves), and practice good personal hygiene, such as frequent handwashing.

3. Injection

Chemical exposure via injection can occur when handling chemically contaminated items such as broken glass, plastic, pipettes, needles, razor blades, or other items capable of causing punctures, cuts, or abrasions to the skin. When this occurs, chemicals can be injected directly into the bloodstream and cause damage to tissue and organs. Due to direct injection into the bloodstream, symptoms from chemical exposure may occur immediately.

Laboratory workers can protect themselves from an injection hazard by wearing proper PPE such as safety glasses/goggles, face shields, and gloves. Inspect all glassware for chips and cracks before use, and immediately discard any glassware or plasticware that is damaged. To help protect coworkers in the lab and building care staff, all broken glass should be disposed of in a puncture resistant container labeled as “Broken Glass”. This can be a commercially purchased “broken glass” container or simply a cardboard box or other puncture resistant container labeled as “Broken Glass”.

Whenever cleaning up broken glass or other sharp items, always use a broom, scoop or dustpan, or devices such as pliers, before using your hands to pick up broken pieces. If you have to use your hands, it is best to wear leather gloves when handling broken glass. For other items that can cause cuts or puncture wounds, such as needles and razor blades, never leave these items out in the open where someone could come into contact with them. EH&S recommends using a device such as a piece of Styrofoam or similar item to secure them for later use. For disposal, use an appropriate “sharps” container.

If you do receive a cut or injection from a chemically contaminated item, if possible, gently try to remove the object and immediately rinse under water while trying to flush the wound and remove any chemical contamination, administer first aid and seek medical attention if necessary, and then complete an Incident Report.

4. Eye and Skin Absorption

Some chemicals can be absorbed by the eyes and skin, resulting in a chemical exposure. Most situations of this type of exposure result from a chemical spill or splash to unprotected eyes or skin. Once absorbed by these organs, the chemical can quickly find its way into the bloodstream and cause further damage, in addition to the immediate effects that can occur to the eyes and the skin.

Symptoms of eye exposure can include itchy or burning sensations, blurred vision, discomfort, and blindness. The best way to protect yourself from chemical splashes to the eyes is to always wear safety glasses in the laboratory whenever eye hazards exist (chemicals, glassware, lasers, etc.). If you are pouring chemicals, then splash goggles are more appropriate than safety glasses. Whenever a severe splash hazard may exist, the use of a face shield, in combination with splash goggles is the best choice for protection. Please note, a face shield by itself does not provide adequate eye protection.

If you do get chemicals in your eyes, immediately go to an eyewash station and flush your eyes for at least 15 minutes. The importance of flushing for at least 15 minutes cannot be overstated! Once the eyewash has been activated, use your fingers to hold your eyelids open and roll your eyeballs in the stream of water so the entire eye can be flushed. After flushing for at least 15 minutes, seek medical attention immediately and complete an Incident Report.

Symptoms of skin exposure to chemicals include dry, whitened skin, redness, swelling, rashes, blisters, itching, chemical burns, cuts, and defatting. Please note that some chemicals can be readily absorbed by the skin.

Laboratory workers can protect their skin from chemical exposure by selecting and wearing the proper gloves, wearing a lab coat and other personal protective equipment for special hazards (such as protective sleeves, face shields, and aprons), and not wearing shorts and sandals in areas where chemicals are being used - even if you are not using chemicals, but someone else in the lab is using chemicals nearby.

For small chemical splashes to the skin, remove any contaminated gloves, lab coats, etc., and wash the affected area with soap and water for at least 15 minutes. Seek medical attention afterward, especially if symptoms persist.

For large chemical splashes to the body, it is important to get to an emergency shower and start flushing for at least 15 minutes. Once under the shower, and after the shower has been activated, it is equally important to remove any contaminated clothing. Failure to remove contaminated clothing can result in the chemical being held against the skin and causing further chemical exposure and damage. After flushing for a minimum of 15 minutes, seek medical attention immediately and complete an Injury/Illness Report.

Please note that some chemicals, such as Hydrofluoric acid, require use of a special antidote (such as Calcium gluconate gel) and special emergency procedures. Be sure to read SDSs for any chemical you work with to determine if a special antidote is needed when chemical exposure occurs.

APPENDIX C – CHEMICAL HAZARDS

A. UNDERSTANDING CHEMICAL HAZARDS

Chemicals pose both health and physical hazards. For the purposes of this document, health hazard will be used interchangeably with chemical hazard and health effects on the body will be used interchangeably with chemical effects on the body.

According to OSHA, health hazard means “a chemical for which there is statistically significant evidence based on at least one study conducted in accordance with established scientific principles that acute or chronic health effects may occur in exposed employees. The term ‘health hazard’ includes chemicals which are carcinogens, toxic or highly toxic agents, reproductive toxins, irritants, corrosives, sensitizers, hepatotoxins, nephrotoxins, neurotoxins, agents which act on the hematopoietic system and agents which damage the lungs, skin, eyes, or mucous membranes.”

According to OSHA, physical hazard means “a chemical for which there is scientifically valid evidence that it is a combustible liquid, a compressed gas, explosive, flammable, an organic peroxide, an oxidizer, pyrophoric, unstable (reactive) or water-reactive.” Physical hazards are covered in other sections within this manual.

B. CHEMICAL HAZARD INFORMATION

As part of the employers Chemical Hygiene Plan the OSHA Laboratory Standard requires that “the employer shall provide employees with information and training to ensure that they are apprised of the hazards of chemicals present in their work area…Such information shall be provided at the time of an employee’s initial assignment to a work area where hazardous chemicals are present and prior to assignments involving new exposure situations.”

It is the responsibility of the Principal Investigator and laboratory supervisor to ensure that staff and students under their supervision are provided with adequate training and information specific to the hazards found within their laboratories.

C. TOXICITY

Toxicity refers to the ability of a chemical to cause harmful effects to the body.

There are a number of factors that influence the toxic effects of chemicals on the body. These include, but are not limited to:

- The quantity and concentration of the chemical.
- The length of time and the frequency of the exposure.
- The route of the exposure.
- If mixtures of chemicals are involved.
- The sex, age, and lifestyle of the person being exposed to the chemical.

a. Toxic Effects

Toxic effects are generally classified as acute toxicity or chronic toxicity.

- Acute toxicity is generally thought of as a single, short-term exposure where effects appear immediately and are often reversible. An example of acute toxicity relates to the over consumption of alcohol and “hangovers”.
- Chronic toxicity is generally thought of as frequent exposures where effects may be delayed (even for years) and are generally irreversible. Chronic toxicity can also result

in acute exposures, with long term chronic effects. An example of chronic toxicity relates to cigarette smoking and lung cancer.

b. Evaluating Toxicity Data

SDSs and other chemical resources generally refer to the toxicity of a chemical numerically using the term Lethal Dose 50 (LD50). The LD50 describes the amount of chemical ingested or absorbed by the skin in test animals that causes death in 50% of test animals used during a toxicity test study. Another common term is Lethal Concentration 50 (LC50), which describes the amount of chemical inhaled by test animals that causes death in 50% of test animals used during a toxicity test study. The LD50 and LC50 values are then used to infer what dose is required to show a toxic effect on humans.

As a general rule of thumb, the lower the LD50 or LC50 number, the more toxic the chemical. Note there are other factors (concentration of the chemical, frequency of exposure, etc.) that contribute to the toxicity of a chemical, including other hazards the chemical may possess.

While exact toxic effects of a chemical on test animals cannot necessarily be directly correlated with toxic effects on humans, the LD50 and LC50 can give a good indication of the toxicity of a chemical, particularly in comparison to another chemical. For example, when making a decision on what chemical to use in an experiment based on safety for the lab worker, a chemical with a high LD50 or LC50 would be safer to work with, assuming the chemical did not possess multiple hazards and everything else being equal.

In general terms, the resource Prudent Practices in the Laboratory lists the following table for evaluating the relevant toxicity of a chemical:

Toxicity Class	Animal LD50	Probable Lethal Dose for 70 kg Person (150 lbs.)	Example
Super Toxic	Less than 5 mg/kg	A taste (7 drops or less)	Botulinum toxin
Extremely Toxic	5 - 50 mg/kg	< 1 teaspoonful	Arsenic trioxide, Strychnine
Very Toxic	50 - 500 mg/kg	< 1 ounce	Phenol, Caffeine
Moderately Toxic	0.5 - 5 g/kg	< 1 pint Aspirin	Sodium chloride
Slightly Toxic	5 - 15 g/kg	< 1 quart	Ethyl alcohol, Acetone

In addition to having a toxic effect on the body, some chemicals can be carcinogenic, mutagenic, teratogenic, and acutely toxic. These specific chemical hazards are covered in more detail under the Particularly Hazardous Substances section in this manual.

D. CHEMICAL EXPOSURE LIMITS

The OSHA Laboratory Standard requires that laboratory employee exposure of OSHA Regulated Substances do not exceed the Permissible Exposure Limits as specified in 29 CFR Part 1010, subpart Z.

The Permissible Exposure Limits (PEL) are based on the average concentration of a chemical to which workers can be exposed to over an 8-hour workday, 5 days per week, for a lifetime without receiving damaging effects. In some cases, chemicals can also have a Ceiling (C) limit, which is the maximum concentration that cannot be exceeded. OSHA has established PELs for over 500 chemicals. Permissible Exposure Limits are legally enforceable.

Another measure of exposure limits are Threshold Limit Values (TLV) which are recommended occupational exposure limits published by the American Conference of Governmental Industrial Hygienists (ACGIH). Similar to PELs, TLVs are the average concentration of a chemical that a worker can be exposed to over an 8-hour workday, 5 days per week, over a lifetime without observing ill effects. TLVs also have Ceiling (C) limits, which are the maximum concentration a worker can be exposed to at any given time. The ACGIH has established TLVs for over 800 chemicals. A main point of difference between PELs and TLVs is that TLVs are advisory guidelines only and are not legally enforceable. Both PELs and TLVs can be found in SDSs. Another good resource for information is the National Institute for Occupational Health and Safety (NIOSH).

Please note, if laboratory personnel follow the guidelines described within this Laboratory Safety Manual – use fume hoods and other engineering controls, use proper PPE, practice good housekeeping and personal hygiene, keep food and drink out of laboratories, and follow good lab practices – the potential for exceeding exposure limits is significantly reduced.

E. CHEMICAL EXPOSURE MONITORING

As a laboratory worker, you may use a variety of potentially hazardous materials on a daily basis. Safe use of these materials depends heavily on following proper laboratory work practices and the utilization of engineering controls. In certain circumstances, it is necessary to verify that work practices and engineering controls are effective in limiting exposures to hazardous materials.

a. The Campus EHS Manager (or designee) or the Director of Facilities Services (or designee**) should** be responsible for environmental monitoring.
b. Employee exposures to any substance regulated by an OSHA standard shall be measured when there is reason to believe that exposure levels routinely exceed the action levels.
c. Employee's exposures to OSHA regulated substances shall not exceed the permissible exposure limit (PEL) specified in 29 CFR (Code of Federal Regulations) Part 1910, subpart Z.
d. Monitoring results shall be provided to the Campus EHS Manager, the Principal Investigator and to the employee(s).

If you think you are receiving a chemical exposure in excess of OSHA exposure limits, such as feeling symptoms commonly associated with exposure to hazardous materials, or work with any of the chemicals listed below, contact EH&S.

APPENDIX D – HAZARD CATEGORIES

A. EXPLOSIVES

The OSHA Laboratory Standard defines an explosive as a chemical that causes a sudden, almost instantaneous release of pressure, gas, and heat when subjected to sudden shock, pressure, or high temperature. Under the Department of Transportation (DOT) hazard class system, explosives are listed as hazard class 1.

Fortunately, most laboratories do not use many explosives; however, there are a number of chemicals that can become unstable and/or potentially explosive over time due to contamination with air, water, other materials such as metals, or when the chemical dries out.

If you ever come across any chemical that you suspect could be potentially shock sensitive and/or explosive, do not attempt to move the container as some of these compounds are shock, heat, and friction sensitive. In these instances, you should contact EH&S, immediately.

Explosives can result in damage to surrounding materials (hoods, glassware, windows, people, etc.), generation of toxic gases, and fires. If you plan to conduct an experiment where the potential for an explosion exists, first ask yourself the question; "Is there another chemical that could be substituted in the experiment that does not have an explosion potential?" If you must use a chemical that is potentially explosive, or for those compounds that you know are explosive, (even low powered explosives) you must first obtain prior approval from the Principal Investigator to use such chemicals. After obtaining prior approval from your Principal Investigator, thoroughly read the SDSs and any other chemical resources related to the potentially explosive compound(s) to ensure potential incidents are minimized.

Whenever setting up experiments using potentially explosive compounds:

Always use the smallest quantity of the chemical possible.

Always conduct the experiment within a fume hood and use in conjunction with a properly rated safety shield.

Be sure to remove any unnecessary equipment and other chemicals (particularly highly toxic and flammables) away from the immediate work area.

Be sure to notify other people in the laboratory what experiment is being conducted, what the potential hazards are, and when the experiment will be run.

Do not use metal or wooden devices when stirring, cutting, scraping, etc. with potentially explosive compounds. Non-sparking plastic devices should be used instead.

Ensure other safety devices such as high temperature controls, water overflow devices, etc., are used in combination to help minimize any potential incidents.

Properly dispose of any hazardous waste and note on the hazardous waste tag any special precautions that may need to be taken if the chemical is potentially explosive.

Always wear appropriate PPE, including the correct gloves, lab coat or apron, safety goggles used in conjunction with a face shield, and explosion-proof shields when working with potentially explosive chemicals.

For storage purposes, always date chemical containers when received and opened. Pay particular attention to those compounds that must remain moist or wet so they do not become explosive (ex. Picric acid, 2,4-Dinitrophenyl hydrazine, etc.). Pay particular attention to any potentially explosive compounds that appear to exhibit the following signs of contamination:

- Deterioration of the outside of the container.
- Crystalline growth in or outside the container.
- Discoloration of the chemical.

If you discover a potentially explosive compound that exhibits any of these signs of contamination, contact Campus Safety at 605-394-6729for more assistance.

Examples of explosive and potentially explosive chemicals include: Compounds containing the functional groups azide, acetylide, diazo, nitroso, haloamine, peroxide, and ozonide, Nitrocellulose, Di- and Tri-nitro compounds, Peroxide forming compounds, Picric acid (dry), 2,4-Dinitrophenylhydrazine (dry), Benzoyl peroxide (dry)

B. FLAMMABLE AND COMBUSTIBLE LIQUIDS

The OSHA Laboratory Standard defines a flammable liquid as any liquid having a flashpoint below 100 degrees F (37.8 degrees C), except any mixture having components with flashpoints of 100 degrees F (37.8 degrees C) or higher, the total of which make up 99% or more of the total volume of the mixture.

Flashpoint is defined as the minimum temperature at which a liquid gives off enough vapor to ignite in the presence of an ignition source. The risk of a fire requires that the temperature be above the flashpoint and the airborne concentration be in the flammable range above the Lower Explosive Limit (LEL) and below the Upper Explosive Limit (UEL).

The OSHA Laboratory Standard defines a combustible liquid as any liquid having a flashpoint at or above 100 degrees F (37.8 degrees C), but below 200 degrees F (93.3 degrees C), except any mixture having components with flashpoints of 200 degrees F (93.3 degrees C), or higher, the total volume of which make up 99% or more of the total volume of the mixture. OSHA further breaks down flammables into Class I liquids, and combustibles into Class II and Class III liquids. Please note this classification is different than the criteria used for DOT classification. This distinction is important because allowable container sizes and storage amounts are based on the particular OSHA Class of the flammable liquid.

Classification Flash Point Boiling Point

Flammable Liquid

Class IA <73 degrees F <100 degrees F

Class IB <73 degrees F >=100 degrees F

Class IC >=73 degrees F, <100 degrees F >100 degrees F

Combustible Liquid

Class II >=100 degrees F, <140 degrees F --

Class IIIA >=140 degrees F, < 200 degrees F --

Class IIIB >=200 degrees F --

Under the Department of Transportation (DOT) hazard class system, flammable liquids are listed as hazard class 3.

Flammable and combustible liquids are one of the most common types of chemicals used at SDSM&T and are an important component in a number of laboratory processes. However, in addition to the flammable hazard, some flammable liquids also may possess other hazards such as being toxic and/or corrosive.

When using flammable liquids, keep containers away from open flames; it is best to use heating sources such as steam baths, water baths, oil baths, and heating mantels. Never use a heat gun to heat a flammable liquid. Any areas using flammables should have a fire extinguisher present. If a fire extinguisher is not present, then contact EH&S at 394-6729 for more assistance.

Always keep flammable liquids stored away from oxidizers and away from heat or ignition sources such as radiators, electric power panels, etc.

When pouring flammable liquids, it is possible to generate enough static electricity to cause the flammable liquid to ignite. If possible, make sure both containers are electrically interconnected to each other by bonding the containers, and connecting to a ground.

Always clean up any spills of flammable liquids promptly. Be aware that flammable vapors are usually heavier than air (vapor density > 1). For those chemicals with vapor densities heavier than air (applies to most chemicals), it is possible for the vapors to travel along floors and, if an ignition source is present, result in a flashback fire.

1. Flammable Storage in Refrigerators/Freezers

It is important to store flammable liquids only in specially designed flammable storage refrigerators/freezers or explosion-proof refrigerators/freezers. Do not store flammable liquids in standard (non-flammable rated) refrigerators/freezers. Standard refrigerators are not electrically designed to store flammable liquids. If flammable liquids are stored in a standard refrigerator, the build up of flammable vapors can be in sufficient quantities to ignite when the refrigerator's compressor or light turns on, resulting in a fire or an explosion.

Properly rated flammable liquid storage refrigerators/freezers have protected internal electrical components and are designed for the storage of flammable liquids. Explosion-proof refrigerators/freezers have both the internal and external electrical components properly protected and are designed for the storage of flammable liquids. Refrigerators and freezers rated for the storage of flammable materials will be clearly identified as such by the manufacturer.

For most laboratory applications, a flammable storage refrigerator/freezer is acceptable. However, some operations may require an explosion-proof refrigerator/freezer. Flammable storage refrigerators currently cost approximately $1500 - $3000 each. In the case of limited funding where a laboratory cannot purchase a flammable storage refrigerator for the laboratory's own use, EH&S strongly encourages departments and laboratory groups on each floor to consider purchasing a communal flammable storage refrigerator for the proper and safe storage of flammable liquids.

2. Flammable Storage Cabinets

The requirements for use of flammable storage cabinets are determined by the classification of the flammable liquids, the quantities kept on hand, the building construction (fire wall ratings), and the floor of the building the flammables are being stored on. As a general rule of thumb, if you have more than 10 gallons of flammable liquids, including materials in use, then you should store the flammable liquids in a properly rated flammable liquid storage cabinet. All flammable liquids not in use should be kept in the flammable liquid storage cabinet. For stand-alone flammable cabinets (as opposed to cabinets underneath fume hoods), there are vent holes on each side of the cabinet (called bung holes) that must have the metal bungs screwed into place for the cabinet to maintain its fire rating. Venting of flammable cabinets is NOT required, however, if a flammable cabinet is vented, it must be vented properly according to the manufacturer's specifications and NFPA 30. Typically, proper flammable cabinet ventilation requires that air be supplied to the cabinet and the air be taken away via non-combustible pipes. If you are planning on venting your flammable storage cabinet, please contact EH&S at 394-6729 for more information.

C. FLAMMABLE SOLIDS

The OSHA Laboratory Standard defines a flammable solid as a "solid, other than a blasting agent or explosive, that is liable to cause fire through friction, absorption of moisture, spontaneous chemical change, or retained heat from manufacturing or processing, or which can be ignited readily and when ignited, burn so vigorously and persistently to create a serious hazard." An example of a flammable solid is gun powder.

Under the DOT hazard class system, flammable solids are listed as hazard class 4. Flammable solids are further broken down into three subcategories:

Flammable Solids – Class 4.1

Spontaneously Combustible – Class 4.2

Dangerous When Wet – Class 4.3

Many of the same principles for handling and storage of flammable liquids apply to flammable solids. Always keep flammable solids stored away from oxidizers, and away from heat or ignition sources such as radiators, electric power panels, etc.

D. SPONTANEOUSLY COMBUSTIBLES

Spontaneously combustible materials are also known as pyrophorics; these chemicals can spontaneously ignite in the presence of air, some are reactive with water vapor, and most are reactive with oxygen. Two common examples are tert-Butyllithium under Hexanes and White Phosphorus. In addition to the hazard of the spontaneously combustible chemical itself, many of these chemicals are also stored under flammable liquids. In the event of an accident, such as a bottle being knocked off a shelf, the chemical can spontaneously ignite and a fire can occur. Extra care must be taken when handling spontaneously combustible chemicals. When transporting these chemicals, it is best to use a bottle carrier and carts.

E. DANGEROUS WHEN WET

Dangerous when wet compounds react violently with water to form toxic vapors and/or flammable gases that can ignite and cause a fire. Please note, attempting to put out a fire involving dangerous when wet materials with water will only make the situation worse. Special "Class D" fire extinguishers are required for use with dangerous when wet compounds. Common examples include sodium metal and potassium metal.

It is important to note that any paper toweling, gloves, etc., that have come into contact with these materials need to be quenched with water before disposing of in metal trash cans in order to prevent potential fires.

If you are using dangerous when wet compounds and do not have a Class D fire extinguisher present, then please contact EH&S for more assistance.

F. OXIDIZERS AND ORGANIC PEROXIDES

The OSHA Laboratory Standard defines an oxidizer as “a chemical other than a blasting agent or explosive that initiates or promotes combustion in other materials, thereby causing fire either of itself or through the release of oxygen or other gases.” Under the DOT hazard class system, oxidizers are listed as hazard class 5.1 and organic peroxides are listed as hazard class 5.2.

The OSHA Laboratory Standard defines an organic peroxide as “an organic compound that contains the bivalent –O-O- structure and which may be considered to be a structural derivative of hydrogen peroxide where one or both of the hydrogen atoms have been replaced by an organic radical.”

Oxidizers and organic peroxides are a concern for laboratory safety due to their ability to promote and enhance the potential for fires in labs.

As a reminder of the fire triangle (now referred to as the fire tetrahedron), in order to have a fire, you need:

- A fuel source.
- An oxygen source.
- An ignition source.
- A chemical reaction.

Oxidizers can supply the oxygen needed for the fire, whereas organic peroxides supply both the oxygen and the fuel source. Both oxidizers and organic peroxides may become shock sensitive when they dry out, are stored in sunlight, or due to contamination with other materials, particularly when contaminated with heavy metals. Most organic peroxides are also temperature sensitive.

As with any chemicals, but particularly with oxidizers and organic peroxides, quantities stored on hand should be kept to a minimum. Whenever planning an experiment, be sure to read the SDS and other reference documents to understand the hazards and special handling precautions that may be required, including use of a safety shield. Also be aware of the melting and autoignition temperatures for these compounds and ensure any device used to heat oxidizers has an overtemperature safety switch to prevent the compounds from overheating.

Laboratory staff should be particularly careful when handling oxidizers (especially high surface area oxidizers such as finely divided powders) around organic materials.

Avoid using metal objects when stirring or removing oxidizers or organic peroxides from chemical containers. Plastic or ceramic implements should be used instead. Laboratory personnel should avoid friction, grinding, and impact with solid oxidizers and organic peroxides. Glass stoppers and screw cap lids should always be avoided and plastic/polyethylene lined bottles and caps should be used instead.

If you suspect your oxidizer or organic peroxide has been contaminated (evident by discoloration of the chemical, or if there is crystalline growth in the container or around the cap), then dispose of the chemical as hazardous waste or contact EH&S. Indicate on the hazardous waste tag that the chemical is an oxidizer or organic peroxide and that you suspect contamination.

G. PEROXIDE FORMING COMPOUNDS

Many commonly used chemicals; organic solvents in particular, can form shock, heat, or friction sensitive peroxides upon exposure to oxygen. Once peroxides have formed, an explosion can result during routine handling, such as twisting the cap off a bottle – if peroxides are formed in the threads of the cap. Explosions are more likely when concentrating, evaporating, or distilling these compounds if they contain peroxides.

When these compounds are improperly handled and stored, a serious fire and explosion hazard exists. The following guidelines should be adhered to when using peroxide forming chemicals:

i. Each peroxide forming chemical container MUST be dated when received and opened. A list of common peroxide forming chemicals can be found at the following website: http://www.med.cornell.edu/ehs/updates/peroxide_formers.htm. Please note this list is not all-inclusive, there are numerous other chemicals that can form peroxides. Be sure to read chemical container labels, SDSs, and other chemical references.

ii. Each peroxide forming chemical container must be tested for peroxides when opened and at least every 6 months thereafter. The results of the peroxide test and the test date must be marked on the outside of the container.

iii. Peroxide test strips are available in the Campus Chemical Storeroom

iv. Due to sunlight's ability to promote formation of peroxides, all peroxidizable compounds should be stored away from heat and sunlight.

v. Peroxide forming chemicals should not be refrigerated at or below the temperature at which the peroxide forming compound freezes or precipitates as these forms of peroxides are especially sensitive to shock and heat. Refrigeration does not prevent peroxide formation.

vi. As with any hazardous chemical, but particularly with peroxide forming chemicals, the amount of chemical purchased and stored should be kept to an absolute minimum. Only order the amount of chemical needed for the immediate experiment.

vii. Ensure containers of peroxide forming chemicals are tightly sealed after each use and consider adding a blanket of an inert gas, such as Nitrogen, to the container to help slow peroxide formation.

viii. A number of peroxide forming chemicals can be purchased with inhibitors added. Unless absolutely necessary for the research, labs should never purchase uninhibited peroxide formers.

ix. Before distilling any peroxide forming chemicals, always test the chemical first with peroxide test strips to ensure there are no peroxides present. Never distill peroxide forming chemicals to dryness. Leave at least 10-20% still bottoms to help prevent possible explosions.

While no definitive amount of peroxide concentration is given in the literature, a concentration of 50 ppm should be considered dangerous and a concentration of >100 ppm should be disposed of immediately. In both cases, procedures should be followed for removing peroxides or the containers should be disposed of as hazardous waste.

***However, compounds that are suspected of having very high peroxide levels because of age, unusual viscosity, discoloration, or crystal formation should be considered extremely dangerous. If you discover a container that meets this description, DO NOT attempt to open or move the container. Notify other people in the lab about the potential explosion hazard and notify EH&S immediately.

For those compounds that must be handled by an outside environmental "bomb squad" company, the cost for such an operation can result in charges of >$1000 per container. However, if laboratory staff follow the guidelines listed above, the chances for requiring special handling for these types of containers or for an explosion to occur is greatly diminished.

H. POISONS

For the purpose of this manual the word "Poison" will be used interchangeably with the word "Toxic". OSHA defines "Toxic" as a chemical falling within any of the following categories:

a. A chemical that has a median lethal dose (LD50) of more than 50 milligrams per kilogram, but not more than 500 milligrams per kilogram of body weight when administered orally to albino rats weighing between 200 and 300 grams each.

b. A chemical that has a median lethal dose (LD50) of more than 200 milligrams per kilogram, but not more than 1000 milligrams per kilogram of body weight when administered by continuous contact for 24 hours (or less if death occurs within 24 hours) with the bare skin of albino rabbits weighing between two and three kilograms each.

c. A chemical that has a median lethal concentration (LC50) in air of more than 200 parts per million, but not more than 2000 parts per million by volume of gas or vapor, or more than two milligrams per liter but not more than 20 milligrams per liter of mist, fume, dust, when administered by continuous inhalation for one hour (or less if death occurs with in one hour) to albino rats weighing between 200 and 300 grams each.

OSHA draws a distinction between toxic chemicals and acutely toxic chemicals. For more information on acutely toxic chemicals, see Particularly Hazardous Substances. OSHA also provides definitions for other health hazards on their website. Under the DOT hazard class system, poisons are listed as hazard class 6.

As a general rule of thumb, all chemicals should be treated as poisons and proper procedures such as maintaining good housekeeping, use of proper PPE, good personal hygiene, etc., should be followed. When working with known poisons, it is very important to have thought an experiment through, addressing health and safety issues before working with the poison. Safety Data Sheets (SDS) and other chemical references should be consulted before beginning the experiment. Some questions to ask before working with poisonous chemicals:

Do I need to use the poisonous chemical or can a less toxic chemical be substituted?

What are the routes of entry into the body for the poison (inhalation, ingestion, injection, or skin absorption)?

What are the signs and symptoms of potential chemical exposure?

What are the proper PPE required (type of glove, safety glasses vs. splash goggles, face shield, etc.)?

Does the chemical require any special antidote?

What are the emergency procedures to be followed?

When working with highly toxic chemicals, you should not work alone. Always wear proper PPE and always wash your hands with soap and water when finished, even if gloves were worn. Be aware that poisonous mixtures, vapors, and gases can be formed during an experiment. Be sure to research both the reactants and products of the chemicals you will be working with first. Additional information can be found in the Exposure Monitoring section and Routes of Chemical Entry section.

If you think you may have received an exposure to a poisonous substance, or may have accidentally ingested a chemical, seek medical attention immediately and/or call the Poison Control Center at 1-(800) 222-1222 followed by Campus Safety at 605-394-6100. If possible, bring a copy of the SDS with you. Upon completion of seeking medical attention, complete an Incident Report.

I. CORROSIVES

OSHA defines a corrosive as “a chemical that causes visible destruction of, or irreversible alterations in living tissue by chemical action at the site of contact.” Under the DOT hazard class system, corrosives are listed as hazard class 8.

Corrosive chemicals can be further subdivided as acids and bases. Corrosives can be in the liquid, solid, or gaseous state. Corrosive chemicals can have a severe effect on eyes, skin, respiratory tract, and gastrointestinal tract if an exposure occurs. Corrosive solids and their dusts can react with moisture on the skin or in the respiratory tract and result in an exposure.

Whenever working with concentrated corrosive solutions, splash goggles should be worn instead of safety glasses. Splash goggles used in conjunction with a face shield provides better protection. Please note that a face shield alone does not provide adequate protection. Use of rubber gloves such as butyl rubber and a rubber apron may also be required.

Corrosive chemicals should be handled in a fume hood to avoid breathing corrosive vapors and gases.

When mixing concentrated acids with water, always add acid slowly to the water (specifically, add the more concentrated acid to the dilute acid). Never add water to acid, this can result in a boiling effect and cause acid to splatter. Do not pour the acid directly into the water; it should be poured in a manner that allows it to run down the sides of the container. Never store corrosive chemicals above eye level and always use a protective bottle carrier when transporting corrosive chemicals.

Some chemicals can react with acids and liberate toxic and/or flammable vapors. When working with corrosive materials, ensure spill cleanup material is available for neutralization, such as Calcium carbonate for acids and Citric acid for bases.

Wherever acids and bases are used, an eyewash and emergency shower must be available. If any corrosive chemical gets splashed in the eyes, immediately go to an eyewash station and flush your eyes for at least 15 minutes. The importance of flushing for at least 15 minutes cannot be overstated! Once the eyewash has been activated, use your fingers to hold your eyelids open and roll your eyeballs in the stream of water so the entire eye can be flushed. After flushing for at least 15 minutes, seek medical attention immediately and complete an Injury/Illness Report.

For small splashes of corrosives to the skin, remove any contaminated gloves, lab coats, etc., and wash the affected area with soap and water for at least 15 minutes. Seek medical attention afterward, especially if symptoms persist.

For large splashes of corrosives to the body, it is important to get to an emergency shower and start flushing for at least 15 minutes. Once under the shower, and after the shower has been activated, it is equally important to remove any contaminated clothing. Failure to remove contaminated clothing can result in the chemical being held against the skin and causing further chemical exposure and damage. After flushing for a minimum of 15 minutes, seek medical attention immediately and complete an Injury/Illness Report.

Please note some chemicals, such as Hydrofluoric acid, require the use of a special antidote (such as Calcium gluconate gel) and special emergency procedures. Read the SDSs for any chemical(s) you work with to determine if a special antidote is needed if a chemical exposure occurs.

1. Hydrofluoric Acid (Top)

    Hydrofluoric Acid (HF) is one of the most hazardous chemicals used at SDSM&T. Small exposures to HF can be fatal if not treated properly. The critical minutes immediately after an exposure can have a great effect on the chances of a victim’s survival.

    HF is a gas that is dissolved in water to form Hydrofluoric acid. The concentration can vary from very low such as in store bought products up to the most concentrated 70% form (anhydrous), with the most common lab use around 48%. The liquid is colorless, non-flammable and has a pungent odor. The OSHA permissible exposure limit is 3 ppm, but concentrations should be kept as low as possible. HF is actually a weak acid by definition and not as corrosive as strong acids such as Hydrochloric (HCl), however, corrosivity is the least hazardous aspect of HF. The toxicity of HF is the main concern.

    HF is absorbed though the skin quickly and is a severe systemic toxin. The fluoride ion binds calcium in the blood, bones and other organs and causes damage to tissues that is very painful and can be lethal. At the emergency room, the victim is often given calcium injections, but pain medication is not generally given since the pain subsiding is the only indication that the calcium injections are working.

    Due to the serious hazard of working with HF, the following requirements and guidelines are provided:

    All users of HF must receive EH&S Hydrofluoric Acid Safety instruction.

A Standard Operating Procedure (SOP) should be written for the process in which HF is used. This SOP should be posted or readily available near the designated area where HF use will occur.

HF should only be used in a designated fume hood and the fume hood should be identified by posting a HF Designated Area sign.

First Aid - A HF first aid kit must be available that includes 2.5% calcium gluconate gel.

Spill Kits - An HF spill kit must be available with calcium compounds such as Calcium carbonate, Calcium sulfate or Calcium hydroxide. Sodium bicarbonate should never be used since it does not bind the fluoride ion and can generate toxic aerosols.

Prior approval - Before anyone uses HF they must have prior approval from the Principal investigator. The Principal Investigator should ensure the employee has completed this list.

- Has read the SDS for HF
- Has read the HF Use SOP developed by the lab
- Has read the Hydrofluoric acid section in this Lab Safety Manual
- Is aware of the designated area for HF use
- Knows the first aid procedure in case of an HF exposure
- Knows what to do incase of an HF spill
- Personal Protective Equipment (PPE) – The following PPE is required for HF use:
- Rubber or plastic apron
- Plastic arm coverings
- Gloves
- Incidental use - double glove with heavy nitrile exam gloves and re-glove if any exposure to the gloves
- Extended use – heavy neoprene or butyl over nitrile or silver shield gloves
- Splash goggles in conjunction with a fume hood sash
- Closed toed shoes
- Long pants and a long sleeve shirt with a reasonably high neck (no low cut)

The following are safe practice guidelines when working with HF:

- Never work alone with HF but have a buddy system.
- Use a plastic tray while working with HF for containment in case of a spill.

Keep containers of HF closed. HF can etch the glass sash and make it hard to see through (if the hood sash becomes fogged and hard to see though due to etching, then please contact EH&S at about installing a polycarbonate sash)

Safety Data Sheet (SDS) – A SDS for HF must be available.

All containers of HF must be clearly labeled.

The stock HF should be stored in plastic secondary containment and the cabinet should be labeled. HF should be stored in lower cabinets near the floor.

Wash gloves off with water before removing them.

Additional information on the safe use and handling of Hydrofluoric acid (HF) can be found on the Honeywell website - the world's largest producer of Hydrofluoric Acid. This website contains useful information on HF such as:

- Safety Data Sheets
- Technical Data Sheets
- Recommended Medical Treatment for HF exposure
- HF Properties charts
- Online Training

2. Perchloric Acid

Perchloric acid is a strong oxidizing acid that can react violently with organic materials. Perchloric acid can also explode if concentrated above 72%. For any work involving heated Perchloric acid (such as in Perchloric acid digestions), the work must be conducted in a special Perchloric acid fume hood with a wash down function. If heated Perchloric acid is used in a standard fume hood, the hot Perchloric acid vapors can react with the metal in the hood ductwork to form shock sensitive metallic perchlorates. When working with Perchloric acid, be sure to remove all organic materials, such as solvents, from the immediate work area. Due to the potential danger of Perchloric acid, if possible, try to use alternate techniques that do not involve the use of Perchloric acid. If you must use Perchloric acid in your experiments, only purchase the smallest size container necessary.

Because Perchloric acid is so reactive, it is important to keep it stored separate from other chemicals, particularly organic solvents, organic acids, and oxidizers. All containers of Perchloric acid should be inspected regularly for container integrity and the acid should be checked for discoloration. Discolored Perchloric acid should be discarded as hazardous waste. Perchloric acid should be used and stored away from combustible materials, and away from wooden furniture. Like all acids, but particularly with Perchloric acid, secondary containment should be used for storage.

APPENDIX E – PHYSICAL HAZARDS

A. ELECTRICAL SAFETY

Electricity travels in closed circuits, and its normal route is through a conductor. Shock occurs when the body becomes a part of the electric circuit. Electric shock can cause direct injuries such as electrical burns, arc burns, and thermal contact burns. It can also cause injuries of an indirect or secondary nature in which involuntary muscle reaction from the electric shock can cause bruises, bone fractures, and even death resulting from collisions or falls. Shock normally occurs in one of three ways. The person must be in contact with ground and must contact with:

EFFECTS OF ELECTRIC CURRENT IN THE BODY

Current	Reaction
1 Milliampere	Perception level. Just a faint tingle.
5 Milliamperes	Slight shock felt. Average individual can let go. However, strong involuntary reactions to shocks in this range can lead to injuries.
6-30 Milliamperes	Painful shock. Muscular control lost.
50-150 Milliamperes	Extreme pain, respiratory arrest, severe muscular contractions. Individual cannot let go. Death is possible.
1,000-4,300 Milliamperes	Ventricular fibrillation. Muscular contraction and nerve damage occur. Death is most likely.
10,000-Milliamperes	Cardiac arrest, severe burns and probable death.

Common Electrical Hazards and Preventative Steps

Many common electrical hazards can be easily identified before a serious problem exists. Read and follow all equipment operating instructions for proper use. Ask yourself, "Do I have the skills, knowledge, tools, and experience to do this work safely?"

- Do not attempt electrical repairs unless you are a qualified electrical technician assigned to perform electrical work by your supervisor. Qualified individuals must receive training in safety related work practices and procedures, be able to recognize specific hazards associated with electrical energy, and be trained to understand the relationship between electrical hazards and possible injury. Fixed wiring may only be repaired or modified by Facilities Services.
- All electrical devices fabricated for experimental purposes must meet state and University construction and grounding requirements. Extension cords, power strips, and other purchased electrical equipment must be Underwriters Laboratories (UL) listed.
- Remove all jewelry before working with electricity. This includes rings, watches, bracelets, and necklaces.
- Determine appropriate personal protective equipment (PPE) based on potential hazards present. Before use, inspect safety glasses and gloves for signs of wear and tear, and other damage.
- Use insulated tools and testing equipment to work on electrical equipment. Use power tools that are double-insulated or that have Ground Fault Circuit Interrupters protecting the circuit. Do not use aluminum ladders while working with electricity; choose either wood or fiberglass.
- Do not work on energized circuits. The accidental or unexpected starting of electrical equipment can cause severe injury or death. Before any inspections or repairs are made, the current must be turned off at the switch box and the switch padlocked or tagged out in the off position. At the same time, the switch or controls of the machine or the other equipment being locked out of service should be securely tagged to show which equipment or circuits are being worked on. Test the equipment to make sure there is no residual energy before attempting to work on the circuit. Employees must follow the University lock-out/tag-out procedures.
- If you need additional power supply, the best solution is to have additional outlets installed by Facilities Services. Do not use extension cords or power strips ("power taps") as a substitute for permanent wiring.
- Extension cords and power strips may be used for experimental or developmental purposes on a temporary basis only. Extension cords can only be used for portable tools or equipment and must be unplugged after use. Do not use extension cords for fixed equipment such as computers, refrigerators/freezers, etc.; use a power strip in these cases. In general, the use of power strips is preferred over use of extension cords.
- Power strips must have a built-in overload protection (circuit breaker) and must not be connected to another power strip or extension cord (commonly referred to as daisy chained or piggy-backed). As mentioned above though, extension cords and power strips are not a substitute for permanent wiring.
- Ensure any power strips or extension cords are listed by a third-party testing laboratory, such as Underwriters Laboratory (UL). Make sure the extension cord thickness is at least as big as the electrical cord for the tool. For more information on extension cords, see the Consumer Product Safety Commission - Extension Cords Fact Sheet (CPSC Document #16).
- Inspect all electrical and extension cords for wear and tear. Pay particular attention near the plug and where the cord connects to the piece of equipment. If you discover a frayed electrical cord, contact your supervisor for assistance. Do not use equipment having worn or damaged power cords, plugs, switches, receptacles, or cracked casings. Running electrical cords under doors or rugs, through windows, or through holes in walls is a common cause of frayed or damaged cords and plugs.
- Do not use 2-prong ungrounded electrical devices. All department-purchased electrical equipment must be 3-prong grounded with very limited exceptions.
- Never store flammable liquids near electrical equipment, even temporarily.
- Keep work areas clean and dry. Cluttered work areas and benches invite accidents and injuries. Good housekeeping and a well-planned layout of temporary wiring will reduce the dangers of fire, shock, and tripping hazards.
- Common scenarios that may indicate an electrical problem include: flickering lights, warm switches or receptacles, burning odors, sparking sounds when cords are moved, loose connections, frayed, cracked, or broken wires. If you notice any of these problems, have a qualified electrician address

the issue immediately.

- To protect against electrical hazards and to respond to electrical emergencies it is important to identify the electrical panels that serve each room. Access to these panels must be unobstructed; a minimum of 3' of clearance is required in front of every electrical panel. Each panel must have all the circuit breakers labeled as to what they control. Contact your supervisor for assistance.
- When performing laboratory inspections, it is a good idea to verify the location of the power panel and to open the door to ensure any breakers that are missing have breaker caps in its place. If no breaker is present and no breaker cap is covering the hole, contact your Facility Services for assistance.
- Avoid operating or working with electrical equipment in a wet or damp environment. If you must work in a wet or damp environment, be sure your outlets or circuit breakers are Ground Fault Circuit Interrupter (GFCI) protected. Temporary GFCI plug adapters can also be used, but are not a substitute for GFCI outlets or circuit breakers.
- Fuses, circuit breakers, and Ground-Fault Circuit Interrupters are three well-known examples of circuit protection devices.
- Fuses and circuit breakers are over-current devices that are placed in circuits to monitor the amount of current that the circuit will carry. They automatically open or break the circuit when the amount of the current flow becomes excessive and therefore unsafe. Fuses are designed to melt when too much current flows through them. Circuit breakers, on the other hand, are designed to trip open the circuit by electro-mechanical means.
- Fuses and circuit breakers are intended primarily for the protection of conductors and equipment. They prevent overheating of wires and components that might otherwise create hazards for operators.
- The Ground Fault Circuit Interrupter (GFCI) is designed to shut off electric power within as little as 1/40 of a second, thereby protecting the person, not just the equipment. It works by comparing the amount of current going to an electric device against the amount of current returning from the device along the circuit conductors. A fixed or portable GFCI should be used in high-risk areas such as wet locations and construction sites.
- Entrances to rooms and other guarded locations containing exposed live parts must be marked with conspicuous warning signs forbidding unqualified persons to enter. Live parts of electric equipment operating at 50 volts or more must be guarded against accidental contact. Guarding of live parts may be accomplished by:
    - Location in a room, vault, or similar enclosure accessible only to qualified persons.
    - Use of permanent, substantial partitions or screens to exclude unqualified persons.
    - Location on a suitable balcony, gallery, or platform elevated and arranged to exclude unqualified persons, or
    - Elevation of 8 feet or more above the floor.

B. MACHINE GUARDING

Safeguards are essential for protecting workers from needless and preventable machinery-related injuries. The point of operation, as well as all parts of the machine that move while the machine is working, must be safeguarded. A good rule to remember is: Any machine part, function, or process which may cause injury, must be safeguarded.

Moving machine parts have the potential for causing severe workplace injuries, such as crushed fingers or hands, amputations, burns, or blindness. Safeguards are essential for protecting workers from these needless and preventable injuries. When the operation of a machine or accidental contact with it can injure the operator or others in the vicinity, the hazards must be either eliminated or controlled.

Requirements for safeguards:

- Prevent contact - prevent worker's body or clothing from contacting hazardous moving parts.
- Secure - must be firmly secured to the machine and not easily removed.
- Protect from falling objects - ensure that no objects can fall into moving parts.
- Create no new hazards - must not have shear points, jagged edges or unfinished surfaces.
- Create no interference - must not prevent worker from performing the job quickly and comfortably.
- Allow safe lubrication - if possible, be able to lubricate the machine without removing the

safeguards.

Machine Safety Responsibilities

The following responsibilities are assigned to employees as follows:

Management

- Ensure all machinery is properly guarded.

Supervisors

- Train employees on specific machine guarding rules in their areas.
- Ensure machine guards remain in place and are functional.
- Immediately correct machine guard deficiencies.

Employees

- Do not remove guards unless machine is locked and tagged out.
- Report machine guard problems to supervisors immediately.
- Do not operate equipment unless guards are in place.
- Operators should receive the following training:
- Hazards associated with particular machines.
- How the safeguards provide protection and the hazards for which they are intended.
- How and why to use the safeguards.
- How and when safeguards can be removed and by whom.
- What to do if a safeguard is damaged, missing, or unable to provide adequate protection.
- Hazards to machine operators that can't be designed around must be shielded to protect the operator from injury or death. Guards, decals and labels which identify the danger must be kept in place whenever the machine is operated. Guards or shields removed for maintenance must be properly replaced before use. Moving parts present the greatest hazard because of the swiftness of their action and unforgiving and relentless motion.

Common Machine Hazards

Common machine hazards occurring around moving parts include:

1. Pinch Points
   - Where two parts move together and at least one of the parts moves in a circle; also called mesh points, run-on points, and entry points. Examples include: Belt drives, chain drives, gear drives, and feed rolls.
   - When shields cannot be provided, operators must avoid contact with hands or clothing in pinch point areas. Never attempt to service or unclog a machine while it is operating or the engine is running.
2. Wrap Points
   - Any exposed component that rotates.
   - Examples include: Rotating shafts such as a PTO shaft or shafts that protrude beyond bearings or sprockets. Watch components on rotating shafts, such as couplers, universal joints, keys, keyways, pins, or other fastening devices. Splined, square, and hexagon-shaped shafts are usually more dangerous than round shafts because the edges tend to grab fingers or clothing more easily than a round shaft, but round shafts may not be smooth and can also grab quickly. Once a finger, thread, article of clothing, or hair is caught it begins to wrap; pulling only causes the wrap to become tighter.
3. Shear Points
   - Where the edges of two moving parts move across one another or where a single sharp part moves with enough speed or force to cut soft material.
   - Remember that crop cutting devices cannot be totally guarded to keep hands and feet out and still perform their intended function. Recognize the potential hazards of cutting and shear points on implements and equipment that are not designed to cut or shear. Guarding may not be feasible for these hazards.
4. Crush Points

    - Points that occur between two objects moving toward each other or one object moving toward a stationary object. Never stand between two objects moving toward one another. Use adequate blocking or lock-out devices when working under equipment.
5. Pull-In Points
    - Points where objects are pulled into equipment, usually for some type of processing. Machines are faster and stronger than people. Never attempt to hand-feed materials into moving feed rollers. Always stop the equipment before attempting to remove an item that has plugged a roller or that has become wrapped around a rotating shaft. Remember that guards cannot be provided for all situations - equipment must be able to function in the capacity for which it is designed. Freewheeling parts, rotating or moving parts that continue to move after the power is shut off are particularly dangerous because time delays are necessary before service can begin. Allow sufficient time for freewheeling parts to stop moving. Stay alert! Listen and Watch for Motion!
6. Thrown Objects
    - Any object that can become airborne because of moving parts.
    - Keep shields in place to reduce the potential for thrown objects. Wear protective gear such as goggles to reduce the risk of personal injury if you cannot prevent particles from being thrown. All guards, shields or access doors must be in place when equipment is operating. Electrically powered equipment must have a lock-out control on the switch or an electrical switch, mechanical clutch or other positive shut-off device mounted directly on the equipment. Circuit interruption devices on an electric motor, such as circuit breakers or overload protection, must require manual reset to restart the motor.

C. LIGHTING

Having a properly lighted work area is essential to working safely. A couple of key points to remember about proper lighting:

- Lighting should be adequate for safe illumination of all work areas (100-200 lumens for laboratories). For more information, see the PDC Design and Construction Standard 16500 – Lighting.
- Light bulbs that are mounted low and susceptible to contact should be guarded.
- If the risk of electrocution exists when changing light bulbs, practice lock-out tag-out.
- For proper disposal of fluorescent bulbs (“universal waste”), see lightbulb recycling.
- As an energy conservation measure, please remember to turn off your lights when you leave your lab.

D. COMPRESSED GASES

Compressed gases are commonly used in laboratories for a number of different operations. While compressed gases are very useful, they present a number of hazards for the laboratory worker:

- Gas cylinders may contain gases that are flammable, toxic, corrosive, asphyxiants, or oxidizers.
- Unsecured cylinders can be easily knocked over, causing serious injury and damage. Impact can shear the valve from an uncapped cylinder, causing a catastrophic release of pressure leading to personal injury and extensive damage.
- Mechanical failure of the cylinder, cylinder valve, or regulator can result in rapid diffusion of the pressurized contents of the cylinder into the atmosphere; leading to explosion, fire, runaway reactions, or burst reaction vessels.

1. Handling Compressed Gas Cylinders

   There are a number of ways that compressed gases can be handled safely. Always practice the following when handling compressed gases:

- The contents of any compressed gas cylinder must be clearly identified. Such identification should be stenciled or stamped on the cylinder or a label or tag should be attached. Do not rely on the color of the cylinder for identification because color-coding is not standardized and may vary with the manufacturer or supplier.
- When transporting cylinders:
    - Always use a hand truck equipped with a chain or belt for securing the cylinder.

  - Make sure the protective cap covers the cylinder valve.
  - Never transport a cylinder while a regulator is attached.
  - Always use caution when transporting cylinders – cylinders are heavy.
- Avoid riding in elevators with compressed gas cylinders. If this is necessary, consider using a buddy system to have one person send the properly secured cylinders on the elevator, while the other person waits at the floor by the elevator doors where the cylinders will arrive.
- Do not move compressed gas cylinders by carrying, rolling, sliding, or dragging them across the floor.
- Do not transport oxygen and combustible gases at the same time.
- Do not drop cylinders or permit them to strike anything violently.

2. Safe Storage of Compressed Gas Cylinders

   Procedures to follow for safe storage of compressed gas cylinders include:

   - Gas cylinders must be secured to prevent them from falling over. Chains are recommended over clamp-plus-strap assemblies due to the hazards involved in a fire and straps melting or burning. Be sure the chain is high enough (at least half way up) on the cylinder to keep it from tipping over.
   - Do not store incompatible gases right next to each other. Cylinders of oxygen must be stored at least 20 feet away from cylinders of hydrogen or other flammable gas, or the storage areas must be separated by a firewall five feet high with a fire rating of 1/2 hour.
   - All cylinders should be stored away from heat and away from areas where they might be subjected to mechanical damage.

   - Keep cylinders away from locations where they might form part of an electrical circuit, such as next to electric power panels or electric wiring.
   - The protective cap that comes with a cylinder of gas should always be left on the cylinder when it is not in use. The cap keeps the main cylinder valve from being damaged or broken.

3. Operation of Compressed Gas Cylinders

   The cylinder valve hand wheel opens and closes the cylinder valve. The pressure relief valve is designed to keep a cylinder from exploding in case of fire or extreme temperature. Cylinders of very toxic gases do not have a pressure relief valve, but they are constructed with special safety features. The valve outlet connection is the joint used to attach the regulator. The pressure regulator is attached to the valve outlet connector in order to reduce the gas flow to a working level. The Compressed Gas Association has intentionally made certain types of regulators incompatible with certain valve outlet connections to avoid accidental mixing of gases that react with each other. Gases should always be used with the appropriate regulator. Do not use adaptors with regulators. The cylinder connection is a metal-to-metal pressure seal. Make sure the curved mating surfaces are clean before attaching a regulator to a cylinder. Do not use Teflon tape on the threaded parts, because this may actually cause the metal seal not to form properly. Always leak test the connection.

   Basic operating guidelines include:

   a. Make sure that the cylinder is secured.
   b. Attach the proper regulator to the cylinder. If the regulator does not fit, it may not be suitable for the gas you are using.
   c. Attach the appropriate hose connections to the flow control valve. Secure any tubing with clamps so that it will not whip around when pressure is turned on. Use suitable materials for connections; toxic and corrosive gases require connections made of special materials.
   d. Install a trap between the regulator and the reaction mixture to avoid backflow into the cylinder.
   e. To prevent a surge of pressure, turn the delivery pressure adjusting screw counterclockwise until it turns freely and then close the flow control valve.
   f. Slowly open the cylinder valve hand wheel until the cylinder pressure gauge reads the cylinder pressure.
   g. With the flow control valve closed, turn the delivery pressure screw clockwise until the delivery pressure gauge reads the desired pressure.
   h. Adjust the gas flow to the system by using the flow control valve or another flow control device between the regulator and the experiment.

i. After an experiment is completed, turn the cylinder valve off first, and then allow gas to bleed from the regulator. When both gauges read “zero”, remove the regulator and replace the protective cap on the cylinder head.
j. When the cylinder is empty, mark it as “Empty”, and store empty cylinders separate from full cylinders.
k. Attach a “Full/In Use/Empty” tag to all of your cylinders, these tags are perforated and can be obtained from the gas cylinder vendor.

Precautions to follow:

- Use a regulator only with gas for which it is intended. The use of adaptors or homemade connectors has caused serious and even fatal accidents.
- Toxic gases should be purchased with a flow-limiting orifice.
- When using more than one gas, be sure to install one-way flow valves from each cylinder to prevent mixing. Otherwise accidental mixing can cause contamination of a cylinder.
- Do not attempt to put any gas into a commercial gas cylinder.
- Do not allow a cylinder to become completely empty. Leave at least 25 psi of residual gas to avoid contamination of the cylinder by reverse flow.
- Do not tamper with or use force on a cylinder valve.

4. Return of Cylinders

- Disposal of cylinders and lecture bottles is expensive, especially if the contents are unknown.

- Make sure that all cylinders and lecture bottles are labeled and included in your chemical inventory. Before you place an order for a cylinder or lecture bottle, determine if the manufacturer will take back the cylinder or lecture bottle when it becomes empty. If at all possible, only order from manufacturers who will accept cylinders or lecture bottles for return.

5. Hazards of Specific Gases

a. Inert Gases
Examples: Helium, Argon, Nitrogen
Can cause asphyxiation by displacing the air necessary for the support of life.

b. Cryogens are capable of causing freezing burns, frostbite, and destruction of tissue.
Cryogenic Liquids
    - Cryogenic liquids are extremely cold and their vapors can rapidly freeze human tissue.
    - Boiling and splashing will occur when the cryogen contacts warm objects.
    - Can cause common materials such as plastic and rubber to become brittle and fracture under stress.
    - Liquid to gas expansion ratio: one volume of liquid will vaporize and expand to about 700 times that volume, as a gas, and thus can build up tremendous pressures in a closed system. Therefore dispensing areas need to be well ventilated. Avoid storing cryogenics in cold rooms, environmental chambers, and other areas with poor ventilation. If necessary, install an oxygen monitor/oxygen deficiency alarm and/or toxic gas monitor before working these materials in confined areas.

c. Oxidizers
Examples: Oxygen, Chlorine
Oxidizers vigorously accelerate combustion; therefore keep away from all flammable and organic materials. Greasy and oily materials should never be stored around oxygen. Oil or grease should never be applied to fittings or connectors.

d. Flammable Gases
    - Examples: Methane, Propane, Hydrogen, Acetylene
    - Flammable gases present serious fire and explosion hazards.
    - Do not store near open flames or other sources of ignition.
    - Cylinders containing Acetylene should never be stored on their side.

- Flammable gases are easily ignited by heat, sparks, or flames, and may form explosive mixtures with air. Vapors from liquefied gas often are heavier than air, and may spread along ground and travel to a source of ignition and result in a flashback fire.

e. Corrosive Gases
Examples: Chlorine, Hydrogen Chloride, Ammonia
    - There can be an accelerated corrosion of materials in the presence of moisture.
    - Corrosive gases readily attack the skin, mucous membranes, and eyes. Some corrosive gases are also toxic.
    - Due to the corrosive nature of the gases, corrosive cylinders should only be kept on hand for 6 months (up to one year maximum). Only order the smallest size needed for your experiments.

f. Poison Gases
Examples: Arsine, Phosphine, Phosgene
    - Poison gases are extremely toxic and present a serious hazard to laboratory staff.
    - Poisonous gases require special ventilation systems and equipment and must only be used by properly trained experts. There are also special building code regulations that must be followed with regard to quantities kept on hand and storage.
    - The purchase and use of poisonous gases require prior approval from EH&S.

E. BATTERY CHARGING

Lead acid batteries contain corrosive liquids and also generate Hydrogen gas during charging which poses and explosion hazard. The following guidelines should be followed for battery charging areas:

- A “No smoking” sign should be posted.
- Before working, remove all jewelry from hands and arms and any dangling jewelry to prevent accidental contact with battery connections (this can cause sparks which can ignite vapors).
- Always wear appropriate PPE such as rubber or synthetic aprons, splash goggles (ideally in combination with a face shield), and thick Neoprene, Viton, or Butyl gloves.
- A plumbed emergency eyewash station must be readily available near the station (please note, hand held eyewash bottles do not meet this criteria.)
- A class B rated fire extinguisher needs to be readily available. If none is available, contact EH&S at 394-6729.
- Ensure there is adequate ventilation available to prevent the buildup of potentially flammable and explosive gases.
- Keep all ignition sources away from the area.
- Stand clear of batteries while charging.
- Keep vent caps tight and level.
- Only use the appropriate equipment for charging.
- Store unused batteries in secondary containment to prevent spills.
- Have an acid spill kit available. The waste from a spill may contain lead and neutralized wastes may be toxic. Contact EH&S at 394-6729 for hazardous waste disposal.
- Properly dispose of your used batteries.

F. HEAT AND HEATING DEVICES

Heat hazards within laboratories can occur from a number of sources; however, there are some simple guidelines that can be followed to prevent heat related injuries. These guidelines include:

- Heating devices should be set up on a sturdy fixture and away from any ignitable materials (such as flammable solvents, paper products and other combustibles). Do not leave open flames (from Bunsen burners) unattended.
- Heating devices should not be installed near drench showers or other water spraying apparatus due to electrical shock concerns and potential splattering of hot water.
- Heating devices should have a backup power cutoff or temperature controllers to prevent overheating. If a backup controller is used, an alarm should notify the user that the main controller has failed.
- Provisions should be included in processes to make sure reaction temperatures do not cause violent reactions and a means to cool the dangerous reactions should be available.
- Post signs to warn people of the heat hazard to prevent burns.

When using ovens, the follow additional guidelines should be followed:

- Heat generated should be adequately removed from the area.
- If toxic, flammable, or otherwise hazardous chemicals are evolved from the oven, then only use ovens with a single pass through design where air is ventilated out of the lab and the exhausted air is not allowed to come into contact with electrical components or heating elements.
- Heating flammables should only be done with a heating mantle or steam bath.
- When using heating baths, these additional guidelines should be followed:
- Heating baths should be durable and set up with firm support.
- Since combustible liquids are often used in heat baths, the thermostat should be set so the temperature never rises above the flash point of the liquid. Check the SDS for the chemical to determine the flashpoint. Compare that flashpoint with the expected temperature of the reaction to gauge risk of starting a fire.

G. HEAT STRESS

Another form of heat hazard occurs when working in a high heat area. Under certain conditions, your body might have trouble regulating its temperature. If your body cannot regulate its temperature, it overheats and suffers some degree of heat stress. This can occur very suddenly and, if left unrecognized and untreated, can lead to very serious health affects.

- Heat stress disorders range from mild disorders such as fainting, cramps, or prickly heat to more dangerous disorders such as heat exhaustion or heat stroke. Symptoms of mild to moderate heat stress can include: sweating, clammy skin, fatigue, decreased strength, loss of coordination and muscle control, dizziness, nausea, and irritability. You should move the victim to a cool place and give plenty of fluids. Place cool compresses on forehead, neck, and under their armpits.
- Heat stroke is a medical emergency. It can cause permanent damage to the brain and vital organs, or even death. Heat stroke can occur suddenly, with little warning. Symptoms of heat stroke may include: no sweating (in some cases victim may sweat profusely), high temperature (103? or more), red, hot, and dry skin, rapid and strong pulse, throbbing headache, dizziness, nausea, convulsions, delirious behavior, unconsciousness, or coma.
- In the case of heat stroke, call 911 & get medical assistance ASAP! In the meantime, you should move the victim to a cool place, cool the person quickly by sponging with cool water and fanning, and offer a conscious person 1/2 glass of water every 15 minutes.
- There are a number of factors that affect your body's temperature regulation:

    - Radiant heat sources such as the sun or a furnace.
    - Increased humidity causes decreased sweat evaporation.
    - Decreased air movement causes decreased sweat evaporation.
    - As ambient temperature rises, your body temperature rises and its ability to regulate decreases.

- You should be especially careful if:

    - You just started a job involving physical work in a hot environment.
    - You are ill, overweight, physically unfit, or on medication that can cause dehydration.
    - You have been drinking alcohol.
    - You have had a previous heat stress disorder.
    - In order to prevent heat stress, please follow these recommendations:
    - Acclimatize your body to the heat. Gradually increase the time you spend in the heat. Most people acclimatize to warmer temperatures in 4-7 days. Acclimatization is lost when you have been away from the heat for one week or more. When you return, you must repeat the acclimatization process.
    - Drink at least 4-8 ounces of fluid every 15-20 minutes to maintain proper balance during hot and/or humid environments. THIRST IS NOT A GOOD INDICATOR OF DEHYDRATION. Fluid intake must continue until well after thirst has been quenched.

- During prolonged heat exposure or heavy workload, a carbohydrate-electrolyte beverage is beneficial.
- Alternate work and rest cycles to prevent an overexposure to heat. Rest cycles should include relocation to a cooler environment.
- Perform the heaviest workloads in the cooler part of the day.
- There should be no alcohol consumption during periods of high heat exposure.
- Eat light, preferably cold meals. Fatty foods are harder to digest in hot weather.

H. COLD TRAPS

- Because many chemicals captured in cold traps are hazardous, care should be taken and appropriate protective equipment should be worn when handling these chemicals. Hazards include flammability, toxicity, and cryogenic temperatures, which can burn the skin.
- If liquid nitrogen is used, the chamber should be evacuated before charging the system with coolant. Since oxygen in air has a higher boiling point than nitrogen, liquid oxygen can be produced and cause an explosion hazard.
- Boiling and splashing generally occur when charging (cooling) a warm container, so stand clear and wear appropriate protective equipment. Items should be added slowly and in small amounts to minimize splash.
- A blue tint to liquid nitrogen indicates contamination with oxygen and represents an explosion hazard. Contaminated liquid nitrogen should be disposed of appropriately.
- If working under vacuum see the “reduced pressure” section.

See “cryogenics” for safety advice when working with cryogenic materials.

I. AUTOCLAVES

Autoclaves have the following potential hazards:

- Heat, steam, and pressure.
- Thermal burns from steam and hot liquids.
- Cuts from exploding glass.

Some general safety guidelines to follow when using autoclaves:

- All users should be given training in proper operating procedures for using the autoclave.
- Read the owner’s manual before using the autoclave for the first time.
- Operating instructions should be posted near the autoclave.
- Follow the manufacturer’s directions for loading the autoclave.
- Be sure to close and latch the autoclave door.
- Some kinds of bottles containing liquids can crack in the autoclave, or when they are removed from the autoclave. Use a tray to provide secondary containment in case of a spill, and add a little water to the tray to ensure even heating.
- Only fill bottles half way to allow for liquid expansion and loosen screw caps on bottles and tubes of liquid before autoclaving, to prevent them from shattering.
- Do not overload the autoclave compartment and allow for enough space between items for the steam to circulate.
- Be aware that liquids, especially in large quantities, can be superheated when the autoclave is opened. Jarring them may cause sudden boiling, and result in burns.
- At the end of the run, open the autoclave slowly: first open the door only a crack to let any steam escape slowly for several minutes, and then open all the way. Opening the door suddenly can scald a bare hand, arm, or face.
- Wait at least five minutes after opening the door before removing items.
- Large flasks or bottles of liquid removed immediately from the autoclave can cause serious burns by scalding if they break in your hands. Immediately transfer hot items with liquid to a cart; never carry in your hands.
- Wear appropriate PPE, including eye protection and insulating heat-resistant gloves.

J. CENTRIFUGES

Some general safety guidelines to follow when using centrifuges:

- Be familiar with the operating procedures written by the manufacturer. Keep the operating manual near the unit for easy reference. If necessary contact the manufacturer to replace lost manuals.
- Handle, load, clean, and inspect rotors as recommended by the manufacturer.
- Pay careful attention to instructions on balancing samples -- tolerances for balancing are often very restricted. Check the condition of tubes and bottles. Make sure you have secured the lid to the rotor and the rotor to the centrifuge.
- Maintain a logbook of rotor use for each rotor, recording the speed and length of time for each use.
- To avoid catastrophic rotor failure, many types of rotors must be "de-rated" (limited to a maximum rotation speed that is less than the maximum rotation speed specified for the rotor when it is new) after a specified amount of use, and eventually taken out of service and discarded.
- Use only the types of rotors that are specifically approved for use in a given centrifuge unit.
- Maintain the centrifuge in good condition. Broken door latches and other problems should be repaired before using the centrifuge.
- Whenever centrifuging biohazardous materials, always load and unload the centrifuge rotor in a Biosafety cabinet.

Centrifuge Rotor Care

Basic centrifuge rotor care includes:
- Keep the rotor clean and dry, to prevent corrosion.
- Remove adapters after use and inspect for corrosion.
- Store the rotor upside down, in a warm, dry place to prevent condensation in the tubes.
- Read and follow the recommendations in the manual regarding:
    - Regular cleaning
    - Routine inspections
    - Regular polishing
    - Lubricating O-rings
    - Decontaminating the rotor after use with radioactive or biological materials
    - Remove any rotor from use that has been dropped or shows any sign of defect, and report it to a manufacturer’s representative for inspection.

K. CRYOGENIC SAFETY

A cryogenic gas is a material that is normally a gas at standard temperature and pressure, but which has been supercooled such that it is a liquid or solid at standard pressure. Commonly used cryogenic materials include the liquids nitrogen, argon, and helium, and solid carbon dioxide (dry ice).

Hazards associated with direct personal exposure to cryogenic fluids include:

- Frostbite - Potential hazards in handling liquefied gases and solids result because they are extremely cold and can cause severe cold contact burns by the liquid, and frostbite or cold exposure by the vapor.
- Asphyxiation - The ability of the liquid to rapidly convert to large quantities of gas associated with evaporation of cryogenic liquid spills can result in asphyxiation. For instance, nitrogen expands approximately 700 times in volume going from liquid to gas at ambient temperature. Total displacement of oxygen by another gas, such as Carbon dioxide, will result in unconsciousness, followed by death. Exposure to oxygen-deficient atmospheres may produce dizziness, nausea, vomiting, loss of consciousness, and death. Such symptoms may occur in seconds without warning. Death may result from errors in judgment, confusion, or loss of consciousness that prevents self-rescue.
- Working with cryogenic substances in confined spaces, such as walk-in coolers, can be especially hazardous. Where cryogenic materials are used, a hazard assessment is required to determine the potential for an oxygen-deficient condition. Controls such as ventilation and/or gas detection systems may be required to safeguard employees. Asphyxiation and chemical

toxicity are hazards encountered when entering an area that has been used to store cryogenic liquids if proper ventilation/purging techniques are not employed.

- Toxicity - Many of the commonly used cryogenic gases are considered to be of low toxicity, but still pose a hazard from asphyxiation. Check the properties of the gases you are using, because some gases are toxic, for example, Carbon monoxide, Fluorine, and Nitrous oxide.
- Flammability and Explosion Hazards - Fire or explosion may result from the evaporation and vapor buildup of flammable gases such as hydrogen, carbon monoxide, or methane. Liquid oxygen, while not itself a flammable gas, can combine with combustible materials and greatly accelerate combustion. Oxygen clings to clothing and cloth items, and presents an acute fire hazard.
- High Pressure Gas Hazards - Potential hazards exist in highly compressed gases because of the stored energy. In cryogenic systems, high pressures are obtained by gas compression during refrigeration, by pumping of liquids to high pressures followed by rapid evaporation, and by confinement of cryogenic fluids with subsequent evaporation. If this confined fluid is suddenly released through a rupture or break in a line, a significant thrust may be experienced. Over-pressurization of cryogenic equipment can occur due to the phase change from liquid to gas if not vented properly. All cryogenic fluids produce large volumes of gas when they vaporize.
- Materials and Construction Hazards - The selection of materials calls for consideration of the effects of low temperatures on the properties of those materials. Some materials become brittle at low temperatures. Brittle materials fracture easily and can result in almost instantaneous material failure. Low temperature equipment can also fail due to thermal stresses caused by differential thermal contraction of the materials. Over-pressurization of cryogenic equipment can occur due to the phase change from liquid to gas if not vented properly. All cryogenic fluids produce large volumes of gas when they vaporize.

Cryogenic Safety Guidelines

1. Responsibilities
   Personnel who are responsible for any cryogenic equipment must conduct a safety review prior to the commencement of operation of the equipment. Supplementary safety reviews must follow any system modification to ensure that no potentially hazardous condition is overlooked or created and that updated operational and safety procedures remain adequate.
2. Personal Protective Equipment
   Wear the appropriate PPE when working with cryogenic materials. Face shields and splash goggles must be worn during the transfer and normal handling of cryogenic fluids. Loose fitting, heavy leather or other insulating protective gloves must be worn when handling cryogenic fluids. Shirt sleeves should be rolled down and buttoned over glove cuffs, or an equivalent protection such as a lab coat, should be worn in order to prevent liquid from spraying or spilling inside the gloves. Trousers without cuffs should be worn.
3. Safety Practices
   Cryogenic fluids must be handled and stored only in containers and systems specifically designed for these products and in accordance with applicable standards, procedures, and proven safe practices.
   - Transfer operations involving open cryogenic containers such as dewars must be conducted slowly to minimize boiling and splashing of the cryogenic fluid. Transfer of cryogenic fluids from open containers must occur below chest level of the person pouring the liquid.
   - Only conduct such operations in well-ventilated areas, such as the laboratory, to prevent possible gas or vapor accumulation that may produce an oxygen-deficient atmosphere and lead to asphyxiation. If this is not possible, an oxygen meter must be installed.
   - Equipment and systems designed for the storage, transfer, and dispensing of cryogenic fluids need to be constructed of materials compatible with the products being handled and the temperatures encountered.
   - All cryogenic systems including piping must be equipped with pressure relief devices to prevent excessive pressure build-up. Pressure reliefs must be directed to a safe location. It should be noted that two closed valves in a line form a closed system. The vacuum insulation jacket should also be protected by an over pressure device if the service is below 77 degrees Kelvin. In the event a pressure relief device fails, do not attempt to remove the blockage; instead, call EH&S.
   - The caps of liquid nitrogen dewars are designed to fit snugly to contain the liquid nitrogen, but also allow the periodic venting that will occur to prevent an overpressurization of the vessel. Do not ever attempt to seal the caps of liquid nitrogen dewars. Doing so can present a significant

hazard of overpressurization that could rupture the container and cause splashes of liquid nitrogen and, depending on the quantity of liquid nitrogen that may get spilled, cause an oxygen deficient atmosphere within a laboratory due to a sudden release and vaporization of the liquid nitrogen.
- If liquid nitrogen or helium traps are used to remove condensable gas impurities from a vacuum system that may be closed off by valves, the condensed gases will be released when the trap warms up. Adequate means for relieving resultant build-up of pressure must be provided.

4. First Aid
   - Workers will rarely, if ever, come into contact with cryogenic fluids if proper handling procedures are used. In the unlikely event of contact with a cryogenic liquid or gas, a contact "burn" may occur. The skin or eye tissue will freeze. The recommended emergency treatment is as follows:
   - If the cryogenic fluid comes in contact with the skin or eyes, flush the affected area with generous quantities of cold water. Never use dry heat. Splashes on bare skin cause a stinging sensation, but, in general, are not harmful.
   - If clothing becomes soaked with liquid, it should be removed as quickly as possible and the affected area should be flooded with water as above. Where clothing has frozen to the underlying skin, cold water should be poured on the area, but no attempt should be made to remove the clothing until it is completely free.
   - Complete an Incident Report.

L. EXTRACTIONS AND DISTILLATIONS

Extractions

- Do not attempt to extract a solution until it is cooler than the boiling point of the extractant due to the risk of overpressurization, which could cause the vessel to burst.
- When a volatile solvent is used, the solution should be swirled and vented repeatedly to reduce pressure before separation.
- When opening the stopcock, your hand should keep the plug firmly in place.
- The stopcock should be lubricated.
- Vent funnels away from ignition sources and people, preferably into a hood.
- Keep volumes small to reduce the risk of overpressure and if large volumes are needed, break them up into smaller batches.

Distillations

- Avoid bumping (sudden boiling) since the force can break apart the apparatus and result in splashes. Bumping can be avoided by even heating, such as using a heat mantle. Also, stirring can prevent bumping. Boiling stones can be used only if the process is at atmospheric pressure.
- Do not add solid items such as boiling stones to liquid that is near boiling since it may result in the liquid boiling over spontaneously.
- Organic compounds should never be allowed to boil to dryness unless they are known to be free of peroxides, which can result in an explosion hazard.
- Reduced pressure distillation
- Do not overheat the liquid. Superheating can result in decomposition and uncontrolled reactions.
- Superheating and bumping often occur at reduced pressures so it is especially important to abide by the previous point on bumping and to ensure even, controlled heating. Inserting a nitrogen bleed tube may help alleviate this issue.
- Evacuate the assembly gradually to minimize bumping.
- Allow the system to cool and then slowly bleed in air. Air can cause an explosion in a hot system (pure nitrogen is preferable to air for cooling).
- See "reduced pressure" for vacuum conditions.

M. GLASS UNDER VACUUM PRESSURE

Reduced pressure

Some general guidelines for glass under vacuum include:

- Inspect glassware that will be used for reduced pressure to make sure there are no defects such as chips or cracks that may compromise its integrity.
- Only glassware that is approved for low pressure should be used. Never use a flat bottom flask (unless it is a heavy walled filter flask) or other thin walled flask that are not appropriate to handle low pressure.
- Use a shield between the user and any glass under vacuum or wrap the glass with tape to contain any glass in the event of an implosion.

Vacuum pumps

- Cold traps should be used to prevent pump oil from being contaminated which can create a hazardous waste.
- Pump exhaust should be vented into a hood when possible.
- Ensure all belts and other moving parts are properly guarded.
- Whenever working on or servicing vacuum pumps, be sure to follow appropriate lock-out procedures.

N. GLASSWARE WASHING

In most cases laboratory glassware can be cleaned effectively by using detergents and water. In some cases it may be necessary to use strong chemicals for cleaning glassware. Strong acids should be avoided unless necessary. In particular, Chromic acid should not be used due to its toxicity and disposal concerns. One product that may be substituted for Chromic acid is “Nochromix Reagent”. The Fisher catalog describes this material as: “Nochromix Reagent. Inorganic oxidizer chemically cleans glassware. Contains no metal ions. Rinses freely—leaving no metal residue, making this product valuable for trace analysis, enzymology, and tissue culture work. (Mix with sulfuric acid).” Unused Nochromix Reagent can be neutralized to a pH between 5.5 and 9.5 and drain disposed. Acid/base baths should have appropriate labeling and secondary containment. Additionally a Standard Operating Procedure (SOP), proper personal protective equipment (PPE), and spill materials should be available. Proper disposal for spent acid/base bath contents is neutralization and drain disposal.

When handling glassware, check for cracks and chips before washing, autoclaving or using it. Dispose of chipped and broken glassware immediately in an approved collection unit. DO NOT put broken glassware in the regular trash. Handle glassware with care – avoid impacts, scratches or intense heating of glassware. Make sure you use the appropriate labware for the procedures and chemicals. Use care when inserting glass tubing into stoppers: use glass tubing that has been fire-polished, lubricate the glass, and protect your hands with heavy gloves.

If your department/building has a glass washing service there are certain protocols that must be followed before sending the glassware to be washed. It is the responsibility of the lab to empty and rinse all glassware before it leaves the lab. Although the contents may not be hazardous, the washroom support staff cannot be certain of the appropriate PPE to wear, disposal regulations or possible incompatibilities with items received from other researchers. Be aware that labeling for lab personnel is not sufficient for areas outside the lab as per the OSHA Hazard Communication Standard. It is the responsibility of the glassware washing staff to reject or return glassware that is not acceptable due to breakage or containing chemicals. For this reason, glassware should be labeled with the name of the person who is responsible for it.

O. GENERAL EQUIPMENT SETUP

The following recommended laboratory techniques for general equipment set up was taken from the American Chemical Society’s booklet – Safety in Academic Chemistry Laboratories.

1. Glassware and Plasticware

- Borosilicate glassware (i.e. pyrex) is recommended for all lab glassware, except for special experiments using UV or other light sources. Soft glass should only be used for things such as reagent bottles, measuring equipment, stirring rods and tubing.
- Any glass equipment being evacuated, such as suction flasks, should be specially designed with heavy walls. Dewar flasks and large vacuum vessels should be taped or guarded in case of flying glass from an implosion. Household thermos bottles have thin walls and are not

acceptable substitutes for lab Dewar flasks.
- Glass containers containing hazardous chemicals should be transported in rubber bottle carriers or buckets to protect them from breakage and contain any spills or leaks. It is recommended to transport plastic containers this way as well since they also can break or leak.

2. Preparation of Glass Tubing and Stoppers

   To cut glass tubing:
   - Hold the tube against a firm support and make one firm quick stroke with a sharp triangular file or glass cutter to score the glass long enough to extend approximately one third around the circumference.
   - Cover the tubing with cloth and hold the tubing in both hands away from the body. Place thumbs on the tubing opposite the nick 2 to 3 cm and extended toward each other.
   - Push out on the tubing with the thumbs as you pull the sections apart, but do not deliberately bend the glass with the hands. If the tubing does not break, re-score the tube in the same place and try again. Be careful to not contact anyone nearby with your motion or with long pieces of tubing.
   - All glass tubing, including stir rods, should be fire polished before use. Unpolished tubing can cut skin as well as inhibit insertion into stoppers. After polishing or bending glass, give ample time for it to cool before grasping it.

   When drilling a stopper:
   - Use only a sharp borer one size smaller than that which will just slip over the tube to be inserted. For rubber stoppers, lubricate with water or glycerol. Holes should be bored by slicing through the stopper, twisting with moderate forward pressure, grasping the stopper only with the fingers, and keeping the hand away from the back of the stopper.
   - Keep the index finger of the drilling hand against the barrel of the borer and close to the stopper to stop the borer when it breaks through. Preferably, drill only part way through and then finish by drilling from the opposite side.
   - Discard a stopper if a hole is irregular or does not fit the inserted tube snugly, if it is cracked, or if it leaks.

   Corks should have been previously softened by rolling and kneading. Rubber or cork stoppers should fit into a joint so that one-third to one–half of the stopper is inserted.
   When available, glassware with ground joints is preferable. Glass stoppers and joints should be clean, dry and lightly lubricated.

3. Insertion of Glass Tubes or Rods into Stoppers

   The following practices will help prevent accidents:

   - Make sure the diameter of the tube or rod is compatible with the diameter of the hose or stopper.
   - If not already fire polished, fire polish the end of the glass to be inserted; let it cool.
   - Lubricate the glass. Water may be sufficient, but glycerol is a better lubricant.
   - Wear heavy gloves or wrap layers of cloth around the glass and protect the other hand by holding the hose or stopper with a layered cloth pad.
   - Hold the glass not more than 5 cm from the end to be inserted.
   - Insert the glass with a slight twisting motion, avoiding too much pressure and torque.
   - When helpful, use a cork borer as a sleeve for insertion of glass tubes.
   - If appropriate, substitute a piece of metal tubing for glass tubing.
   - Remove stuck tubes by slitting the hose or stopper with a sharp knife.

4. ASSEMBLING APPARATUS

Following these recommendations will help make apparatus assembly easier and equipment safer:

Keep your work space free of clutter.

- Set up clean, dry apparatus, firmly clamped and well back from the edge of the lab bench making adequate space between your apparatus and others work. Choose sizes that can properly accommodate the operation to be performed. As a rule, leave about 20% free space around your work.
- Use only equipment that is free from flaws such as cracks, chips, frayed wire, and obvious defects. Glassware can be examined in polarized light for strains. Even the smallest crack or chip can render glassware unusable. Cracked or chipped glassware should be repaired or discarded.
- A properly placed pan under a reaction vessel or container will act as secondary containment to confine spilled liquids in the event of glass breakage.
- When working with flammable gases or liquids, do not allow burners or other ignition sources in the vicinity. Use appropriate traps, condensers, or scrubbers to minimize release of material to the environment. If a hot plate is used, ensure the temperatures of all exposed surfaces are less than the autoignition temperature of the chemicals likely to be released and that the temperature control device and the stirring / ventilation motor (if present) do not spark.
- Whenever possible, use controlled electrical heaters or steam in place of gas burners.
- Addition and separatory funnels should be properly supported and oriented so that the stopcock will not be loosened by gravity. A retainer ring should be used on the stopcock plug. Glass stopcocks should be freshly lubricated. Teflon stopcocks should not be lubricated.
- Condensers should be properly supported with securely positioned clamps and the attached water hoses secured with wire or clamps.
- Stirrer motors and vessels should be secured to maintain proper alignment. Magnetic stirring is preferable. Only non-sparking motors should be used in chemical laboratories. Air motors may be an option.
- Apparatus attached to a ring stand should be positioned so that the center of gravity of the system is over the base and not to one side. There should be adequate provision for removing burners or baths quickly. Standards bearing heavy loads should be firmly attached to the bench top. Equipment racks should be securely anchored at the top and bottom.
- Apparatus, equipment, or chemical bottles should not be placed on the floor. If necessary, keep these items under tables and out of aisleways to prevent creating a tripping hazard.
- Never heat a closed container. Provide a vent as part of the apparatus for chemicals that are to be heated. Prior to heating a liquid, place boiling stones in unstirred vessels (except test tubes). If a burner is used, distribute the heat with a ceramic-centered wire gauze. Use the thermometer with its bulb in the boiling liquid if there is the possibility of a dangerous exothermic decomposition as in some distillations. This will provide a warning and may allow time to remove the heat and apply external cooling. The setup should allow for fast removal of heat.
- Whenever hazardous gases or fumes are likely to be evolved, an appropriate gas trap should be used and the operation confined to a fume hood.
- Fume hoods are recommended for all operations in which toxic or flammable vapors are evolved as is the case with many distillations. Most vapors have a density greater than air and will settle on a bench top or floor where they may diffuse to a distant burner or ignition source. These vapors will roll out over astonishingly long distances and, if flammable, an ignition can cause a flash back to the source of vapors. Once diluted with significant amounts of air, vapors move in air essentially as air itself.
- Use a hood when working with a system under reduced pressure (which may implode). Close the sash to provide a shield. If a hood is not available, use a standing shield. Shields that can be knocked over must be stabilized with weights or fasteners. Standing shields are preferably secured near the top. Proper eye and face protection must be worn even when using safety shields or fume hoods.

5. WELDING SAFETY

Training is required prior to performing any welding operations.

- Welding Location – Never weld or cut materials near or around flammable materials. Materials that are flammable, or materials that may catch fire, must be moved a safe distance from any operation that may ignite these materials.

- Safety Glasses - Welding helmets do not satisfy the requirement for primary eye protection. Safety glasses must be worn under arc welding helmets to fulfill the eye protection requirement.
- Contact Lenses - Never wear contact lenses while welding. Contact lenses can literally be welded to your eyes by the intense thermal radiation produced by many welding processes.
- Hot materials - Never pick up hot materials with welding gloves. Never touch metal to see if it is hot. Place your bare hand above the material and feel for radiated heat to determine the temperature. Use a piece of soapstone to label "hot" material if you must leave the area before the material cools down.
- Acetylene Regulators - Always set acetylene regulators to less than 15 psi. Above 15 psi, acetylene becomes explosively unstable. Always back the acetylene regulator pressure completely off before turning on the tank valve. The acetylene tank valve should only be opened 1/4 to 1/2 turn so that it can be closed quickly in an emergency.
- High Pressure Gas Regulators - Most compressed gas tanks (except acetylene) utilize high pressure regulators. These regulators should be backed off before turning on the tank valve. The bottle valve has a double seat and should be opened all the way to prevent leakage around the valve stem.
- Welding Ventilation - Never weld in an enclosed area without proper ventilation. Many welding operations produce noxious and sometimes toxic gases. Never weld or cut galvanized materials without specially designed ventilation.
- Protective Clothing - All forms of electric arc welding and cutting produce extremely intense ultraviolet and infrared light that can cause serious burns to unprotected skin. These intense burns are suspected as promoting skin cancer in later years. Always wear appropriate protective clothing including, as a minimum, welding hood, welding gloves, long sleeves, long pants, leather footwear, etc.
- Wire Wheels - A face shield is required to be worn over your safety glasses when using a wire wheel.
- Welding Hoods - Inspect the welding hood before use to ensure that the lenses and filters are in good condition, and of the proper shading, for the operation being performed. Never attempt to weld without proper eye protection.

6. MERCURING CONTAINING EQUIPMENT

Elemental Mercury (Hg) or liquid Mercury is commonly seen in thermometers, barometers, diffusion pumps, sphygmomanometers, thermostats, high intensity microscope bulbs, fluorescent bulbs, UV lamps, batteries, Coulter Counter, boilers, ovens, welding machines, etc.

Most of these items can be substituted with equipment without Mercury, thus greatly decreasing the hazard potential. Larger laboratory equipment may be more difficult to identify as “Mercury containing” due to the fact that mercury can be hidden inside inner components such as switches or gauges.

The concerns surrounding mercury containing equipment are:

- It is difficult to identify exposures or cross-contamination due to Mercury leaks or spills.
- The amount of Mercury used is usually much greater than the Department of Environmental Conservation (DEC) reportable quantities for releases to the environment.
- People may be unaware of the Mercury and thus may not be properly trained for use, maintenance, spills, transport or disposal or may not use the appropriate engineering controls or Personal Protective Equipment (PPE).
- There is legal liability if human health and the environment are not properly protected.
- To minimize the potential for Mercury spills and possible exposures, laboratory personnel is strongly encouraged to follow these recommendations:
- Identify and label “Mercury Containing Equipment”.
- Write a Standard Operating Procedure (SOP).
- Train personnel on proper use, maintenance, transport and disposal.
- Conduct periodic inspections of equipment to ensure no leaks or spills have occurred.
- Consider replacing Mercury with electronic or other replacement components.
- Have available proper PPE such as nitrile gloves.
- Use secondary containment, such as trays as a precaution for spills.

- Plan for emergency such as a spill or release of mercury.
- Decontaminate and remove Mercury before long-term storage, transport or disposal.
- For new equipment purchases, please attempt to procure instruments with no or little Mercury

P. ERGONOMICS

Many lab tasks such as looking through microscopes, working in exhaust hoods, pipetting, and continuously looking down for bench tasks require both significant repetitive movements and sustained awkward posturing. Often there is no leg room when sitting at counters or hoods, which causes more leaning and reaching. Although the essential job tasks probably cannot change, you can develop important personal strategies that can improve comfort and health. There may also be equipment changes you can make.

The section below outlines some steps you can take to reduce your risk for injury from this demanding work. Links to product ideas and additional related information are provided. Product links do not imply endorsement.

1. Seating

- Take the time to adjust the seat depth and chair back height and tilt in order to maximize individual back support. Consider a slightly reclined position to promote better support.
- Try using chairs “backward”, supporting the torso when leaning forward to do bench/hood/microscope work, as a means for changing positions throughout the day.
- Make sure the feet reach the floor, foot ring or separate footrest comfortably. The stabilization of both feet makes it easier to sit back in a supported manner. Some lab chairs have adjustable foot rings—consider this feature when buying new chairs. For lower surfaces use office-style footrests. Step.n.Up or NeXtep are adjustable rests that attach to the cylinder of lab stools. Another style of freestanding rest with extended height adjustment is by Safco or similar.
- Seat height—be sure lab chairs have adequate height adjustment. Extended cylinder heights (32 inch) may provide additional adjustment that will help employees comfortably reach/perform work at counter height.
- Pull your torso close to the work surface and then sit back. This technique will help avoid ‘perching’ on the edge of the chair.
- Select benches where there is leg room under the surface.

2. Extended Standing

- Standing all day for bench work, particularly on concrete/tile flooring, is difficult. The body requires time to recover from these demands, even within a given shift.
- Recommendations to minimize risks from extended standing include:
- Microbreaks--allow time (as little as 30 seconds - 1 minute every 20 minute) and a chair/stool so spinal structures and joints can recover from extended standing.
- Consider anti-fatigue matting in areas where practical.
- Proper footwear is important and using a foam/gel insole can also reduce fatigue. Remember, they need to be replaced before they appear worn out.

- Provide a footrest so you can elevate one foot, then the other. This will reduce static fatigue. If safe/appropriate, try opening cabinets to create a footrest.

3. Microscope Station

- Be cognizant of neutral postures while working. Adjust the chair or microscope as needed to maintain an upright head position. Elevate, tilt or move the microscope closer to the edge of the counter to avoid bending your neck.
- Avoid leaning on the hard edges on the table - consider padding the front lip of microscope

table (AliEdge or similar) or using forearm pads. A simple, versatile solution is a variety of foam pads, like Wedge-Ease. Be sure these supports do not cause awkward wrist postures when focusing/adjusting the stage.

- Keep scopes repaired and clean.
- Spread microscope work throughout the day and between several people, if possible.
- Observe seating adjustment and support techniques.
- Additional resources can be found at Nikon Microscopy U and UC Berkely.

4. Pipetting

- Below are some general guidelines to reduce the physical impact of pipetting.
- Sit or stand close to your work at bench. If safe/appropriate, try opening cabinets to create legroom.
- Work at appropriate heights to minimize twisting of the neck and torso. Elevate your chair rather than reaching up to pipette.
- Alternate or use both hands to pipette.
- Select a lightweight pipette sized for your hand. Hold the pipette with a relaxed grip and use minimal pressure while pipetting.
- Avoid standing or sitting for long periods. Alternating between sitting and standing provides relief and recovery time for fatigued body structures.
- Additional resources can be found at UCLA, UC Berkeley

5. Hood Work

- Observe seating recommendations to promote supported postures.
- Position work supplies as close as possible in order to avoid awkward leaning/reaching while working. Consider turntables to rotate materials closer to the user. Be sure that only essential materials are in the hood to avoid unnecessary reaching around clutter.
- Consider lower-profile sample holders, solution container, waste receptacles to prevent awkward bending of wrist, neck and shoulders. Reduced repetitive movement also means increased efficiency.

6. Other Tips

- Gloves— Wear slightly snug gloves to reduce forces on hands and improve accuracy during fine manipulation. Wearing loose gloves during pipetting and other tasks makes manipulating small materials more forceful and difficult.
- Rotate tasks throughout the work day and among several people, whenever possible. Take frequent small rest breaks (1-2 minute in duration) every 20 minutes. Every 45-60 minutes, get up to stretch and move.
- Take vision breaks during intensive computer and fine visual work. Every 20 minutes, close the eyes or focus on something in the distance.

APPENDIX F – SOP FORMAT

Generic or Specific Standard Operating Procedure Outline

I. General Statement of Coverage
II. Hazard Assessment
III. Resources
  A. Existing Standards B. Operating Manual Instructions
  C. Literature References D. CHP Chemical Tables

IV. Chemical Storage
  A. Special Storage B. Securing Gas Cylinders

V. Personal Protection Equipment
  A. Eye and Face Protection B. Eye Wash
  C. Safety Showers D. Gloves
  E. Protective Clothing F. Hearing Protection
  G. Respirators
VI. Controls
  A. Designated Areas B. Chemical Fume Hoods
  C. Glove Boxes D. Safety Shielding
  E. Special Ventilation F. Vacuum Protection
  G. Signs and Labels H. Utilities
    1. Doorways:
    2. Containers:
  I. Fire Protection J. Site Monitoring
VII. Specific Procedures
VIII. Emergency Procedures
  A. Notification
  B. Spill Response
IX. Decontamination and Waste Disposal
  A. Decontamination Procedures
    1. Personnel:
    2. Area:
    3. Equipment:
  B. Waste Disposal
X. Approvals
XI. SOP Prepared by ____________________________ Date _____________
  Reviewed by ________________________________ Date ____________

APPENDIX G – HYDROGEN GUIDELINES

Hydrogen Gas – H_2

Hydrogen (H_2) is a colorless, odorless, flammable gas which is compressed to high pressure. The flammable range of hydrogen is 4.0%-75.0% in air. High pressure leaks can ignite spontaneously and burn with a colorless flame. This appendix discusses precautions that should be taken when using Hydrogen.

Safety Precautions for Hydrogen use

- User Training
    - (M)SDS ((Material) Safety Data Sheets) on Hydrogen should be available to anyone working with this gas, online versions can be obtained from: http://www.sdsmt.edu/Campus-Services/Environmental-Health-and-Safety/
    - Select and use the correct regulator connector by checking the CGA number
        - Incorrect connectors can sometimes be installed on inappropriate gas cylinders
        - CGA 350 is the standard connector for Hydrogen
    - Check the overall condition of the regulator
        - Do not use a regulator that has been used for other gases.
        - Leak test the connections.
    - Never work on a pressurized system
        - If there is a leak, close the cylinder valve.
        - Purge the system in a safe manner
- Handling and Storage
    - Use adequate ventilation.
    - Separate Hydrogen cylinder from oxygen, chlorine, and other oxidizers by at least 20 feet (6.1 meters) or use an approved gas cabinet.
    - Store only where temperatures will not exceed 125°F (52°C)
    - There must be no source of ignition in areas where hydrogen is being stored.
    - Segregate empty cylinders from full cylinders.
    - When a cylinder is not in use, screw the valve protection cap firmly in place.
    - Secure cylinders upright at the top third of the cylinder. Ensure that the cylinder is tightly secured.
- Personal Protective Equipment (PPE)
    - Wear safety glasses when handling any compressed gas.
    - If you have questions, EHS can help
    - Contact us if you need assistance with training on hazards, proper storage, handling and emergency procedures, or if you have any questions regarding the use of Hydrogen.

Adapted from the Caltech Environment, Health and Safety Office- Safety bulletin on Hydrogen
3/2017