UNIVERSITY OF ROCHESTER

CHEMICAL HYGIENE PROGRAM

IN COMPLIANCE WITH OSHA 29 CFR 1910.1450

OCCUPATIONAL EXPOSURE TO HAZARDOUS CHEMICALS IN LABORATORIES

The Chemical Hygiene Program has been prepared by the University of Rochester's Environmental Health & Safety (EH&S) Department's Laboratory Safety Unit for use in laboratories where hazardous chemicals are used. The Chemical Hygiene Program is reviewed and updated as needed following major incidents, drills, exercises, or when new or special safety information becomes available. The recommended revisions are peer reviewed by the Laboratory Safety Unit prior to approval and posting onto the web. The Laboratory Safety Unit's Manager maintains documentation of the review.

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Laboratory Safety Unit Manager Signature: _____ _____
Robert Passalugo Date

Director of EH&S Signature: _____ _____
Mark Cavanaugh Date

UNIVERSITY OF ROCHESTER

CHEMICAL HYGIENE PROGRAM

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List of Acronyms/Abbreviations used in the Chemical Hygiene Program

ACGIH	American Conference of Governmental Industrial Hygienists
ACH	Air Changes Per Hour
AL	Allowable Limit
ASHRAE	American Society of Heating, Refrigeration and Air Conditioning Engineers
BSC	Biological Safety Cabinet
CFR	Code of Federal Regulations
CHP	Chemical Hygiene Program
DOT	Department of Transportation
HEPA	High Efficiency Particulate Air Filters
HCS	Hazard Communication Standard
EH&S	Environmental Health and Safety
GHS	Globally Harmonized System
HVAC	Heating Ventilation Air Conditioning
IARC	International Agency for Research on Cancer
JHA	Job Hazard Assessment
LC_{50}	Lethal Concentration $_{50}$
LD_{50}	Lethal Dose $_{50}$
LLE	Laboratory for Laser Energetics
LSO	Laboratory Safety Officer
MERT	Medical Emergency Response Team
NFPA	National Fire Protection Association
NIOSH	National Institute for Occupational Safety and Health
NSF	National Sanitation Foundation
NTP	National Toxicology Program
NYSDEC	New York State Dept. of Environmental Conservation
OSHA	Occupational Safety and Health Administration
PEL	Permissible Exposure Limit
PI	Principal Investigator
PPE	Personal Protective Equipment
PPM	Parts Per Million
RACE	Rescue Alert Confine Evacuate
SOEM	Strong Occupational and Environmental Medicine
SDS	Safety Data Sheets (formerly Material Safety Data Sheets)
SMH	Strong Memorial Hospital
STEL	Short Term Exposure Limit
TLV	Threshold Limit Value
TWA	Time Weighted Average
UCAR	University Committee for Animal Resources
UCHO	University Chemical Hygiene Officer
UHS	University Health Service
UofR	University of Rochester
USEPA	United States Environmental Protection Agency

I. GENERAL PRINCIPLES

The Chemical Hygiene Program (CHP) is written to comply with the Occupational Safety and Health Administration (OSHA) regulation set forth in 29 CFR 1910.1450, the Occupational Exposure to Hazardous Chemicals in Laboratories (the "Laboratory Standard"). This regulation mandates a program of practices, procedures, and policies designed to protect employees who use hazardous chemicals in a laboratory setting. These laboratory chemicals include not only those regulated in 29 CFR 1910, Subpart Z, but also any chemical meeting the definition of a hazardous chemical with respect to physical and health hazards as defined in OSHA's Hazard Communication Standard, 29 CFR 1910.1200.

The CHP applies to all UofR laboratories. This "Program" includes research laboratories, clinical labs, student labs, instrumental labs, lab support locations, environmental chambers/rooms, quality control labs, store rooms for lab equipment, linear equipment rooms, and corridors adjoining labs. Locations not covered by the "Program" include sound labs, - computer labs, and many electrical engineering labs.

The purpose of the CHP is to provide laboratory personnel with basic safety information regarding the use of chemicals in laboratories. Although a number of chemicals are mentioned in this "Program", they are not the only chemicals that may be present. They serve to illustrate hazards that may be present. This "Program" also presents information on the safe storage, use, and disposal of chemicals/wastes in laboratories.

It is the policy of the UofR to provide an environment free from recognized hazards that could cause injury or illness. To this end, employees may not be exposed at or above a chemical's Permissible Exposure Limits (PEL) or Short Term Exposure Limit (STEL) set by OSHA Working with any chemical involves a degree of risk. Even though a chemical may not be considered hazardous by today's standard, all employees are advised to minimize their exposure to chemicals by using established safe practices. Three main categories exist to control exposure include: (1) engineering controls, (2) work practices and administrative controls, and (3) personal protective equipment (PPE).

Engineering controls, the preferred method of reducing exposure, should be used whenever the chemical hazard information on the chemical label or the Safety Data Sheet (SDS) indicates "use local exhaust." Examples of engineering controls include fume hoods, canopy hoods, slot hoods, glove boxes, and biological safety cabinets. Also, the Principal Investigator or lab supervisor should make all efforts to ensure the least hazardous substances are used and that all chemicals are used in the most efficient manner to minimize both exposure and waste.

Work practices and administrative controls are another method in reducing employee exposure after the use of engineering controls. SDS and chemical labels must be reviewed for specific work practice instructions. Additional work practices and administrative controls include items such as not working alone and compiling specific experimental protocols that include safe work practices, as listed in this document, and Standard Operating Procedures, both written/approved by the

PI/supervisor and those listed in the appendices of this document. Some chemical manufacturers may have detailed work practices to follow for the safe use of extremely hazardous agents. For example, Sigma-Aldrich provides detailed work practices that can be down-loaded for tertiary butyl lithium.

PPE must be used in addition to, but not as a substitute for, engineering controls and work practices to reduce exposure. PPE may consist of respiratory protection, eye protection, face protection, gloves, hearing protection, dermal coverings, or protective clothing. SDS and chemical labels contain specific information on the PPE needed. When PPE is selected, its use shall be in accordance with OSHA standard 29 CRF 1910, sections 132-134, in accordance with the UofR Personal Protective Equipment Program (http://www.safety.rochester.edu/ih/ppe/ppe.html), the UofR Respiratory Protection Program (http://www.safety.rochester.edu/ih/respiratoryprotection/respprogram.html), and the UofR Hearing Protection Program (http://www.safety.rochester.edu/ih/hearing/hearing.html), as well as the UofR's Human Resource Policy "Safety or Personal Protective Equipment Policy" (#158, Appendix 1).

It is not enough, however, to provide safe equipment, Standard Operating Procedures, and training if the "culture" does not encourage and support working safely in the laboratory. Therefore, the University of Rochester encourages all laboratory staff including Principal Investigators to place the highest priorities on best practices and to raise concerns to colleagues and supervisors when they identify or are concerned about potential safety problems.

The CHP is a continually evolving program. The CHP can be modified by the approval of the Manager of the Laboratory Safety Unit and the Director of Environmental Health and Safety, with input from the Laboratory Safety Officers. The most recent copy of this document is available on-line.
Many University laboratories utilize not only hazardous chemicals but also have/use biological agents, radioisotopes, research animals, special instruments (lasers, mass spectrophotometers), and/or have physical hazards Biological hazards are handled/controlled by the Institutional Biosafety Committee. Radioisotopes are handled/controlled by EH&S's Radiation Safety Unit. The 2015 edition of the University's Chemical Hygiene Program includes several new sections to better control hazardous chemicals/drugs administered to animals, physical hazards, ventilation issues and common reaction hazards.

II. RESPONSIBILITY

Responsibility for implementing the CHP resides with each department that has a UofR laboratory. EH&S's Laboratory Safety Unit was given the responsibility to develop the written CHP, implement the "Program", and act as the University Chemical Hygiene Officer (UCHO). Those departments that have labs must follow the requirements of this "Program".

A. **Principal Investigators / Supervisors:** Principal Investigators (PIs) and supervisors have primary responsibility for the safety of the labs under their jurisdiction. They are responsible for providing leadership and promoting and advancing the laboratory safety culture. The PI/supervisor may delegate safety duties for which he/she is responsible for but can't relinquish that responsibility/obligation. He/she must ensure that the delegated safety duties are carried out. These responsibilities include:

1. Appointing a Laboratory Safety Officer (LSO) to oversee safety issues of the assigned spaces and activities under his/her direction. Some departments may wish to designate a single individual as the LSO for the entire department. Such a selection must be endorsed by the department chair and reported to the Laboratory Safety Unit.

2. Perform risk assessments for hazardous chemicals and procedures prior to conducting the proposed laboratory work.

3. Selecting and employing engineering controls and laboratory practices to reduce potential exposure to the lowest practical level in accordance with the CHP.

4. Establishing safe work practices for handling chemicals for all laboratories and projects under their direction by creating site specific operating procedures (SOPs) for the hazardous chemicals or procedures/activities completed by his/her staff members. Generic SOPs for many chemicals/processes can be found on the EH&S web site but must be customized for the activities completed in the lab.

5. Ensuring that lab members are trained and competent – possess the experience, knowledge, skills and abilities necessary to perform their tasks without injury to themselves or others.

6. Select personal protective equipment based on the risk assessment or as written in the pertinent site specific SOPs.

7. Informing lab members of potential hazards associated with the use of hazardous chemicals.

8. Directing laboratory members attend an EH&S Laboratory Safety Training session annually and providing specific training for lab employees using hazardous chemicals in his/her labs. Site specific training by the PI/supervisor must be provided and documented for lab members upon initial assignment and when new processes/procedures are implemented in the lab.

9. Completing a chemical inventory for the laboratory locations under his/her direction. Chemical inventories must be updated annually in Chematix, the University's electronic chemical inventory system.

10. Investigating and reporting all incidents and near misses, especially to the use of hazardous chemicals.

11. Ensuring hazardous chemicals are disposed of through the Environmental Compliance/Hazardous Waste Group.

12. Selecting chemicals and maintaining a record of chemical use for OSHA Carcinogens, IARC Group 1 carcinogens, and reproductive hazards for all personnel under his/her direction.

13. Making arrangements through EH&S's Laboratory Safety Unit for any needed chemical monitoring of the laboratory staff and maintaining a record of the monitoring results provided from the Laboratory Safety Unit.

14. Completing and submitting to EH&S the annual "Declaration of Possession of Regulated Laboratory Chemicals and Biologicals", a listing of Department of Homeland Security and Select Agents Regulations (biological agents). This form is sent electronically to PIs for review and submission and is also available on the web at http://www.safety.rochester.edu/labsafety/pdf/biochemsurvey.pdf .

15. Providing emergency contact information on all lab entry doors and on special equipment.

16. Ensuring proper decommissioning is completed when labs under his/her jurisdiction are vacated. Specific responsibilities for lab decommissioning are listed at http://www.safety.rochester.edu/labsafety/labdecommission/labdecommission.html .

17. For any high acute/chronic hazard agent, as listed in Section IV.D and XVII.B and C, the PI or designated individual shall complete a SOP for the planned use of the agent prior to its purchase and submit it to EH&S's Laboratory Safety Unit. EH&S's Laboratory Safety Unit will authorize the purchase and use of the agent only should they find the SOP and facility acceptable for the agent's safe use and after federal government approval, if applicable.

18. Ensuring all lab staff requiring respirators are medically cleared, fit tested annually, provided training on the respirator's use and limitations, and that respirators are used in accordance with the University's Respirator Protection Program.

19. The PI/supervisor is responsible to resolve safety issues identified through the Laboratory Safety Unit's inspections. Any unresolved issue(s) will be escalated to the department chair and/or the appropriate dean for action.

B. **Laboratory Employees:** Laboratory employee responsibilities include:

1. Completing EH&S Laboratory Safety Training session annually.

2. Completing laboratory specific safety training.

3. Planning and conducting laboratory procedures in accordance with the laboratory's SOPs and the University's CHP.

4. Developing and practicing good laboratory practices and personal hygiene habits (examples include frequent hand washing, no eating/drinking in labs, maintaining good housekeeping, not wearing gloves outside of the laboratory, etc.

5. Wearing clothing and attire appropriate to lab activities. This includes, but is not limited to, wearing pants that cover the entire leg (no shorts, short skirts, or Capri pants), confining long hair, not wearing clothing that has dangling laces/straps or is loose fitting, not wearing dangling jewelry, and wearing only completely enclosed shoes (no sandals, clogs, crocks, high heels or light-weight slipper shoes).

6. Wearing Personal Protective Equipment when and where required, such as wearing lab coats over street clothes, and eye/face protection, gloves and hearing protection for high noise areas.

7. Reporting unsafe conditions to the PI/supervisor or the LSO.

8. Reporting incidents of hazardous chemical exposures and near misses to the PI/supervisor or the LSO using the University's Employee Incident Report System.

9. Ensuring chemicals and hazardous wastes are not stored on the floor.

10. Ensuring hazardous waste is collected at the point of generation and handled in accordance with protocols issued by the University's Hazardous Waste Unit and adhering to the "Learners Guide for Responsible Hazardous Chemical Waste Management", available at http://www.safety.rochester.edu/envcompliance/pdf/BlueLearnerGuide_new.pdf.

11. If respiratory equipment is required, ensuring medical clearance is obtained, training on the respirator is received annually, fit testing is completed annually, and using the respirator in accordance with the University's Respirator Protection Program.

12. Using compressed gases and cryogenic liquids properly by securing the cylinders in the upright position with a stand or cylinder strap, ensuring caps are placed on cylinders when not in use, and verifying the regulator is approved for the gas to be used for the pressure in the cylinder.

13. Ensuring at least one other individual is present (never work alone) when using chemicals of moderate, chronic or high acute toxicity.

C. **Laboratory Safety Officers (LSO):** The LSO, appointed by the PI/supervisor, will assist the PI/Supervisor in maintaining a high level of safety in their laboratory spaces. The LSO's responsibilities include:

1. Ensuring all lab members participate in an EH&S Laboratory Safety Training annually. The link for EH&S training is available at http://www.safety.rochester.edu/ih/ihlabhome.html . Alternately, LLE and LLE affiliated lab personnel can participate in LLE's live or electronic Laboratory Safety Training.

2. Ensuring all lab members attends lab specific safety training upon initial assignment and when new processes/procedures are implemented in the lab.

3. Maintaining records of all training the lab staff has completed.

4. Overseeing the annual documentation for employees who receive medical clearances for the use of respirators.

5. Enforcing adherence to PPE requirements in accordance with University policies and programs and the laboratory's SOPs.

6. Assisting in developing precautions and the implementation of SOPs for chemical hygiene policies and practices within the PI/supervisor's allocated spaces.

7. Assisting in the procurement, inventory, use, and disposal of chemicals used in the PI/supervisor's allocated laboratory spaces.

8. Serving as a liaison between the department and EH&S.

9. Reporting unsafe conditions to the PI/supervisor and facilitating the implementation of temporary corrective actions.

10. Sharing lessons learned and injuries/near miss reports with lab members.

11. Ensuring the laboratory has a chemical inventory in Chematix, the University's chemical inventory system, and the lab member has been provided training to access to the SDSs in the system.

12. Inspecting chemical containers annually for expiration dates, incompatibility and container integrity. Potentially explosive compounds (PECs) are to be checked at least every 6 months.

13. Ensuring the lab has a spill kit and the spill kit's contents are full.

14. Verifying eye wash stations are flushed weekly and the documentation of this activity is maintained.

15. Verifying Facilities perform periodic shower testing for those showers located within their lab.

16. Ensuring appropriate lab safety signage and labels are prominently posted, per Section X of this program.

17. For labs using ductless fume hoods, being responsible for matching the types of filters to the chemicals being used and documenting the filters are being changed out at the prescribed frequency.

18. Ensuring all biological safety cabinets are recertified annually by an outside vendor.

19. Ensuring lab members adheres to the requirements for the disposal of hazardous waste, as listed in the "Learners Guide for Responsible Hazardous Chemical Waste Management".

20. Overseeing the decommissioning of laboratories should the PI/supervisor leave the University or move to other spaces.

21. Seeking ways to improve the CHP.

D. **Deans, Administrators, and Department Heads:** Deans, administrators, and department heads have ultimate responsibility for administration and compliance with the UofR Personal Protective Equipment Program (PPE), the Respiratory Protection Program, and Hearing Protection Program, the Reproductive Protection Policy (Appendix 2), and the CHP. The administrators shall assist in maintaining an accurate record of laboratory employees to assist in Lab Safety Training compliance, as listed in Section XI.B.

   In the case of recalcitrant Principal Investigators or lab groups, disciplinary actions up to and including lab closures will be considered by the department chairs and the University Administration to ensure safe working conditions.

E. **EH&S's Laboratory Safety Unit Staff:** Responsibilities includes broad oversight in the implementation of the CHP and:

   1. Working with PIs, supervisors, administrators and LSOs to develop and implement good chemical hygiene policies and practices.

   2. Providing generic safety training to employees who work in laboratories.

3. Providing additional training materials to assist the PI/supervisor and the LSO in lab specific training efforts.

4. Evaluating areas where certain hazardous chemicals are used regularly and determining if monitoring of airborne contaminants is necessary and the frequency at which the monitoring will occur.

    a. Based on the chemical inventory or a request from the lab, a workplace evaluation will be completed to determine the potential of inhalation exposure. This evaluation will ne used to determine the monitoring schedule.

    b. The Laboratory Safety Unit shall retain chemical monitoring reports as prescribed by OSHA.

    c. Any workplace assessment and subsequent chemical monitoring will be reported to the employee monitored and his/her immediate supervisor. Should an over-exposure be determined, a copy of the report will be sent to UHS or SOEM. Recommendations for reducing exposures will also be included in the report.

    d. Requests for the purchase/use of high hazard chemicals (as listed in IV.D and XVII.B and C): The Laboratory Safety Unit shall determine through their workplace assessment whether the SOP and lab's engineering controls are acceptable. If the control measures are deemed adequate, the Laboratory Safety Unit will authorize the purchase and use of the listed agent. Periodic reassessments shall be completed based on the frequency listed in the appropriate regulation.

5. Knowing the current legal requirements concerning regulated substances and disseminating this information to the appropriate personnel.

6. Overseeing periodic laboratory safety inspections and the annual check of fume hoods by EH&S's Laboratory Safety Unit to ensure compliance with the CHP. The results of the safety inspections will be sent to the PI/Supervisor, the LSO, and, if needed, the Department Chair or applicable Dean for corrective action.

7. Issuing and sharing advisories or alerts relative to laboratory safety issues PIs/supervisors and to the LSO.

8. Providing training to Facilities employees on the hazards that may be found in laboratories and making recommendations for controlling the hazards

9. Seeking ways to improve the CHP and updating the CHP periodically.

F. **Facilities:** Facilities personnel have direct control over the laboratory's general and local ventilation systems and utility systems. Facilities responsibilities include:

1. Informing laboratory personnel in advance of scheduled utility or maintenance shutdowns (gas, water, fume hoods, etc.) through the posting of the notices.

2. Maintaining local exhaust (fume hoods, slot hoods, ducted biological safety cabinets, etc.) systems to provide the engineering controls necessary to maintain safe laboratory conditions.

3. The internal blowers of biological safety cabinets are NOT to be serviced by Facilities personnel. Only contractors accredited by the National Sanitation Foundation's Standard Number 49 Class II Biohazard Cabinetry may work on the internal blowers or filters of these special units. Facilities can perform activities such as the repair of electrical outlets, gas outlet repairs, and light bulbs of these units. Contact EH&S's Laboratory Safety Unit for additional information.

4. Informing EH&S's Laboratory Safety Unit when a major change of an air handler system (HVAC) is contemplated or completed.

5. Inspecting and flushing safety showers at the frequency specified by EH&S, correcting any identified problems with the showers, and maintaining documentation of these activities.

6. Inspecting and flushing eyewash units in linear equipment rooms, located in the Cancer Center, Ophthalmology, k-MRB, and MRB-X.

7. Attending/participating in safety training sessions offered by EH&S.

III. EMPLOYEE INFORMATION AND TRAINING

A. **Required Training and Purpose**

EH&S provides live and web based laboratory safety training to laboratory personnel. It is the responsibility of the PI/supervisor to have new employees and students complete a training session before they begin bench work. EH&S training includes the following topics:

1. The existence of the CHP and the requirements of OSHA's Laboratory Standard.

2. Control methods (engineering controls, work place practices, administrative controls, and personal protective equipment) to minimize employee exposure to hazardous chemicals in the laboratory.

3. Modes of potential exposure to chemicals and signs and symptoms associated with exposure to common hazardous chemicals used in the laboratories.

4. The location and availability of known reference materials within the University - including SDSs, information on the hazards, safe handling, and storage of chemicals.

5. How to read and understand the information found on an SDS.

6. The proper use of emergency equipment and the proper use, maintenance, and limitations of PPE, including respirators and hearing protection, and other safety equipment.

7. Emergency procedures to follow in the event of a fire, exposure, or spill.

8. Requirements for the storage and emergency response for chemicals as well as the disposal of hazardous waste in laboratories.

9. Review and follow the information listed in the laboratory's Standard Operating Procedures for particular hazardous chemicals and for the general procedures for hazard classes of chemicals.

The PI/supervisor must provide and document the training/orientation for the laboratory staff under his/her direction. The training is to include topics such as departmental safety policies, Standard Operating Procedures, and any other procedures/activities performed in the employee's work location(s). When a new hazard(s) is/are introduced in the workplace, the PI/supervisor must train and document the training the employees received for these hazard(s).

B. **Documentation of Training**

Documentation of live general training is the responsibility of the EH&S. EH&S will grade attendance sheets and enter the results of training into the HRMS data system.

Successfully completed general laboratory safety training through Blackboard or MyPath will automatically be entered into the HRMS data system.

Site specific and continuing employee training and documentation of this training is the responsibility of the PI/Supervisor. The Laboratory Safety Unit can provide reference and educational materials to assist the PI/supervisor and the LSO in the required site specific training for chemicals or procedures that may introduce a risk to the employees. The LSO will assist in maintaining training records for staff members in the PI's laboratories.

C. **Frequency of Training**

All individuals working at the bench or directly supervising persons who work at the bench are required to complete an EH&S Laboratory Safety Training session annually*.

Site specific training addressing the hazards posed by the lab's activities must be provided by the PI/supervisor upon initial assignment. The PI/supervisor is to provide site specific training when new processes/procedures are implemented and maintain the associated documentation. Should laboratory personnel be found not to follow safe working procedures, the PI/supervisor is to provide retraining and maintain the associated documentation.

*Laboratory employees at LLE participate in LLE equivalent general lab safety training that is specific for their building or can complete a EH&S Laboratory Safety Training session.

IV. HAZARDOUS CHEMICALS

The term "hazardous chemical" refers to a chemical for which there is statistical evidence that acute or chronic health effects may occur in exposed employees, or if it is listed in any of the following:

- OSHA, 29 CFR 1910 Subpart Z, Toxic and Hazardous Substances;
- "Threshold Limit Values for Chemical Substances and Physical Agents in the Work Environment", ACGIH (latest edition);
- "The Registry of Toxic Effects of Chemical Substances", NIOSH (latest edition); or,
- Select Agents Regulations: 42 CFR 73, 9 CFR 121, and 7 CFR 331.

In 2012, OSHA revised the Hazard Communication Standard (HCS) 29 CFR 1910.1200 and aligned the program with the United Nation's Globally Harmonized System (GHS) of Classification and Labeling of Chemicals. One key component of the updated program utilizes pictograms to help identify hazards. The pictogram and the common descriptions of the hazards identified are listed below. Some chemicals and most mixtures could have more than one pictogram to identify the hazard(s).

A. Types of Health Hazards

1. **Irritants**: Irritants are agents that can cause inflammation of the body surface with which they come in contact. Irritants can also cause changes in the mechanics of respiration and lung function. Common irritants include:

Common Skin Irritants	Common Respiratory Irritants
Ammonia	Acetic acid
Alkaline dusts and mists	Acrolein
Acids	Formaldehyde
Halogens	Formic acid
Nitrogen dioxide	Halogens
Ozone	Hydrochloric acid (hydrogen chloride)
Phosgene	Sulfur dioxide
Phosphorous chloride	Sulfuric acid

The pictogram for chemicals in this hazard group is:

2. **Asphyxiants**: Ashpyxiants are broken into two groups. Simple asphyxiants deprive the tissue of oxygen. Chemical asphyxiants render the body incapable of maintaining an adequate oxygen supply. Examples include:

Simple Asphyxiants	Chemical Asphyxiants
Carbon dioxide	Carbon monoxide
Helium	Cyanides
Nitrogen	Hydrogen sulfide
Nitrous oxide	

The pictograms for chemicals for this hazard group can include one or both of the following:

3. **Hepatotoxic agents**: Hepatotoxic agents cause damage to the liver. Examples include:

Carbon tetrachloride	Ethylene dibromide
Dichloropropane	Nitrosamines
Dimethylformamide	Tetrachloroethane
Diphenyl	

The pictogram for chemicals for this hazard group is:

4. **Nephrotoxic agents**: Nephrotoxic agents damage the kidneys. Examples include:

Cyclosporin	NSAIDs
Ethylene glycol	Radiological contrast media
Halogenated hydrocarbons	Uranium compounds

The pictogram for chemicals for this hazard group is:

5. **Neurotoxic agents**: Neurotoxic agents damage the nervous system. Generally, the nervous system is sensitive to organometallic compounds and sulfide compounds. Examples include:

Carbon disulfide	Methyl mercury
Chlorinated solvents	Naphthalene
Formaldehyde	N-hexane
Manganese	Organic phosphorous insecticides
Lithium	Tetraethyl lead
Methylene chloride	Thallium
Methyl diisocyanide	Trialkyl tin compounds

The pictogram for chemicals for this hazard group is:

6. **Hematopoietic System Effects**: These agents act on the blood. The blood cells can be directly affected or the bone marrow can be damaged. Examples include:

Analine	Nitrobenzene
Benzene	Toluidine
Nitrites	

The pictogram for chemicals for this hazard group is:

7. **Carcinogens**: A carcinogen is any agent that can initiate or speed the development of malignant or potentially malignant tumors, or malignant neoplastic proliferation of cells. Select carcinogens are those substances that meet one of the following criteria:
   - It is regulated by OSHA as a carcinogen;
   - It is listed under the category" known to be carcinogens", as listed in the latest edition of the National Toxicology Program's (NTP) "Annual Report of Carcinogens"; or,
   - It is listed under Group 1, "carcinogenic to humans" by the International Agency for Research on Cancer Monographs (IARC).

   Carcinogens are too numerous to list in this section but are in Appendix 12 of this document.

   The pictogram for chemicals for this hazard group is:

8. **Reproductive hazards**: Reproductive hazards are those chemicals that affect the reproductive health of women and men or the ability to have healthy children. This can be from chromosomal damage (mutagens) and effects on the fetus (teratogens). Mutagens change the genetic material, usually DNA, and increase the frequency of mutations. A teratogen is an agent that interferes with normal embryonic development without damage to the mother or lethal effects on the fetus. Examples include:

Dioxin	Many pesticides
Endocrine disrupters	Carbon disulfide
Lead	Ethylene oxide

   The pictogram for chemicals for this hazard group is:

9. **Sensitizer**: A sensitizer is an agent that causes a majority of the exposed population to

develop an allergic reaction in normal tissue after repeated exposures to the chemicals. Reactions can range from mild, such as a rash, to severe, such as anaphylactic shock. Examples include:

Chlorinated hydrocarbons	Nickel compounds
Chromium compounds	Toluene diisocyanates
Epoxies	

The pictograms for chemicals for this hazard group can include:

10. **Acutely Toxic Chemicals**: These chemicals are substances falling into the following categories:
    - A chemical that has a median lethal dose (LD_{50}) of 50 mg/kg or less of body weight, when administered to rats weighing 200 to 300 g each;
    - A chemical that has a median lethal dose (LD_{50}) of 2000 mg/kg or less of body weight, when administered by continuous contact for 24 hours to the bare skin of rabbits weighing 200 to 300 g each; or,
    - A chemical that has a median lethal concentration (LC_{50}) in air of 200 ppm by volume or less when administered by continuous inhalation for one hour to rats weighing 200 to 300 g each.

    A list of acutely toxic chemicals is listed in Appendix 12 of this document.

    The pictograms for many of the chemicals for this hazard group can include:

11. **Nanomaterials**: The health effects for exposures to nanomaterials are not fully understood at this time. Until the potential risks and more definitive findings are available, researchers working with nanomaterials must implement a combination of

engineering controls, work place practices and use personal protective equipment to minimize potential exposures. Follow the guidelines outlined in the UofR's Nanomaterials Safety Program at http://www.safety.rochester.edu/restricted/NanomaterialsSafetyProgram.pdf and the "Site Specific Procedures for Nanomaterials" in Appendix 12 of this document.

There is no pictogram for this group of chemical. The appropriate pictogram is based on the hazard of the individual chemical(s) present(s).

B. **Physical Hazards**

1. **Flammable agents**: Flammable agents are any solid, liquid, or gas that will ignite easily and burn rapidly.

   a. Flammable solids can include dusts or fine powders (metallic or organic substances such as cellulose, flour, etc.), those that ignite spontaneously at low temperatures (white phosphorous), those in which internal heat is built up by microbial or other degradation activities, or films, fibers, and fabrics of low-ignition point materials.

   b. Flammable liquids are classified by the NFPA and the DOT as those having a flash point less than 100F and a vapor pressure of not over 40 psia at 100F.

   c. Flammable gases are ignited very easily and the flame and heat propagation rate is so great as to resemble an explosion, especially if the gas is confined. Common examples of flammable gases include hydrogen, carbon monoxide, and acetylene.

   The pictogram for chemicals for this hazard group is:

2. **Combustible agents**: Combustible solids are those solids that are relatively difficult to ignite and that burn relatively slowly. Combustible liquids were previously defined as those liquids that have a flash point greater than 100F. Under the GHS, chemicals in this grouping are now listed under flammable agents. Examples include:

Greases	Mineral oil
Kerosene	Paraffin oil
Lubricants	Vegetable oil

The pictogram for chemicals for this hazard group is:

3. **Oxidizers:** Oxidizers are agents that, by yielding oxygen, may cause or contribute to the combustion of other materials. Examples include:

Hydrogen peroxide	Perchlorates
Nitric oxide	Permanganates
Oxygen	

The pictogram for chemicals for this hazard group is:

4. **Compressed Gases / Cryogenic Liquids**: A **compressed gas** is a substance that is a gas at normal room temperature and pressure, and is contained under pressure, usually in a cylinder. Some compressed gases (e.g. acetylene) are stabilized in the cylinder by dissolving the gas in a liquid or solid matrix. These materials can pose both a health hazard and a physical hazard to personnel. Compressed gases can create pressure hazards and dilute the oxygen content or create flammable atmospheres should a sudden release occur.

The pictogram for chemicals for this hazard group is:

5. **Explosive, Highly Reactive / Unstable Materials**: These substances have the potential to decompose, condense, vigorously polymerize, react with water, react with moisture in the air, or otherwise form peroxides upon exposure to light or oxygen in the air. A list of these chemicals is too numerous to include here and can be found in the appendices of this document.

   The pictograms for chemicals for this hazard group can include:

C. **Special Hazardous Chemical Groupings**

Some laboratory locations may use some chemicals for research or clinical purposes for which EH&S has developed safe work practices. These include but are not limited to antineoplastic agents, agents that can cause cancer or reproductive effects, hydrogen fluoride, formaldehyde, compressed gases, and cryogenic liquids. Consult the Laboratory Safety Unit's web pages at http://www.safety.rochester.edu/ih/ihlabindex.html for these special handling and work practice information sheets. Standard Operating Procedures (SOPs) for classes of chemicals, some specific chemicals and certain processes is provided in Appendices of this document.

D. **High Hazard Chemicals**

Some laboratory locations may use some high hazard chemicals that may present severe health and/or physical hazards that require approval prior to purchase and use in experimental procedures. These agents include:

- APHIS and CDC Select Agent Toxins as listed in 7 CFR 331, 9 CFR Part 121, and 42 CFR Part 73 (http://www.selectagents.gov/Regulations.html). Refer to the UR Select Agent Program for additional information.

- OSHA Carcinogens, as listed in 29 CFR 1910.1003 (http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=10007).
- OSHA high energy chemicals, categorized as Division 1.1 and 1.2 chemicals, as listed in 29 CFR 1910.1200, Appendix B (http://www.osha.gov/dsg/hazcom/appendix_b.pdf).

It is the responsibility of the PI/supervisor to develop Site Specific Procedures (SOPs) for the use of these agents and to provide the Laboratory Safety Unit copies of the SOPs prior to the purchase and use of these agents. The Laboratory Safety Unit will audit the SOPs and complete a workplace evaluation for the planned storage/use location and, upon successful findings, authorize the purchase/use of the planned agents. Periodic workplace evaluations as required by the pertinent regulation will be completed. Records of these evaluations will be retained by the Laboratory Safety Unit.

V. MEDICAL CONSULTATION AND EXAMINATIONS

Medical consultations and examinations are available for research personnel from University Health Service (UHS) and for clinical lab personnel at Strong Occupational and Environmental Medicine (SOEM). In the event of a serious injury or after hour emergency, care is available at Strong Memorial Hospital's Emergency Department. All required medical examinations and consultations are performed by and under the direct supervision of a licensed physician and are provided without cost to the employee.

A. **Consultations:** Consultations and medical examinations for work-related illnesses, injury, and other medical conditions related to an exposure to hazardous chemical(s), are made available under the following circumstances:

1. When an employee develops signs or symptoms associated with a hazardous chemical to which he/she may have been exposed in the laboratory.

2. Where exposure monitoring reveals any exposure level routinely above the OSHA Action Level (AL), Short Term Exposure Limit (STEL), Ceiling Limit, or Permissible Exposure Limit (PEL) for which there are exposure monitoring and medical surveillance requirements. The Laboratory Safety Unit will report to UHS/SOEM those employees who have been monitored and found to be over-exposed to a hazardous chemical so they may be included in the appropriate medical surveillance program. Subsequent periodic chemical monitoring, if the employees are still working with the hazardous chemical, will be sent to UHS/SOEM.

3. Whenever an unusual event takes place in the work area such as a spill, leak, an explosion, or other occurrence resulting in the likelihood of a hazardous chemical exposure or injury. For these events, an Incident Report is to be submitted so the medical expense is not incurred by the employee.
   a. For research personnel experiencing a chemical exposures or other injury: During working hours of 8 AM to 4:30 PM, call x5-2662. Identify yourself, state that a person (provide name) has been injured or exposed (if exposed to a chemical, identify the chemical, the extent of the exposure, etc.), what preliminary precautions have been taken, and that the exposed patient needs medical attention. For chemical exposures, bring a copy of the SDS for the chemical/mixture.
   b. For clinical lab personnel (Division 50) experiencing a chemical exposure or other minor injury: During working hours of 8 AM to 4:30 PM, call Strong Occupational and Environmental Medicine at x5-1164 and provide the information as listed in 3.a. above. Medical treatment will be triaged to the appropriate medical care location (i.e. AC3 or Strong ED). Bring a copy of the SDS for the medical personnel for chemical exposures.
   c. For chemical exposures occurring at other times or those sustaining serious injuries: Call x13 (Public Safety) and request a MERT Response. SMH's Emergency Department should be utilized for these types of serious injuries.

d. For other concerns for research personnel, call the UHS Occupational Health Program at x5-4955.

B. **Physician Findings**

1. The physician shall examine the employee and determine any associated medical tests that may be needed in the medical determination.

2. Based on the medical examination and any associated medical tests, the physician shall provide a written opinion to the employee and provide recommendations for further medical follow up, medical tests, or further examinations/treatments.

3. The physician's written opinion shall state any medical condition that may place the employee at increased risk as a result of an exposure to any hazardous chemical found in their work location. This written opinion shall NOT reveal specific findings/diagnosis unrelated to occupational exposure to hazardous chemicals.
   a. The immediate supervisor and the Laboratory Safety Unit shall be provided copies of the written opinion verifying the employee has been informed of the consultation, examination, and any other medical condition that may require further examination or treatment. The Laboratory Safety Unit shall complete a workplace assessment to ensure proper controls are in place to minimize potential exposures to hazardous chemicals of concern.
   b. The Laboratory Safety Unit will provide to the employee, the immediate supervisor, and UHS/SOEM written confirmation of the workplace assessment and the recommended actions to be taken.

4. UHS/SOEM shall maintain records of any medical examination, medical tests, chemical monitoring from the Laboratory Safety Unit, or other findings and make them available to the employee. Such information shall be transferable.

C**.** **Special Programs:** Special medical surveillance programs are provided when indicated by a department or unit's unique needs and are available through UHS or SOEM. The department must contact the medical care provider for department charges and other information.

VI. PERSONAL PROTECTIVE EQUIPMENT (PPE) AND EMERGENCY EQUIPMENT

A. **Personal Protective Equipment (PPE)**

Laboratory personnel must wear PPE as necessary, in accordance with OSHA standard 29 CRF 1910, sections 132-134, in accordance with the UofR Personal Protective Equipment Program (http://www.safety.rochester.edu/ih/ppe/ppe.html) , the UofR Respiratory Protection Program (http://www.safety.rochester.edu/ih/respiratoryprotection/respprogram.html) , and the UofR Hearing Protection Program (http://www.safety.rochester.edu/ih/hearing/hearing.html), to help prevent exposures. All laboratory personnel must be made aware of the limitations of the PPE before use.

Any necessary PPE is provided by the PI/supervisor at no cost to the employee. The PI/supervisor is to determine the PPE by completing appropriate SOPs that include the PPE to be used or complete a Job Hazard Assessment (JHA). A generic SOP form can be found in Appendix 13 and the JHA at http://www.safety.rochester.edu/ih/jha/pdf/hazardassessment.pdf .

PPE may include, but is not limited to:

1. Appropriate eye protection: to be worn by all persons, including visitors, where chemicals are stored or handled. The eye and face protection needed must comply with the most recent edition of ANSI's "Practice for Occupational and Educational Eye and Face Protection" (ANSI Z.87.1).

2. Appropriate gloves: to be worn when the potential for contact with toxic or corrosive materials exists. The gloves are to be inspected before each use and replaced periodically. Disposable gloves must never be reused. The selection of gloves is to be based on chemical permeability. Because of the wide number of gloves and manufacturers available, information from the manufacturer should be obtained to ensure the appropriate glove selection has been made. Laboratory Safety Unit can be contacted to assist in the selection of gloves.
   a. Gloves are to be removed and hands washed before leaving the lab to prevent contaminating surfaces (door knobs, elevator buttons, etc.) outside of the lab.
   b. Powdered latex gloves are not recommended to be used when handling chemicals. These gloves can present a risk to some individuals who have been sensitized to latex.

3. An appropriate lab coats must be worn in the lab when working with chemicals to protect your skin and clothing from spatters and spills. In the event of an accident, a lab coat is easier to remove than street clothes. A variety of lab coats are available and the proper selection is important.
   a. Lab coats made with a blend of Polyester and/or Rayon provide splash protection when working with aqueous solutions. However, when used with flammable liquids; they can ignite.

b. For those frequently using large quantities of flammable liquids, a Nomex HRC1 or 2 rated lab coats are recommended. Cotton lab coats are recommended when working with lower quantities of flammable liquids and when working with an open flame.
c. Lab coats are to fit properly to allow them to be fully buttoned and the sleeves extended (not rolled up).
d. Do not wear lab coats outside of laboratory locations.
e. Do not take lab coats home for laundering because they may contaminate others in your household.

4. When air contaminants are not sufficiently controlled by engineering controls, appropriate respiratory equipment is to be worn. Before any respirator is to be used, a work place assessment must be performed by the Laboratory Safety Unit. Those required to wear respirators must comply with the University's Respirator Protection Program. The use of a respirator shall be considered a temporary measure until needed engineering controls and additional work place practices are implemented.

5. Some lab personnel may still wish to wear a respirator in locations where contaminants are controlled. These individuals must still comply with the University's Respirator Protection Program for the voluntary use of a respirator.

6. Other PPE may be used provided the limitations of its use are made known to the laboratory personnel.

B. **Emergency Equipment**

Emergency equipment may be required based on the quantity and the hazard classes of the chemicals used. This equipment may include:

1. A "hands free" eyewash station is required where corrosive materials are used or stored. Access must be free of obstructions that would inhibit immediate use and the eyewash must be reachable within 10 seconds of the hazard (roughly 50-75 feet). The University specifies the eyewash unit to be a Water Saver Unit or equivalent that meets the present ANSI Standard.

2. An easily accessible drench-type safety shower is required within 10 seconds (75 feet) of locations where hazardous chemicals are used or stored.

3. A fire blanket is recommended in those locations where large quantities of flammable materials are used or stored.

4. The University Fire Marshal shall determine the types and locations where fire extinguishers are required.

5. Spill control kits are to be readily available for minor chemical spills that may occur within a laboratory. Individual spill kits for different chemical classes are available through

scientific supply companies and their purchase is highly recommended.

VII. CHEMICAL PROCUREMENT, DISTRIBUTION AND STORAGE

A. **Procurement**

1. Whenever possible, researchers should consider using safer alternative chemicals in place of hazardous chemicals.

2. To reduce future wastes, purchase only those quantities needed for immediate/near future needs.

3. Before a chemical/mixture is used, information on the chemical properties, proper handling, storage, and disposal must be made available for those who will be using the substance. This information is often listed in the SDS. No chemical container is to be accepted without an adequate identifying label.

4. Because Safety Data Sheets are frequently updated, the LSO can obtain the most recent edition of the SDS by using the web and accessing the chemical manufacturer/supplier. In the event of an emergency (spill or exposure) during normal business hours, EH&S can be contacted by calling 275-3241 to obtain a chemical's SDS. SDSs are also available through Chematix.

B. **Chemical inventories** must be maintained and regularly updated. Starting in 2015, Chematix , the University's electronic chemical inventory system, shall be used by all departments with the exception of LLE.

C. **Distribution**

When chemicals are transported by hand or cart, the container is to be sealed and placed within a secondary containment vessel to prevent spillage.

D. **Storage and Use**

1. New York State Building Code limits the quantities of chemicals allowed to be stored in buildings. The Laboratory Safety Unit can assist you in minimumizing the quantities of chemicals to be stored in your labs and associated Linear Equipment Rooms.

2. Store chemicals in cabinets or shelving according to chemical classes. Routine storage of chemicals on bench tops and in chemical fume hoods is not recommended.

3. Highly odorous chemicals (mercaptoethanol, for example) must be stored in the cabinet under a fume hood, in a vented cabinet, or within a fume hood.

4. Chemicals must be stored in a manner to prevent their exposure to heat or direct sunlight.

5. Building code requirements greatly limits the quantity of flammable liquids that can be stored in a laboratory or fire control area. The preferred locations for the storage of

flammable liquids are in flammable material storage cabinets, cabinets with doors, explosion-resistant refrigerators, or explosion-proof refrigerators. Flammable liquids must never be stored in standard refrigerators or cold rooms. Contact the Laboratory Safety Unit or the Fire Safety Unit should you have a question/concern of the quantity of flammable liquids that are permitted in your area.

6. Laboratory refrigerators and walk-in cold rooms must never be used for the storage of food or beverages for human consumption.

7. Peroxidizable compounds must be dated when received and opened. See Appendix 6 in this document for a listing of Peroxidizable Compounds. Peroxidizable compounds must be tested every six months thereafter for peroxide formation or turned in as hazardous waste. Test methods are included in the "Peroxidizable Compounds" appendix of this document.

8. Unneeded or excess items should be sent to the Hazardous Waste Unit (x5-2056) for reissue or disposal.

9. Stored chemicals must be examined at least annually for expiration dates and visually examined for container and label integrity. Expired chemicals or chemical containers showing possible deterioration need to be disposed of through the Hazardous Waste Unit.

10. Incompatible chemicals must be adequately separated by distance, secondary containment, or separate storage areas. Consult Appendix 7 of this document for a listing of "Incompatible Chemicals". Most chemicals should be stored by general hazard groups, as listed in the appendix of this document, rather than alphabetically.

11. Extremely toxic substances, carcinogens, reproductive agents, mutagens, and teratogens must be segregated from other chemicals. Storage trays or secondary containment can be used for identification and segregating purposes.

12. Chemicals must NOT be stored on the floor, even as a temporary measure.

13. All compressed gas cylinders are:
    a. to be secured with an approved cylinder chain or strap to the wall or bench or supported with a cylinder stand;
    b. to be used in an upright position;
    c. to be used with the proper regulator;
    d. to be capped when not in use; and,
    e. never to be stored or used in corridors or in egress paths such or near a lab exit door. For cylinders near a lab exit door, an oxygen sensor or other life safety device, as approved by EH&S, must be installed.

14. Lecture bottles, small compressed gas cylinders containing flammable or toxic compressed gases, must be:
    a. stored in a well ventilated area (in a cabinet under a chemical fume hood, a fume hood, ventilated storage cabinet, or a ventilated gas cabinet); and,
    b. used in a chemical fume hood or a ventilated gas cabinet unless the cylinder's use is for a special instrument used in the lab.

VIII. WASTE DISPOSAL PROGRAM

A. Purpose

The Waste Disposal Program was established to minimize any harm to people, the facility, and the environment that results from the disposal of laboratory wastes. Appendix 4 "Research and Clinical Laboratory Waste Disposal" lists the proper practices for many materials disposed from laboratories. If a particular waste material is not listed, contact the Laboratory Safety Unit or the Hazardous Waste Group for information/assistance.

Examples of wastes generated from labs include recyclable papers, glassware, plastic-ware, biohazardous waste, radioactive waste, and chemical (hazardous) wastes. Many locations at the University participate in a recycling program for papers and glass products. Lab employees are encouraged to participate in this program. For those labs that generate biohazardous waste, including infectious wastes and sharps, these materials must be disposed of as specified in the University's Bloodborne Pathogens Plan. For those generating radioactive waste, these wastes are disposed of through Radiation Safety. For chemical wastes, the term "hazardous waste" will be used hereafter.

Minimize the generation of hazardous wastes. Before purchasing chemicals, limit the quantities ordered to what is needed for 1 year duration. Upon receiving a chemical, enter the chemical into Chematix, and store the chemical as recommended in the appendices of this document. Rotate chemicals by placing older chemicals in front of newer chemicals containers to ensure the older chemicals are used first.

B. Materials Available from Hazardous Waste Unit

"The Learners Guideline for Responsible Hazardous Chemical Waste Management," from Environmental Compliance (Hazardous Waste Group), specifies all steps that are to be followed in the disposal of hazardous wastes. The content of the "Learners Guide" specifies how waste will be collected, segregated, stored, and transported. The booklet provides guidance on waste determination, disposal, hazardous waste tags, scheduling waste pickups, waste minimization, availability of free (recycled) chemicals, and a review of waste disposal requirements. For additional information, call x5-2056 or visit their web site at http://www.safety.rochester.edu/homepages/envcompliancehome.html .

C. Discarding Chemical Stocks

Any laboratory having unlabeled chemicals or solutions is responsible for the identification of the contents before disposal by the Hazardous Waste Group. Before an individual's employment in the laboratory ends, chemicals for which that person was responsible for must be properly disposed, reassigned to another individual, or recycled as listed in Section VIII.B. The department is ultimately responsible for the removal of all chemical materials from the lab upon termination of lab activities. For additional information, see:

http://www.safety.rochester.edu/labsafety/labdecommission/pdf/LabDecommission.pdf .

D. **Frequency of Disposal**

Hazardous waste is routinely removed from labs throughout the University by the Hazardous Waste Group. A pick up can be arranged electronically through Chematix or call x5-2056.

Laboratory personnel must comply with the U.S. Environmental Protection Agency (USEPA) and the New York State Department of Environmental Conservation (NYSDEC) regulations while accumulating hazardous waste. These include:

1. Hazardous waste is defined by the USEPA as those chemicals that are listed wastes or have the characteristics of ignitability, toxicity, corrosivity, or reactivity.

2. Federal and state regulations prohibit the disposal of hazardous waste into the sewer or in the trash.

3. Waste collection containers must be marked with the words "Hazardous Waste" and other words that identify the contents of the containers. The concentration/volume of the waste must also be listed on the container. A sample label is available through the Laboratory Safety Unit or the Hazardous Waste Unit.

4. Hazardous waste containers are to be placed in a designated and labeled “Hazardous Waste Satellite Accumulation Area”. These areas must be selected to permit the proper containment of the waste and must be located in the same room where the waste is generated. Storage of hazardous waste on the floor, even with the use of secondary containment, is not permitted. Should the waste storage location be within a chemical fume hood, sufficient space must be maintained in the hood to prevent compromising its effectiveness and allow work space for handling higher hazard chemicals. Guidance for waste storage locations is available from the Hazardous Waste Group.

5. Waste containers must be closed when waste is not actively being added. The outside of the waste containers must be clean and the container must be compatible for the waste being collected.

6. Waste collection containers should be placed in a secondary containment tray that can hold the contents of the largest container. More than one secondary containment container/tray may be necessary to accommodate wastes of different hazard classes.

7. Prior to removing a hazardous waste container from a laboratory, a “Hazardous Waste Tag” must be completed and attached to the bottle. This tag permits the tracking of the waste that was generated. The tags are available from the Hazardous Waste Unit. Starting in 2015, “electronic” waste tags, available through Chematix, may be used in your location in place of the paper tags. For either system, the tags must be affixed to the bottle prior to removal from the lab.

IX. LABORATORY DECOMMISSIONING

A. Intention

1. Laboratory decommissioning involves the formal deactivation of a laboratory, assuring the safety of the space for further cleaning, renovation, or occupancy. The Laboratory Safety Unit checks laboratory locations, and lab support locations, where chemicals, biological materials, radioactive materials, non-fixed equipment, supplies, and physical hazards are present or used.

2. Prior to vacating laboratories, the PI/supervisor must complete all the activities listed in the Laboratory Decommissioning Program (http://www.safety.rochester.edu/ih/labdecommission/labdecommission.html). A partial list of the requirements includes:
   a. The removal and disposal, as appropriate, of all chemicals, radioactive and biological materials;
   b. The removal of all non-fixed laboratory equipment and supplies;
   c. The removal of all unwanted and waste materials; and,
   d. The cleaning/disinfecting of counter tops and other visibly contaminated surfaces in the lab.

B. Responsibilities

1. For research locations, the Principal Investigator must make the necessary notifications as listed in the University of Rochester's Laboratory Decommissioning Program. In the event the PI fails to make the notification, the departmental administrator is responsible for the notification.

2. For clinical lab locations, an administrator can make the necessary notifications.

3. Should a lab be vacated and the necessary notifications or the removal of equipment or hazardous materials has not been accomplished, the department is responsible for the cost involved for the needed decommissioning activities.

4. Decommissioning of jointly used spaces, such as cold rooms, are the responsibility of the previous users and their department.

C. References

See http://www.safety.rochester.edu/ih/labdecommission/pdf/LabDecommission.pdf for the comprehensive list of the actions that need to be taken for lab decommissioning.

X. SIGNS AND LABELS

A. **Signs:** Signs of the following types shall be displayed in laboratory and laboratory support locations:

1. Location signs identifying safety showers, eyewash stations, other safety equipment, first aid equipment, and emergency exits.

2. Warnings in areas or on equipment where special or unusual hazards exist.

3. Cabinets where flammable liquids are stored must be labeled "FLAMMABLE LIQUID STORAGE" or "FLAMMABLE STORAGE".

4. A "Hazardous Waste Satellite Accumulation Area" label/sign must be posted where hazardous waste is stored within the laboratory.

5. The doors to those laboratories storing/using chemicals will utilize a door labeling system generated by the Laboratory Safety Unit and posted near the entry door(s) of the labs by the PI/supervisor. The sign will identify the name of the Department and the PI, the principal hazard classes of chemicals, precautions for the fire department and Facilities personnel, the type of lab, and contact information for the lab. This sign will be updated annually. Those locations that have a comparable signage program, such as LLE, will not be required to comply with EH&S's signage program.

6. Those locations where potential over-exposures to formaldehyde may occur will require signage as listed in the "UofR Chemical Safety Manual for Laboratory Carcinogens and Reproductive Agents".

7. Locations where Nanomaterials are manufactured will require appropriate signage. The University's Chemical Hygiene Officer will determine the signage required and include this information on the lab door signage.

8. Appendix 10 of this document lists important phone numbers and other information. Emergency phone numbers for Public Safety (x13), medical assistance for SOEM and UHS (x5-1164), and the Poison Center (1-800-222-1222) should be posted near all phones. Another method of compliance is the posting of the UofR Emergency 13 Flip Chart in a prominent location.

9. There are other hazardous materials/agents present in labs using chemicals that require special signage. For example:
   a. Laboratories using radiological isotopes or radiation generating devices must have the appropriate signage, as required by the Radiation Safety Officer.
   b. Laboratories having biological hazards or biohazards must have the appropriate biohazard signage, as required by the Biosafety Officer.

c. Those laboratories having Class 3R, 3B or 4 lasers will have the appropriate laser signage, as required by the Research Laser Safety Officer.
d. Those laboratories that have strong magnetic fields will have the appropriate signage.

B. **Chemical Labels**

All chemicals and solutions must have identity labels showing the contents of the containers and the associated hazards.

1. Never remove or deface labels on any chemical container. Should labels become difficult to read, the labels must be replaced. The labels must be written in English.

2. For those locations that wish to use abbreviations on chemical labels, the abbreviations listed in Appendix 9 of this document can be used. Personnel may use these abbreviations provided a printed copy of the appendix is prominently posted in the lab or the listing is placed in the SOP manual of the lab. For such solutions, the name of the solution, the concentration and the date are to be placed on the container.

3. For research labs, the synthesis of new compounds presents a challenge because the compound's structure and hazards may be unknown. Labeling of containers of these synthesized chemicals can be achieved by unique identifiers listed in the researcher's notebook.

XI. RECORDS

A. Injuries, chemical exposures and near misses will be recorded using the University's electronic Employee Incident Report form http://www.safety.rochester.edu/SMH115.html . A copy of the submitted form/information is to be retained by the PI/Supervisor and the employee.

B. Attendance sheets for those attending a live session of the Laboratory Safety Training must be submitted to the Laboratory Safety Unit for entry into the HRMS System. Those successfully participating in lab safety training through Blackboard or Cornerstone will be recorded directly into the HRMS system. Department administrators have access to the HRMS System and can assist their department in verifying training compliance.

C. Chemical inventories will be maintained as specified in Section II.A.7. Usage for high-risk substances is to be retained by the PI as specified in Section XVII.C.6.

D. Medical records are retained per University protocol.

E. Chemical monitoring records are maintained by the Laboratory Safety Unit and retained as required by the applicable regulation. A copy of the chemical monitoring completed for lab personnel is to be retained by the PI/supervisor.

F. Site-specific training records are to be retained by the PI.

XII. SAFETY DATA SHEETS

Safety Data Sheets (SDS) are provided by manufacturers/suppliers for hazardous chemicals. SDS must be readily available for all chemicals used in the laboratory and needs to provide the employees at their request.

To obtain a SDS for a chemical, EH&S recommends personnel utilize the EH&S web site http://www.safety.rochester.edu/msdsintro.html . Copies of SDS for any chemical are available by calling EH&S (275-3241) or by written request. LLE has made SDSs available for their staff at http://safety.lle.rochester.edu/530_chemical/msds.php .

Because Safety Data Sheets are frequently updated, personnel can obtain the most recent edition of the SDS by using the web and accessing the chemical manufacturer/supplier. In the event of an emergency (spill or exposure) during normal business hours, EH&S can be contacted by calling 275-3241 to obtain a chemical's SDS. After hours EH&S can be contacted through Public Safety at x13.

Starting in 2015, the Laboratory Safety Unit will begin collecting SDS information in Chematix. This information will be available at https://www.rochester.chematix.com/Chematix/ .

It is strongly recommended that all labs have hard (paper) copies of the higher hazard (acutely toxic, mutagenic, teratogenic, carcinogenic, reproductive hazards) chemicals in their labs. In case of an incident or spill, the SDS is readily available and can be provided to the responders (Spill Team, Fire Department, Emergency Department, UHS or SOEM.

XIII. EMERGENCY MANAGEMENT FOR MC/RC LABORATORIES

Personnel must be prepared to respond in the event of a fire, spill, or other situation requiring emergency action or evacuation. Emergency management is utilized to provide the proper organization for the University to mitigate any incident utilizing the appropriate emergency responses and resources. Special "Emergency 13" Flip Charts have been prepared and distributed to personnel to better manage emergency actions. These "flip charts" are to be posted in each laboratory. Additional copies are available through EH&S. Red and white flipcharts are available for Medical Center locations while blue and white flipcharts are available for River Campus locations.

A. Emergency Management Process

For all emergencies call Public Safety (x13). Effective emergency management includes Mitigation, Preparedness, Response, and Recovery. Depending upon the location of the emergency, the appropriate University Emergency Response Plan will be utilized. These plans are available at http://www.safety.rochester.edu/homepages/ep_homepage.html .

1. **Mitigation:** Designed to alleviate the effects of an incident or reduce the probability of the incident occurring. Examples include compliance with building codes and regulations or substituting to a less hazardous product.

2. **Preparedness:** Preparedness and prevention activities are designed to prevent injuries and minimize damage. Examples include inspections/audits of locations to identify potential issues that include minimizing the quantity of hazardous materials in laboratory areas, placing materials in storage after use, and establishing appropriate emergency shutdown procedures.

3. **Response:** These activities are designed to provide emergency assistance to personnel and reduce the likelihood of secondary damage. Should an emergency occur, lab staff should know and be prepared for emergency shut-down procedures for emergency evacuation.

4. **Recovery**: Recovery is a short-term activity to return the area to normal or improved condition. Recovery planning should include a review of procedures to avoid future emergencies.

B. Fires

How you react to a fire can determine whether the incident remains controlled or escalates into an out of control situation. Learn emergency procedures appropriate to your work area. Also know whether you work in a **FIGHT** or **FLIGHT** building. **FIGHT** buildings/areas are described as those where evacuation is not feasible or where, without immediate intervention, a fire could expand rapidly. University designated fight buildings/areas are: Strong Memorial Hospital, the Medical School, Hutchison Hall, and LLE. For these locations, the building fire

alarm systems must be activated prior to attempting to fight a small fire. All others buildings are **FLIGHT** buildings where the most appropriate action in a fire situation is to activate the building fire alarm and evacuate immediately. Regardless of the location, those who do not have the necessary training or confidence in fighting a fire should evacuate. OSHA 29 CFR1910.157 states that only those who receive annual training on the use of a fire extinguisher should attempt to extinguish a fire. Those who do not receive this training at the University or through a fire department should evacuate.

Before deciding to fight a fire, follow the acronym **RACE**:

Rescue anyone in immediate danger and remove the person to a safe area.

Activate the building fire alarm. Then call Public Safety (x13) from a safe location to report the fire.

Confine the fire by closing all doors, beginning with the door to the room of origin.

Evacuate if the fire has spread beyond the point of origin, if the fire could block your exit, or if you are not sure how to use an extinguisher. **E**xtinguish the fire if you have activated the fire alarm and have received training on the use of a fire extinguisher, closed the doors, if the fire is small and contained, and you have a clear exit from the fire.

C. **Spills**

1. The following **preplanning** is required for working with highly toxic chemicals:
   a. Determine the potential location of releases.
   b. Determine the quantities of material that might be released.
   c. Know the chemical and hazards of the material (physical state, vapor pressure, air or water reactivity, toxicity, reactivity, corrosivity, flammability).
   d. Have appropriate spill kits for the hazardous materials used in the location.
   e. Have available the personal protective equipment that may be needed.

2. Chemical spills are to be cleaned up immediately. Some spills can create conditions that can lead to additional hazards.

3. Spills can be classified as either a minor clean-up procedure or a major spill. **Minor spill, also called "Low Risk Spills",** do not expose laboratory employees to over-exposures but should be cleaned up immediately by the laboratory staff wearing the appropriate PPE. **A listing of chemicals falling under the category of "Low Risk Spills" can be found in Appendix 11 of this document.** In the event of a minor spill or "Low Risk Spill", the following **general procedures** are to be followed:
   a. Survey the situation for the potential hazards present before approaching a spill area. If possible, attend to anyone who may have been contaminated.
   b. Notify persons in the immediate area about the spill.

c. Evacuate non-essential personnel from the spill area.
d. Close the door.
e. Untrained laboratory personnel are not to clean up spills.
f. If the spill material is flammable, turn off ignition and heat sources.
g. Use the appropriate spill kit to absorb or neutralize the spilled material.
h. Avoid breathing vapors of the spilled material.
i. Leave the local exhaust ventilation (fume hoods, etc.) on.
j. Collect the mixture of the absorbent and the chemical and place it into a sealable waste container for disposal through the Hazardous Waste Unit.
k. Additional information on "Low Risk Spills" can be found in Appendix 11 of this document.

4. Many hazardous substances necessitate special clean-up procedures to minimize hazards to clean-up personnel. **Major spill** clean-up should **not** be attempted by laboratory personnel. If personnel are present at the time of the major spill and a spill kit is readily available, the contents of the spill kit can be emptied onto the spill to assist in stabilizing the spill until the Spill Response Team arrives. **Contact Public Safety (x13) to activate the University's Spill Team.**

D. **Exposures**

Avoid unnecessary exposure to chemicals by any route. Develop and encourage safe work habits. Do not smell or taste chemicals. Should an exposure occur, personnel should consult Section V, Medical Consultations and Examinations, for additional details.

The hazards of chemicals differ. Consult the SDS on individual chemical hazards/toxicity. Personnel should avoid exposures to any chemical. For exposures, the following actions are recommended:

1. **Inhalation:** Remove the affected person to fresh air. If breathing becomes difficult, seek medical attention.

2. **Eye Contact:** Promptly flush eyes with room temperature water at an eyewash station for a prolonged period (15 minutes), and seek medical attention.

3. **Skin Contact:** Promptly remove any contaminated clothing and flush the affected area with water at a sink, an eyewash station, or safety shower for a minimum of 15 minutes. If symptoms persist after washing, notify the supervisor/PI or the Laboratory Safety Officer and seek medical attention. The use of chemical neutralizers or absorbers directly on the skin is **NOT** recommended.

4. **Ingestion:** Call the Poison & Drug Information Center at 1-800-222-1222 for immediate first aid procedures to follow.

5. **Fill out an Incident Report:** All chemical exposures shall be documented by completing an employee incident report (SMH-115 form). The form is available electronically at http://www.safety.rochester.edu/SMH115.html . A copy of the completed incident report should be retained by the PI/supervisor and the employee.

XIV. LABORATORY INSPECTION PROGRAM

As noted in Section II RESPONSIBILITIES, the Principal Investigator / Supervisor and their Laboratory Safety Officer (LSO) or Laboratory Managers direct the activities in laboratories and have a principle role in maintaining safe lab operations. In 2014, the Laboratory Safety Unit implemented an integrated laboratory inspection program, combining chemical and biological issues, to maintain a high level of safety in laboratory spaces.

A. Purpose and Scope

In the past, inspectors from the IBC and Occupational Safety completed separate laboratory inspections. Starting January 1, 2015, a single inspector has been assigned from the Laboratory Safety Unit to complete a single comprehensive inspection for your laboratory and to act as a liaison between EH&S and your laboratory. This lessens the time spent by lab members escorting the inspectors and lessens the confusion as to which inspection is being done. This new format will also establish a single point of contact for each lab group with EH&S.

Both research and clinical laboratory personnel should view these inspections as an opportunity to raise awareness in health and safety issues in their laboratories, implement safe work practices in their laboratories, to better understand regulatory obligations, and to minimize workplace hazards. They should never be viewed as a means of disciplining or penalizing laboratories.

B. Implementation and Frequency

The inspector assigned to a department will normally inspect all labs and lab support locations in that department. The inspector will audit the facility, as well as review the hazards materials (e.g., biological agents, chemicals/drugs), protocols (Standard Operating Procedures), training, fire safety, electrical safety, emergency management, waste disposal, and any physical hazards (e.g., UV lights, noise, temperature) that might be present.

Both clinical and research laboratory locations will be inspected annually. Based on the risk assessment for the locations and any requirements by the oversight committees or federal mandates, the intensity of the inspection will be adjusted accordingly.

The Laboratory Safety Unit staff member (the inspector) assigned will contact the PI/supervisor, LSO/manager, and or administrator by email or phone, provide the check list that will be used for the inspection, schedule the inspection (providing the date and approximate time of the survey). Laboratory personnel can use the check list any time to review recommended safe work practices and to correct any issue found prior to the inspection. Starting in 2015, the forms used for the inspections will be available through Chematix.

C. Inspections and Reports

Either the PI/supervisor or the LSO/manager should be present for the inspection to show/provide documentation of training and Standard Operating Procedures (SOPs) to the inspector.

Any problem will be reported by email to the PI/supervisor as well as the LSO/manager for corrective actions. During the inspection, the laboratory staff is encouraged to correct any minor issues immediately. The electronic inspection report will note any corrective actions were already completed and will list a deadline for correcting problems. Either the PI/supervisor or the LSO/lab manager is to send an electronic response to the inspector to document the actions taken to correct the identified problems. For maintenance or Facility issues, a work order number will suffice.

D. Escalation of Problems

The expectation of the lab inspection program is to maintain a high level of safety in University laboratories. Non-correction of identified problems could place those in the lab at risk of exposure or injury.

Those problems which are not corrected as well as those problems that recur will be reported to the PI/supervisor, the LSO/Lab Manager, as well as the department chair/unit head. A repeat unannounced inspection may take place approximately 30 days after the inspection report is issued. Any remaining issues noted during this repeat inspection will then be reported electronically to the PI/supervisor, LSO/Lab Manager, the Department Chair/Unit Head, as well as the applicable Dean for action. The intention is a clear time-line with expectations and consequences should the problems not be met.

XV. GENERAL VENTILATION

OSHA requires the use of engineering controls to prevent exposures to laboratory employees. Although Section XVI provides information on local exhaust ventilation systems that can be used for hazardous chemicals, general ventilation is also required for locations where chemicals are stored and used. The following lists the required general ventilation needed in laboratory locations.

A. Regulations on Ventilation Rates

Ventilation rates for laboratories at the University are required to comply with the Mechanical Code of New York State (Section 401), NFPA-45, and OSHA 29CFR1910.1450. Unfortunately, the ventilation rates varies significantly and does not take into account that labs with higher ceilings require additional air volumes to achieve the same air changes per hour or obstructions and other factors reduce the effective ventilation rates. Labs for the 21st Century provides good practice strategies to assist in optimizing laboratory ventilation. As stated in their publication, the concept "more is better" – that increased ventilation rates will provide an increase in safety, worker comfort, and research productivity – is NOT the case. The best practices utilize local exhaust systems and optimizing the general ventilation.

The table below lists references for laboratory ventilation rates:

Standard	Air Changes Per hour (ACH)	Comments
OSHA Lab Standard 29CFR1910.1450	4-12	OSHA's range is broad and normally adequate if local exhaust systems such (fume hoods) are used as the primary method of control.
Mechanical Code of N. Y. State	------	Table 403.3 specifies 20 CFM per person, based on the square footage of the area being ventilated.
NFPA-45-2004	Occupied "typically" greater than 8 ACH. Minimum 4 ACH unoccupied.	Specifies supply diffusers have low exit velocities and be located as far as possible from fume hoods.
ASHRAE Lab Guide	4-12	This guide includes considerations for supply air changes, exhaust air changes, minimum outdoor air changes, and recirculation considerations.
Guidelines for Design and Construction of Health Care Facilities*	4-12 (depending upon type of lab).	Table 7-1 specifies labs be negative to adjacent areas, a supply of at least 2 ACH of fresh outside air, and all air exhausted directly outdoors (no recirculation of air).
ACGIH – Industrial Ventilation	Depends on generation rate & toxicity of contaminant, not room size.	Chapter 7: Does not use air change rates because ceiling heights, location of air supply outlets, and exhausts effect the effective air change rate.

Some table information adapted from "Labs for the 21st Century"
*This publication lists the "requirements" for clinical lab locations.

As listed in the above table, ASHRAE's Guide discusses the use of reduced air flows for unoccupied periods. The airflow rate for unoccupied laboratories, in conjunction with NFPA, lists a minimum of 4 ACH, regardless of the type of laboratory and does not take into account state of the art ventilation controls. Occupancy sensors, that nearly instantaneously returns the supply/exhaust ventilation to normally occupied periods, are required for locations that have reduced airflow rates for unoccupied periods. Labs that are not in use, such as student labs and some laboratory support locations, may be set lower.

B. Strategies to Optimize Lab Ventilation

Determining the ventilation rate for a particular lab is not an exact science. The best and most effective strategy to minimize potential exposure to chemicals starts with source control, using both containment and minimization. Several factors help determine the minimum ventilation rate for a lab. These factors include:

- The types of air diffusers in a lab and the lab layout;
- The heat load in the lab;
- The particular process and chemicals used in a lab;
- The local exhaust systems present in the lab; and,
- User issues, such as the establishment and use of Standard Operating Procedures (SOPs) in the lab.

Attempts have been made to institute Control Banding in many laboratories. Control Banding groups substances used in an activity or a location and establishes a strategy to control possible risks. Control Banding can be used in a lab provided the procedures and chemical hazard classes do not vary significantly during the year and only low hazard chemicals are utilized on lab benches. Periodic review of the processes and chemicals is required to ensure the strategy is sufficient to control the risks present.

C. Chemical Safety Levels

The use of biological materials prompted the NIH and CDC to implement biological safety levels. The American Chemical Society's "Identifying and Evaluating Hazards in Research Laboratories, 2013", in Table 8-1, established a similar process called Chemical Safety Levels to identify locations where higher hazard levels can be found. Slight modifications were made to their table to accommodate the research laboratories that can be found at the UofR (listed as Chemical Safety Levels). An operational and certified chemical fume hood or other approved local exhaust ventilation is needed for the use of hazardous chemicals.

The modified table which follows utilizes a Control Banding strategy to identify hazards in lab locations and then assigns a Chemical Safety Level to that lab. As stated previously, the lab staff for a location must use hazardous chemicals in a chemical fume hood or utilize other approved local exhaust systems. The lab staff must follow their Standard Operating Procedures (SOPs). The Chemical Safety Levels range from 1 to 4, where the higher the number, the greater the potential risk. The use of this table will better standardize ventilation rates and reduce the confusion as to what constitutes an effective ventilation rate for a laboratory.

Table for Control Banding for Chemical Safety Levels (CSL)

Description Of Control	CSL1	CSL2	CSL3	CSL4
Hazard Level	**Nearly no hazards present**. Hazards equivalent to typical "household" locations.	**Low level lab hazards** Teaching lab settings (minimal hazardous chemicals. Well-established procedures in place).	**Moderate (variable) laboratory hazards.** Typical labs at University where moderate quantities of chemicals are used.	**High hazard chemical labs or processes** Severe physical or health hazards to personnel
Chemicals Used or Stored	Consumer product Low hazard chemicals in use Low hazard gases in use (up to 2 cylinders like nitrogen and carbon dioxide)	Low conc. of acids or bases Some alcohols or solvents present (less than 6 gal.) Solid salts and solutions Less than 4 gas cylinders (carbon dioxide, nitrogen, argon) Open flames used	Some flammable solvents (more than 6 gallons) Some corrosives (conc. acids and bases) Some toxics used More than 4 compressed gas cylinders One tank (160 liters) cryogenics Open flames Lab free of air/water reactive and pyrophoric chemicals	More than 6 gallons of flammable solvents outside of flammable storage cabinet Air/water reactive chemicals Frequent use of oxidizers and corrosives HF used on lab bench Use of catalysts (air reactive) Multiple tanks (160 liters) of cryogenics Frequent use of toxic and carcinogen materials Open flames Frequent use of oxidizers Use of chemicals considered pyrophoric or explosive
Typical Lab Locations	Most student labs Many storage rooms (not flammable storage rooms) Dish washing rooms and autoclave rooms Some instrumental labs (balance rooms, microscope labs, etc.) Fly labs Corridors Some procedure rooms "Dry" photo and x-ray rooms	Higher hazard student labs Instrumental labs (using hazardous materials) Some graduate student labs (not Chemistry Dept. labs) "Wet" Photo and x-ray development labs Instrumental labs with piped or gas cylinders (no cryogenic gases) Tissue culture labs Specimen storage (in formalin, no cryogenic gases) Large chemical storage rooms Most laser labs.	A majority of research labs (not necessarily Chemistry Dept.) Microbiological laboratories Most clinical labs Many specimen storage locations Chemical storage rooms (little to no flammable liquids present) Labs using nanomaterials Animal procedure rooms	A majority of Dept. of Chemistry Labs Flammable storage rooms Many specimen storage rooms (3 or more 160 liter cryogenic tanks) Gas storage rooms (manifold system present) Linear equipment rooms Labs manufacturing nanomaterials Special cadaver use labs Animal surgery room (gas anesthesia)
ACH occupied	Minimum 6 ACH	Minimum 8 ACH	Minimum 10 ACH	Minimum 12 ACH
ACH non-occupied	Minimum 2 ACH	Minimum 4 ACH	Minimum 6 ACH	Minimum 6 ACH

Adapted from the American Chemical Society's "Identifying and Evaluating Hazards in Research Laboratories, 2013", Table 8-1

XVI. LOCAL EXHAUST SYSTEMS

OSHA requires the use of engineering controls to prevent exposures to laboratory employees. Many chemicals should be used only with the appropriate local exhaust system (fume hoods, slot hoods, canopy hoods, glove boxes, etc.) to prevent inhalation exposures. By far, laboratory staff using a chemical fume hood as it is intended is the most important component of engineering control.

A. Fume Hoods

1. University Fume Hood Standard (new fume hoods)
   a. New chemical fume hoods must undergo acceptance testing by the Laboratory Safety Unit. Acceptance testing shall be conducted in accordance to the most recent edition of the University of Rochester Design Standards, Division 15, Standard 860, and EH&S Construction Guidance Document. Should a chemical fume hood be found not to conform to University standards, a report will be made to Campus Planning, Design, & Construction Management to have corrective actions taken.
   b. Once the new chemical fume hood is found to meet acceptable face velocity, a sticker is placed on the hood indicating the acceptable sash height for use, the date of the testing, the initials of the inspector, and an expiration date, one year from the acceptance test.
   c. All new chemical fume hoods must have an electrical flow indicator to warn personnel when the hood is not functioning properly.

2. Existing Chemical Fume Hoods
   a. Many University chemical fume hoods installed before 1990 do not have an alarm to confirm adequate hood performance for use. When a lab changes occupancy or a renovation occurs in a lab (other than a paint and patch), a local fume hood alarm system must be installed. Contact the Laboratory Safety Unit for acceptable alarm systems.
   b. The face velocities of chemical fume hoods at the University are checked by the Laboratory Safety Unit, except for those fume hoods located in Hutchison Hall, which are checked by River Campus Facilities.

B. Fume Hood Face Velocity Measurements

1. Standard chemical fume hood face velocity shall be 100 ± 20 linear feet per minute (fpm) with the fume hood sash approximately 2/3 open (18-19.5" opening). For those fume hoods with horizontally sliding sashes, the Laboratory Safety Unit will determine the appropriate sash position to afford the 100 ± 20 fpm value.

2. Low-flow or high-efficiency chemical fume hoods shall be 80 ± 10 linear feet per minute (fpm) with the fume hood sash approximately 2/3 open (18-19.5" opening) to comply with NIH requirements. For those low-flow or high-efficiency fume hoods with horizontally sliding sashes, the Laboratory Safety Unit will determine the appropriate sash position to

afford the 80 ± 10 fpm value.

3. Green Technologies ductless chemical fume hoods shall be 60 ± 10 linear feet per minute (fpm) with the fume hood sash approximately 2/3 open (18-19.5" opening). This very low air flow was found acceptable because the filters were found to remove the low hazard chemical vapors from the airstream very effectively (see XVI.K for details). **These hoods are limited to the use of chemicals that are effectively removed from the air.**

4. A sticker will be placed on the chemical fume hood indicating the acceptable sash height for use, the date of the testing, the initials of the inspector, and an expiration date. If the chemical fume hood is found not to have an acceptable face velocity, the problem will be reported to Facilities for corrective action.

5. Any existing chemical fume hood that does not have a mechanical or electrical flow indicator will have a piece of surveyor's tape, or equivalent, attached to the sash to indicate proper air movement into the hood. When the chemical fume hood is operational, the tape should be drawn into the fume hood. Hoods with operational mechanical or electrical flow indicator devices do not require the use of surveyor's tape.

6. The face velocities of all chemical fume hoods are to be measured annually except for those hoods in labs that are not occupied. Hoods in these locations will be posted with a sign stating "FUME HOOD NOT OPERATIONAL – DO NOT USE". These hoods will be reevaluated when the Laboratory Safety Unit is notified that the space will again be used.

C. Chemical Fume Hoods Not Meeting University Standards

1. If a chemical fume hood is found NOT to be functioning properly, lab personnel must notify Facilities immediately by calling x3-4567. A note must be placed on the fume hood stating "HOOD BROKEN, FACILIITE HAS BEEN CALLED" as a reminder to lab staff of the problem.

2. Upon notification that the chemical fume hood has been repaired, Facilities is to notify the Laboratory Safety Unit so the face velocity of the chemical fume hood can be checked. If the chemical fume hood still does NOT work or conform to University standards, Facilities will be notified immediately. Those chemical fume hoods that do not pass will have a sign posted on the sash stating, **"DO NOT USE FUME HOOD"**.

3. Those chemical fume hoods not meeting University Standards can be used for storage of materials. These hoods must have a sign posted on the sash stating **"FUME HOOD FOR STORAGE ONLY"**.

D. Expectation of Fume Hood Users

1. Check the airflow alarm before and during use. These alarms can normally be found on the right side of the chemical fume hood. The face velocity of these alarms can vary during use

(especially on windy days) but should be close to the value as listed in XVI.B above. Those hoods installed before 1990 may not have an electronic airflow alarm need to observe the piece of surveyor's tape, or equivalent, attached to the sash to indicate proper air movement into the hood.

2. Do not work in a malfunctioning hood. If your hood does not appear to be working properly, call Facilities at x3-4567.

3. Check the inspection sticker on the hood to verify it has been inspected within the last 12 months. If it is over 12 months, call the Laboratory Safety Unit at x5-3241.

4. Use the chemical fume hood properly by:
   a. Always work at least 6" inside the chemical fume hood to ensure chemicals and vapors are not released into the lab.
   b. Do not use fume hood with the sash higher than the approved working height.
   c. Always keep items stored in a chemical fume hood to a minimum. The greater the number and size of the items, the higher the probability of the creation of a disruptive air flow that could generate chemicals and vapors into the lab.
   d. If large items must be used inside of a chemical fume hood (for example, a drying oven), place 2" blocks under the equipment to allow air to readily flow through the hood.
   e. Never place your head inside a chemical fume hood. Such action could result in chemical exposures.
   f. Chemical fume hoods are for the use of chemicals. Use a biological safety cabinet for the control of biological hazards.
   g. Do not modify your chemical fume hood. The installation of shelves on the side or back walls of the unit can compromise the air flow within the hood resulting in chemical exposures.
   h. All electrical appliances need to be plugged into outlets outside of a chemical fume hood. Never place a power strip within a chemical fume hood to permit plugging in appliances.
   i. Even though some protection may be afforded by the sash, eye protection is still required.

E. Slot Hoods

1. Photographic development processes lend themselves to the use of slot hoods. Such an application permits the removal of vapors from the solutions to help prevent inhalation exposures to those in the room. Although there are no recognized standards for these slot hoods, personnel are advised to contact the Laboratory Safety Unit should they believe the slot hoods are not working as designed.

2. Slot hoods can also be used for those applications where the directional air flow is away from the employee and towards the exhaust system to assist in the removal of vapors from

laboratory processes and minimize potential exposures. Such applications can include cell staining trays and special grossing stations used in Pathology.

F. Canopy Hoods

1. Canopy hoods are often placed above laboratory equipment that can release odorous or potentially hazardous agents. Such equipment includes autoclaves, automated staining units, and atomic absorption devices. Although there are no recognized standards for canopy hoods, personnel are advised to contact the Laboratory Safety Unit should they believe they are not working as designed.

2. The installation of some canopy hoods may require special alignment and/or practices to ensure that all of the odors or hazardous components are contained and exhausted from the location and out of the building. Contact the Laboratory Safety Unit for assistance should problems be noted for these systems.

G. Glove Boxes

1. Glove boxes provide personnel with special containment devices for the more hazardous chemical agents. Many glove boxes utilize an oxygen-free and moisture-free atmosphere.

2. To prevent the release of odors/vapors from gloves box, the exhaust for these devices can be directed into a fume hood or other local exhaust system. Contact the Laboratory Safety Unit for assistance on the planning/installation of such a system.

H. Class II Biological Safety Cabinets

1. Biological safety cabinets (BSCs) are traditionally used for the control of particulates that may be released while working with biological agents and are designed to provide product, environment, and employee protection. Some labs utilize BSCs for the control of high hazard agents such as beryllium or antineoplastic agents. BSCs use vertical laminar airflow to create a barrier to airborne particles. HEPA filters (High Efficiency Particulate Air), within the biosafety cabinet, filter the air going into the environment or laboratory with an efficiency of 99.97% for a 0.3 micron size particle. HEPA filters do not filter out gases or vapors.

2. There are two major groups of Class II BSCs: the Type A2 and the Type B. Class II Type A BSC vents the filtered air directly into the laboratory while Class II Type B cabinet is ducted like a fume hood and vents the filtered air outside. Since the Type A2 and B1 cabinets recirculate much of the air entering the cabinet, it is important to minimize the quantity of flammable materials such as alcohols that may be used to "disinfect" the cabinet prior to use. Class II **B2** cabinets or fume hoods are required for using larger amounts of hazardous volatile chemicals; both of these devices use negative pressure and single-pass air for employee protection.

3. All BSCs are certified according to the National Sanitation Foundation (NSF) 49 Class II (Laminar Flow) when initially installed. As a general rule, BSCs then must be re-certified at least annually, following service, and following re-location of a cabinet. Servicing of the internal workings of these units is performed only by a NSF certified 3rd party contractors.

4. As a general rule, BSCs must be decontaminated with formaldehyde gas, generated from paraformaldehyde, prior to being moved to another location and prior to service or maintenance that involves opening a contaminated plenum. Such decontamination is performed only by a NSF certified 3rd party contractor.

I. Clean Benches (Blow Out Hoods, Unidirectional Hoods)

A laminar flow "Clean Bench" provides the horizontal or vertical positive pressure flow air environment for product protection only. The horizontal flow clean benches can be used in clinical, pharmaceutical, and laboratory facilities for certain manipulations of clean materials (e.g. pouring agar plates, etc.) but must not be used for biohazard materials, toxic chemicals/drugs, or radioactive materials.

J. Special HEPA/ULPA Cabinets

Some locations that utilize only chemicals (no biologicals) may have ducted HEPA filtered or ULPA cabinets that operate in a similar manner as BSCs (particulate control). They provide product, environment, and employee protection. Contact the Laboratory Safety Unit for requirements for the servicing and installing these devices.

K. Ductless Fume Hoods

1. Many companies/manufacturers distribute ductless fume hoods as a means of protection for lab personnel. Such use requires the laboratory users to match the type of filters to the chemicals to be used and requires the filter be changed at the prescribed frequency. This frequency is related to the quantity of solvent that passes through the filter, the time the filter is in use, and using solvents that offer good warning properties (odor can be detected before a possible over-expLaboratory Safety Unitre can occur. The use of a ductless fume hood with one or more chemicals that pass directly through the filter offers NO protection for lab personnel. The Laboratory Safety Unit will determine which units can be purchased based on acceptable protection for the users. At this time, the Green Fume Hood Technologies ductless fume hoods have a listing of those chemicals that can be used in the units and also provides a list of prohibited chemicals. The unit's sensors will provide adequate warnings to the users should the first filter no longer removes the contaminants.

2. Ductless fume hoods can be used only in those locations and applications as approved by the Laboratory Safety Unit prior to their purchase or use. Such use requires that the date of the last filter change be listed on the hood, the filter changed at the prescribed frequency as

listed by the manufacturer, and the location of use provides good general ventilation.

3. The Laboratory Safety Unit reserves the right to remove ductless fume hoods for those locations where the units were installed inappropriately or used inappropriately.

L. Down-Draft Dissection Stations

These stations are constructed of stainless steel to allow for easy disinfection of surfaces. Each unit has a down draft exhaust ventilation system to help remove air contaminants from the work zone. They are also equipped with a recessed sink, water fixtures, a hand spray hose, electrical duplexes, and a grinder.

The Laboratory Safety Unit will review plans for the installation of any down-draft dissection tables to ensure they are set up with the proper exhaust ventilation, supply ventilation system, and any other special needs.

XVII. GENERAL PROCEDURES FOR WORKING WITH CHEMICALS

The Chemical Hygiene Plan requires laboratory employees to know and follow laboratory rules and procedures. **In addition to the information provided in the preceding sections**, the following should also be followed.

A. General Rules for All Laboratory Work with Chemicals

The following "rules" are considered "good laboratory practices" and are to be used for all laboratory work with chemicals:

1. **Equipment and Glassware**
   a. Handle and store laboratory glassware with care to avoid damage. Discard clean damaged glassware immediately in "glass waste" boxes or other approved container.
   b. Use extra care with Dewar flasks and other evacuated glass apparatus. Check these devices before each use for cracks or damage and discard them if found. As a precaution, these devices should be shielded or wrapped to contain chemicals and fragments should an implosion occur.
   c. Do not use equipment with damaged or frayed electrical cords, wires, or plugs.
   d. Do not use extension cords as permanent wiring. Never couple extension cords together. Never couple power strips together. Never couple an extension cord with a power strip.
   e. Hose clamps are to be placed on all condenser water connections.
   f. For procedures where equipment such as vacuum pumps might become chemically contaminated, a prefilter such as a cold trap (finger), a scrubber, or a filtration system should be used. The exhaust should then be vented into a chemical fume hood. Decontaminate vacuum pumps or other contaminated equipment, including glassware, in a hood before removing them from the designated area.

2. **Choice of Chemicals:** Use only those chemicals for which the quality of the available ventilation system is appropriate.

3. **Eating, Smoking, Etc.**
   a. Eating, drinking, taking medications, smoking, chewing gum, applying cosmetics, or handling contact lenses in areas where laboratory chemicals are present is prohibited. Wash hands and any potentially exposed skin before leaving the lab to conduct these activities.
   b. Food and beverages must not be stored in refrigerators, freezers or cold room used for specimens or chemical storage. Laboratory glassware, utensils, and microwaves are not to be used for the storage, cooking or consumption of food or beverages.
   c. The handling of iPods, MP3 players, cell phones, etc., while wearing gloves is not allowed.

4. **Mouth Suction:** Mouth suction for pipeting or starting a siphon is prohibited.

5. **Personal Apparel:** Severe injuries and death have been reported to have occurred to lab personnel because their hair was caught in moving lab equipment or inappropriate clothing was worn. Although the PI/supervisor is responsible for having his/her personnel wear appropriate apparel, the University requires lab personnel, at a minimum:
   a. to confine or tie long hair and loose clothing;
   b. not wear dangling items (laces,/strings, neckties, jewelry);
   c. utilize break-away lanyards for IDs;
   d. wear only shoes/sneakers that enclose the entire foot, preferably NOT made of a material that would readily absorb liquids;
   e. never wear high-heeled shoes, light weight shoes or slippers that do not provide protection from broken glass or hazardous materials that may be released or may be on the floor;
   f. wear lab coats over street clothes to minimize potential chemical contamination when working with chemicals;
   g. wear a flame retardant lab coat when working frequently with flammable and pyrophoric agents;
   h. wear eye and face protection as determined by the SOP or JHA; and,
   i. wear hearing protection, when required.

6. **Personal Housekeeping:** Keep the work-area clean and uncluttered. Chemicals and equipment should be properly labeled and stored. Clean up the work area on completion of an operation or at the end of each day.

7. **Planning:** Employees are to seek information and advice about hazards, plan appropriate protective procedures, and plan positioning of equipment before beginning any new operation/protocol.

8. **Unattended Operations:** An appropriate sign (including an emergency contact person and phone number) is to be placed on the door for any unattended operation. Provisions for the containment of toxic substances in the event of failure of a utility service (such as cooling water) are to be made for all unattended operations.

9. **Working Alone:** Multiple personnel need not be present when using common low hazard chemicals. However, a minimum of two employees must be present for procedures using chemicals of moderate, chronic, high acute toxicity, or high hazard chemical..

B. **Work with Chemicals of Moderate Chronic or High Acute Toxicity**

Examples of these materials include hydrofluoric acid, diisopropylfluorophosphate, hydrogen cyanide. The following supplemental rules, in addition to those listed in A, are to be followed:

1. **Location:** Use and store these substances only in areas of restricted access with appropriate warning signs. Always use a chemical fume hood or other containment device for

procedures that could result in the generation of aerosols or vapors containing the substance. Trap released vapors to prevent their discharge into the workspace by exhausting them into the hood exhaust.

2. **Personal Protection:** Always avoid skin contact by using gloves and other protective apparel, as established by the JHA or the lab's SOP. Always wash hands and any potentially exposed skin immediately after working with these materials.

3. **Prevention of Spills and Accidents:** Be prepared for accidents and spills. Assure that at least 2 people are present at all times when using a highly toxic chemical or one of unknown toxicity. Containers of these substances are to be stored in chemically resistant trays, capable of holding 110% of the contents of the stored chemicals. Also, work and mount apparatus on trays, or cover work and storage surfaces with removable, absorbent, plastic backed paper. If a major spill occurs outside the hood, evacuate the area and notify Public Safety of the location of the spill, the chemicals, and the quantities involved. If hydrogen fluoride is involved in the spill, immediate first aid measures need to be taken for skin exposures. Consult http://www.safety.rochester.edu/ih/pdf/hydrofluoricemergency.pdf for emergency first aid procedure for HF exposures.

C. **Work with Chemicals of High Chronic Toxicity**

Examples of these materials include acroline, arsine, chlorine, diazomethane, diborane (gas), hydrogen cyanide, hydrogen fluoride, methyl fluorosulfonate, nickel carbonyl, nitrogen dioxide, osmium tetroxide, ozone, phosgene, sodium azide, sodium cyanide, carcinogens, and reproductive agents. Further supplemental rules to be followed, in addition to those listed previously in A & B above, include:

1. **Access:** Conduct all transfers and work with these substances in a "controlled area" - a restricted access hood, glove box, or portion of a lab designated for use of highly toxic substances for which all people with access are aware of the substances being used and necessary precautions.

2. **Non-Contamination/Decontamination:** Protect vacuum pumps against accidental contamination by using cold traps (fingers), scrubbers, or HEPA filters, and vent the exhaust into a fume hood. Decontaminate vacuum pumps or other contaminated equipment, including glassware, in the hood before removing them from the controlled area. The controlled area must be decontaminated before normal work is resumed there.

3. **Exiting:** Upon leaving a controlled area, reusable protective equipment must be decontaminated and any disposable protective apparel discarded in an appropriately labeled waste container. Hands and any potentially exposed skin surface must be washed thoroughly.

4. **Housekeeping:** For dry powders, use a wet mop or a vacuum cleaner equipped with a

HEPA filter.

5. **Medical Surveillance:** If using toxicologically significant quantities of such a substance on a regular basis (e.g., 3 times per week), and where a potential for exposure exists, consult a UHS Occupational Health physician at x5-4955 concerning desirability of regular medical surveillance.

6. **Records:** Users are to keep accurate records of the amounts of these substances stored and used, the dates of use, and the names of users.

7. **Signs and Labels:** Assure that the controlled area is conspicuously marked with warning and restricted access signs and that all containers of these substances are appropriately labeled with identity and warning labels.

8. **Spills:** Assure that contingency plans, equipment, and materials (spill kits) are available to minimize exposure to people and property are available.

9. **Storage:** Store containers of these chemicals only in a ventilated, limited access area in appropriately labeled, unbreakable, chemically resistant, secondary containers.

10. **Glove Boxes:** For a negative pressure glove box, ventilation rate must be at least 2 volume changes/hour and a negative air pressure at least 0.5 inches of water. For a positive pressure glove box, thoroughly check for leaks before each use. In either case, trap the exit gases or filter them through an HEPA filter and then release them into a fume hood.

11. **Waste and Decontamination:** Prepare a plan for the disposal of these materials prior to use. Whenever possible; ensure that containers of contaminated waste (including washings from contaminated flasks) are transferred to the hazardous waste container for disposal through the Hazardous Waste Unit.

D. Animal Work with Chemicals

Lab personnel work with a variety of chemicals while doing animal research. The chemicals could include but are not limited to adjuvants, anesthetic agents, analgesic agents, antibiotics, carcinogens, mutagens, reproductive agents, skin sensitizers, specific target organ toxicants, and teratogens. For each of these chemicals in the listed hazard groupings, appropriate work place practices must be established to work safety. Written safety precautions are provided by the Laboratory Safety Unit for any research chemical/drug administered to an animal to provide a frame work for the safe handling of the chemical agent. For what may be considered low or medium hazard chemical agents, the use of commonly used engineering controls, workplace practices and personal protective equipment will provide adequate protection for the users. For those chemical agents that pose a high chronic toxicity, see XVII.E.

E. **Animal Work with Chemicals of High Chronic Toxicity**

In addition to the precautions outlined in XVII A-D, the following is required:

1 **Administration of the Toxic Substance:** Toxic substances must be administered as specified in the protocol established on the University Committee on Animal Resources (UCAR) and the written review of the Laboratory Safety Unit.

2. **Aerosol Suppression:** Establish procedures that minimize formation and dispersal of contaminated aerosols, including those from food, urine, and feces (e.g., use HEPA filtered vacuum equipment for cleaning; moisten contaminated bedding before removal from the cage, mix diets in closed containers in a hood).

3. **Personal Protection:** When working in the animal room, personnel must wear the personal protective equipment specified on the door to the room.

4. **Waste Disposal:** Soiled bedding is to be removed from the cages at ventilated cage dumping stations. The soiled bedding for many of these agents is disposed of through incineration. Dispose of contaminated animal tissues by incineration.

F. **Site Specific Procedures**

This CHP is to be used for all UofR laboratories. Because of the variety of labs, site-specific procedures (SOP - standard operating procedures) are needed at the laboratory level. Appendix 13 of the CHP provides a template for lab's to create a SOP. Lab specific SOPs must include the circumstances under which a particular laboratory operation, procedure, or activity requires prior approval from the PI/supervisor before being implemented. A lab's collection of SOPs must be placed into the laboratory's manual for easy access by lab personnel.

The PI/supervisor is responsible for the creation and maintenance of the SOPs and for ensuring that lab members are trained and competent – possess the experience, knowledge, skills, and abilities necessary to perform their tasks without injuring themselves or others.

XVIII. COMMON CHEMICAL AND PHYSICAL HAZARDS IN LABS

Many chemicals or processes in laboratories present physical hazards to staff that need to be recognized and controlled. Serious injuries or death have occurred when certain chemical reactions release dangerous by-products (toxic gases) or result in a fire or an explosion. The Laboratory Safety Unit recommends the PI/supervisor train personnel for the safe use of these chemicals. Many of these chemicals should be handled following a written SOP.

A. Common Chemical Reactive Hazards

Aluminum Chloride ($AlCl_3$): Dangerous material if moisture is present. Decomposition can produce hydrogen chloride gas (HCl) and build up pressure in a container. When opening a bottle of aluminum chloride, always cover the top with a heavy towel.

Ammonia: Reacts with iodine to form nitrogen tri-iodide (a contact explosive). Reacts with hypochlorites to produce chlorine. Do not mix with bleach. Ammonia mixed with organic halides can react violently when heated under pressure. Ammonia gas needs to be stored and used in an operational ventilated gas cabinet with the gas line extending into an operational chemical fume hood. Concentrated ammonium hydroxide solutions need to be used in an operational chemical fume hood.

Aqua Regia: This mixture of nitric acid and hydrochloric acid is sometimes used to dissolve nanomaterials, noble metals or as a gas cleaner. This agent should be used only when other agents fail to dissolve the materials of concern or clean the intended glass item(s). Storage of this agent in a closed container can cause the container to rupture/fail. When the nitric acid in Aqua Regia begins to reduce, it evolves toxic nitrogen dioxide gas. Therefore, all uses of Aqua Regia need to be carried out in an operational chemical fume hood.

Benzoyl Peroxide ($C_6H_5CO_2)_2$: Easily ignited and sensitive to shock. Spontaneously decomposes at temperatures above 50C. Hazard can be minimized by the addition of 20% (V/V) water.

Carbon Disulfide (CS_2): Highly toxic and highly flammable. If open to the atmosphere, its vapors can be ignited by heat exceeding 80C (from a hot plate, "hot" light bulb, steam bath, etc.). Handle this agent in an operating chemical fume hood.

Catalysts (Palladium or Platinum with carbon, Platinum oxide, Raney nickel, etc.): When catalysts are used to generate certain catalytic hydrogenation reactions, such catalysts exposed to the air will ignite spontaneously. Keep such catalysts covered with water. When recovering a catalyst, place the material into a water bath immediately after completion of any filtration.

Chlorine (Cl_2): Reacts violently with hydrogen or with hydrocarbons in the presence of sunlight. Chlorine needs to be stored and used in an operational ventilated gas cabinet with

the gas line extending into an operational chemical fume hood.

Diazomethane (CH_2N_2) and Many Diazo Compounds: These agents are very toxic and the pure form of the compounds explode readily. Solutions in ether are "safer". Solutions can be rendered harmless by the drop-wise addition of acetic acid.

Diethylzinc ($(C_2H_5)_2Zn$): Because this agent is such a violent pyrophoric (air-reactive), water-reactive, and light-sensitive, it is normally sold in a mixture of toluene, hexane, or other organic solvent. Do not attempt to concentrate (keep the concentration below 1.1 molar) this agent by allowing the solvent to evaporate. Fires of this agent require the use of a Class D (dry powder) fire extinguisher or the use of soda ash or lime.

Dimethyl Sulfoxide ($(CH_3)_2SO$): Decomposed violently in the presence of halogen compounds. Explosions have been reported when this chemical is mixed with metal halides. Because this chemical readily penetrates the skin, it can carry any other chemical present through the skin as well.

Dinitrophenols ($(NO_2)_2C_6H_3OH$): These compounds are sensitive to friction, shock and light and should never be allowed to dry. 2,4-dinitrophenol reacts with alkalis and ammonia to form explosive salts. Because dinitrophenols are explosive, they are subject to ATF regulations. EH&S must be contacted for the possession of dinitrophenol materials to ensure proper storage and quantity storage. Decomposition of these compounds can produce nitrogen oxides that can cause pulmonary edema and/or genetic changes.

Dry Ice (CO_2, solid carbon dioxide): Dry ice can produce severe skin burns. Dry ice will sublimate at room temperature to carbon dioxide gas. Do not store in walk-in cold rooms because sufficient gas can be generated to cause an oxygen-deficient atmosphere. Do not store in ultra-low freezers because the loss of power can result in the release of sufficient carbon dioxide gas to cause a pressure buildup that could result in a mechanical explosion. For additional information, consult http://www.safety.rochester.edu/ih/dryicehandle.html .

Fulminic Acid (HCNO): Compounds containing the fulminate ion are highly unstable and are friction-sensitive explosive substances. **These compounds are subject to ATF regulations.** The Laboratory Safety Unit must be contacted for the possession of mercury fulminate, silver fulminate, and fulminic acid to ensure proper storage and quantity storage.

Grignard Reagents (R-Mg-X): These alkyl- and aryl- magnesium halides are highly reactive with oxygen and carbonyls compounds. Exposure to moist air can result in spontaneous ignition. Handle Grignard reagents under inert atmospheres (argon or nitrogen) or in solvents such as ethyl ether or tetrahydrofuran.

Halogenated Compounds: Violent explosions can result when halogenated compounds (chloroform, methylene chloride, carbon tetrahydrofuran) are dried with sodium, potassium or other active metals.

Hydrofluoric Acid HF: Hydrofluoric acid exposures can result in severe, deeply penetrating burns to the eyes, lungs and skin. The concentrated form of these compounds can cause a burning sensation. Exposure to dilute solutions may not result in a burn sensation for several hours. This time delay between exposure recognition and treatment can lead to burns that are difficult to treat or other systemic complications. NEVER store hydrofluoric acid or its solutions in glass containers (always use polyethylene containers). Check containers annually and dispose of old container of the acid upon first indication of aging (hairline fractures in the plastic).

Hydrogen Peroxide (H_2O_2): Solutions of 30% or greater of hydrogen peroxide can cause severe skin burns. 30% hydrogen peroxide can decompose violently if mixed or become contaminated with iron, copper, chromium or their metal salts.

Liquid Nitrogen: Approximately one liter of liquid nitrogen will expand to roughly 700 liters. Because of the thermal expansion, good general ventilation is mandatory when handling cryogenic materials to ensure oxygen-deficient atmosphere is not generated. Contact with skin tissue can result in severe burns in a very short period of time. Personnel must wear a face shield and thermal gloves.

Lithium Aluminum Hydride ($LiALH_4$): Do not use this chemical to dry methyl ethers or tetrahydrofurans or a fire may occur. An explosion can occur if mixed with carbon dioxide. Therefore, do not use a carbon dioxide fire extinguisher to put out a lithium aluminum hydride fire. Rather, use sand or a Class D fire extinguisher.

Nitric Acid (NHO_3): Because nitric acid is such a strong oxidizer, do not store nitric acid with organic acids (i.e., acetic acid or formic acid). Nitric acid will react explosively with organic substances (for example, acetic anhydride, acetone, acetonitrile, alcohols, benzene, methylene chloride, etc.). Nitric acid will react violently with bases, reducing agents alkali metals, copper, phosphorous, and ammonia. Nitric acid can react on wood surfaces causing the wood to char.

Nitrocellulose ($(C_6H_7O_{11}N_3)_4$): Dry nitrocellulose (Guncotton, Parlodion, Pyroxylin) is explosive when subject to sudden shock or when heated. This agent needs to be maintained in moistened state.

Nitroglycerin $C_5H_3(NO_{3)3}$: Nitroglycerin in the dry state is a high explosive. Any nitroglycerin that may be present in a lab must be kept moist, usually by the addition of alcohol. **This agent is subject to ATF regulations.** The Laboratory Safety Unit is to be notified for the possession of this agent.

Oxygen: Oil or grease on either fittings or threads of an oxygen tank or a regulator can result in an explosion should the oxygen be turned on from an oxygen tank. Personnel are to inspect the threads of an oxygen tank and the regulator connection before mounting the regulator onto the tank. To minimize potential grease/oils on these surfaces, personnel are to wear disposable gloves. Do not use a soap solution to check for a gas leak from any

connections.

Ozone: Ozone may be generated in a lab when certain ultraviolet sources are used. Such sources should be vented into a local exhaust system (fume hood, slot hood, canopy hood).

Perchlorates: Perchlorates when in contact with metals can result in an explosion hazard. Perchloric acid digestions must be carried out in a special perchlorate hood, equipped with wash down capabilities. Frequent washing of these hoods is needed to minimize the potential build up of perchlorates in the duct. Heated (boiling) 70% perchloric acid in the presence of organic material will readily oxidize the organic material and could lead to an explosion. Do not use perchlorates as a drying agent or concentrate perchloric acid to concentrations greater than 70%.

Permanganates: Permanganates in the presence of sulfuric acid become explosive. Always keep permanganates separate from sulfuric acid in storage and in use.

Peroxides: Explosive mixtures are generated when inorganic peroxides come into contact with or are mixed with combustible materials, barium, sodium, or potassium.

Phosphorus: Explosive mixtures are generated when either red or white phosphorus come into contact with or are mixed with oxidizing agents. Because white (yellow) phosphorus is pyrophoric, it needs to be stored under water. Phosphine, a highly toxic gas, is generated if phosphorus contacts or mixes with aqueous hydroxides.

Phosphorus trichloride PCL_3. Phosphine, a highly toxic gas, can be generated if phosphorus trichloride reacts with water. Eye protection, a face shield and gloves must be worn when opening containers of phosphorus trichloride.

Picric Acid (dinitrophenol) and related compounds (dipicrylamine): These compounds form explosive compounds when they come into contact with or are mixed with combustible materials. These compounds are relatively stable provided they are saturated with water. Should they dry (less than 10% water by weight), they are high explosive and the containers must not be touched/disturbed except by a bomb squad. If these materials are stored in metal containers, highly explosive metal picric salts are generated.

Piranha Solution: Piranha solutions are prepared by mixing sulfuric acid and hydrogen peroxide and when made, can generate heat over 100C. It is used to remove organic material from surfaces. Make only what is needed for immediate use and discard (as hazardous waste) any remaining and the used solution. NEVER STORE UNUSED SOLUTION.

Potassium: Potassium ignites quickly on exposure to humid air. Handle under the surface of mineral oil or kerosene (like sodium). Destroy any scraps of potassium by reacting them with n-butanol. Use a sand or Class D fire extinguisher on alkali fires (do NOT use a CO_2 extinguisher).

Sodium: Sodium reacts violently with water to form hydrogen. The heat that is released can cause ignition. Keep sodium stored under kerosene, toluene, or mineral oil. Destroy any scraps of sodium by reacting them with n-butanol. Use a sand or Class D fire extinguisher on alkali fires (do NOT use a CO_2 extinguisher).

Sodium Azide NaN_3: Sodium azide, even trace quantities, reacts with copper and lead to form explosive copper or lead azide. NEVER drain dispose solutions containing azide compounds. Rather, dispose of these solutions as hazardous waste. Sodium azide is highly toxic. Sodium azide can decompose explosively due to heat, shock, or friction. Sodium azide should never be mixed with nitric or sulfuric acid.

Tertiary Butyl Lithium $(CH_3)_3CLi$: Tert-butyl lithium is the most reactive of commercially available organolithium reagents. It is a pyrophoric chemical – it will spontaneously catch on fire when exposed to air. A dry chemical fire extinguisher is needed in the event of a t-butly lithium fire. A written SOP must be followed for handling this agent.

Trichloroethylene Cl_2CCHCl: Trichloroethylene is toxic. NEVER use this agent as a degreasing solvent. Mixture of trichloroethylene hydroxide (sodium or potassium) can spontaneously ignite in the air.

B. Physical Hazards in Laboratories

Autoclaves: Steam sterilization of materials is a dependable procedure for the destruction of microbial life. The hot, pressurized steam that autoclaves use presents a serious burn hazard to users. These hazards and the precautions for the safe use of an autoclave can be found at **http://www.safety.rochester.edu/ih/autoclaveuse.html .**

Centrifuges: Although centrifuges are typically used for the separation of biological materials, a number of chemicals are used with centrifuges. The use of cesium chloride gradients can present a hazard to the user should the load not be balanced or the rotors are used above the recommended speed for the density of the materials.

Cold Rooms: Because cold rooms do NOT have ventilation, personnel need to limit their use to about 2 hours per day to minimize the buildup of carbon dioxide. Compressed gases and solvents are not to be used in cold rooms. For additional information consult **http://www.safety.rochester.edu/ih/guidelines/coldrooms.html .**

Electrical Hazards: Electrically powered lab equipment pose a significant hazard to personnel. Even currents of 6 milliamps can be painful and ventricular fibrillation can occur at 1000 milliamps. Damaged electric cords/appliance must be taken out of service for repair by an electrician. Check outlets within 6' of a sink to verify outlets are GRI protected.

Glassware: Check all glassware before use for cracks/damage. If damaged, discard immediately into a glass waste container.

Hot Surfaces: Continuously operating hot plates pose a burn hazard to personnel. Post a hazard sign to warn personnel of the hot surface.

Lasers: In addition to the intense coherent, collimated, and monochromatic light lasers generate, lasers can also present eye/skin damage, release particulates into the air, create potential exposures to carcinogens (laser dyes, present intense noise, and can present electrical shock hazards to personnel. For additional information on lasers, consult http://www.safety.rochester.edu/ih/lasers/laser.html .

Liquid Nitrogen Cooled Traps: Should these traps become open to the atmosphere, atmospheric oxygen can condense within the trap resulting in the glass to shatter. If the trap contains organic materials, an explosion could occur.

Magnetic Fields: Intense magnetic fields can present a hazard to personnel with implanted medical devices. Signage will indicate locations that have a static magnetic field of 1.5 Tesla or a spatial gradient field of 1000 Gauss/cm.

Parr Bombs: Handle all bomb calorimeters as high-stress equipment. Such handling includes working with the unit while protected by a bench shield and while wearing eye protection

Pinch Points: Belt driven equipment, such as vacuum pimps, must have a guard in place to prevent fingers/clothes from becoming entangled in the moving parts.

Tubing: Tubing (Tygon and rubber) provide some flexibility when used. When tubing is used for hazardous gases (gas anesthesia or natural gas) check all connections for possible leakage.

UV Light: Exposure to UV light can result in adverse health effects that include erythema (sunburn), photokeratitis (a feeling of sand in the eyes), skin cancer, melanoma, cataracts, and retinal burns. UV lights may be found in germicidal lamps, biological safety cabinets, and transilluminators. See the hazards and precautions as listed in **http://www.safety.rochester.edu/ih/uvlight.html .**

Vacuum Distillation Residues: Explosions can occur when a vacuum distillation still is vented to the air before the material has cooled. Always vent stills with nitrogen, allow the equipment to cool to room temperature, before venting.