Binghamton University Management Procedure #1011

Laboratory
Safety Manual
And
Chemical Hygiene Plan

Updated: 2024

PURPOSE OF THIS MANUAL

The purpose of this manual is to provide laboratories with useful recommendations that can help achieve compliance with the intent of the OSHA Lab Standard and to meet the regulatory requirements of the OSHA Laboratory Standard for the development of a Chemical Hygiene Plan. Throughout this document, areas where regulatory or University requirements exist will be clearly identified using words such as “must”, “required”, “shall”, and “it is the responsibility”, etc. All other information provided within this document are recommendations that Environmental Health and Safety (EH&S) encourage laboratories to follow as best management practices. **Colleges, departments, other units, and individual laboratories are free to establish the guidelines found within this document as required policies for their units or laboratories.**

If you encounter a broken web link, please send an email to EH&S at EHS@binghamton.edu. Include the section and page number of the manual and the name of the link you were trying to reach. If you have suggestions to improve this document, please send an email to EH&S at EHS@binghamton.edu. This Laboratory Safety Manual should be considered a living document and will be reviewed at least annually and updated as needed.

IN CASE OF AN EMERGENCY, CALL 911 from any campus phone or 777-2222 from a cell phone.

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1.0 INTRODUCTION

This Laboratory Safety Manual includes the University's Chemical Hygiene Plan and recommendations for good laboratory practices to serve as a useful resource and to assist laboratories in designing their own site-specific laboratory safety procedures to meet these requirements.

The Occupational Safety and Health Administration (OSHA) regulation 29 CFR 1910.1450, "Occupational Exposure to Hazardous Chemicals in Laboratories", mandates health and safety practices and procedures in laboratories that use hazardous chemicals. The Standard became effective May 1, 1990 and requires that a Chemical Hygiene Plan be developed for each laboratory workplace. The purpose of the Laboratory Standard is to protect laboratory employees from harm due to chemicals while they are working in a laboratory. This regulation applies to all employers engaged in the laboratory use of hazardous chemicals which OSHA defines as:

> "Laboratory" means an instructional or research facility where the "laboratory use of hazardous chemicals" occurs for the main purpose of carrying out scientific experiments that may involve physical or chemical hazards described within sections 5-13 of this document. It is a workplace where relatively small quantities of hazardous chemicals are used on a non-production basis.
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> "Laboratory scale" means work with substances in which the containers used for reactions, transfers, and other handling of substances are designed to be easily and safely manipulated by one person. "Laboratory scale" excludes those workplaces whose function is to produce commercial quantities of materials.
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> "Hazardous chemical" means a chemical for which there is statistically significant evidence based on at least one study conducted in accordance with established scientific principles that acute or chronic health effects may occur in exposed employees. The term "health hazard" includes chemicals which are carcinogens, toxic or highly toxic agents, reproductive toxins, irritants, corrosives, sensitizers, hepatotoxins, nephrotoxins, neurotoxins, agents which act on the hematopoietic systems and agents which damage the lungs, skins, eyes, or mucous membranes. Appendix A and Appendix B of the Hazard Communication standard (29 CFR 1910.1200) provide further guidance in defining the scope of health hazards and determining whether or not a chemical is to be considered hazardous for the purposes of this standard.

A complete description of definitions applicable to laboratories can be found in the OSHA Laboratory Standard.

In all other areas that use chemicals, but do not fall under the OSHA definition of a " laboratory" , the OSHA regulation 29 CFR 1910.1200 –Hazard Communication Standard" applies.

Most laboratories at Binghamton using chemicals are subject to the requirements of the Laboratory Standard. In addition to employees who ordinarily work full-time within a laboratory space, other employees (such as office, custodial, maintenance and repair personnel) who regularly spend a significant amount of their time within a laboratory environment as part of their duties, may also fall under the requirements of the Laboratory Standard. OSHA considers graduate students who get paid for working in a lab as employees who are subject to the requirements of the Laboratory Standard.

The OSHA Laboratory Standard requires employers to develop a Chemical Hygiene Plan (CHP), designate a Chemical Hygiene Officer, and ensure laboratory employees are provided with the proper information and training, including knowing the location of the Chemical Hygiene Plan, and how to work safely in their labs. Binghamton University Environmental Health & Safety has responsibility for maintaining an institutional Chemical Hygiene Plan. Each college, center, department, or laboratory may adopt or modify this plan or write their own chemical hygiene plan as long as the requirements of the OSHA Laboratory Standard are met and approved by EH&S. It is assumed if a college, center, department, or laboratory has not developed their own chemical hygiene plan, then that unit or laboratory has adopted the Binghamton University Chemical Hygiene Plan. An acknowledgment to this effect is located in Appendix K.

The Binghamton University CHP is maintained by the department of Environmental Health and Safety (EH&S). The campus CHP is designed to supplement department and laboratory specific safety manuals and procedures that already address chemical safety in laboratories.

1.1 Chemical Hygiene Plan Accessibility and Applicability

The OSHA Laboratory Standard requires the CHP to be readily available to employees, employee representatives and, upon request, to the Assistant Secretary of Labor for Occupational Safety and Health, U.S. Department of Labor, or designee. This means laboratory employees working with hazardous chemicals in a laboratory must know the location of the CHP, be familiar with the contents, and be able to produce the CHP for any state or federal regulatory inspectors upon request. While EH&S recommends a hard copy be kept in the laboratory, electronic access is acceptable and encouraged. The Chemical Hygiene Plan can be found in Appendix A of this manual.

**** * * It is the responsibility of Principal Investigators and laboratory supervisors to ensure that personnel working in laboratories under their control are familiar with the contents and location of the Chemical Hygiene Plan, including any lab specific standard operating procedures and any department or college level laboratory safety manuals, policies, and procedures.***

1.2 Laboratory Safety Responsibilities

The ultimate responsibility for health and safety within laboratories lies with each individual who works in the laboratory; however, it is the responsibility of the Principal Investigator, faculty, and laboratory supervisor to ensure that employees (including visiting scientists, fellows, volunteers, temporary employees, and student employees) have received all appropriate training, and have been provided with all the necessary information to work safely in laboratories under their control. Proper training documentation is required proving the employees have been trained on lab specified procedures and equipment. Principal Investigators, faculty, and lab supervisors have numerous resources at their disposal for helping to ensure a safe and healthy laboratory that is compliant with state and federal regulations

It is the responsibility of the Principal Investigator and individual supervisors (and individuals working under their supervision) to be in compliance with the components of the University Chemical Hygiene Plan, the University Health and Safety Policies, and any other department or University specific policies.

1.2.1 Environmental Health and Safety

Environmental Health and Safety (EH&S) will provide technical information and program support to assist in compliance with the OSHA Laboratory Standard. This includes developing recommendations and guidelines (as found in this Laboratory Safety Manual), developing and providing training programs designed to meet regulatory requirements, and serving as resources to provide health and safety information to laboratory personnel. EH&S will maintain the campus Chemical Hygiene Plan and the institutional Chemical Hygiene Officer responsibilities.

1.2.2 Chemical Hygiene Officer

The role of the Chemical Hygiene Officer (CHO) and Manager for Laboratory Safety Programs} is to facilitate the implementation of the campus Chemical Hygiene Plan and this Laboratory Safety Manual in laboratories across campus and outlying facilities, and to serve as a technical resource to the campus laboratory community. The CHO can be reached by contacting EH&S at 777-2211.

The major duties of the Chemical Hygiene Officer are:

- Work with campus stakeholders to evaluate, implement, review annually, and make updates as needed to the Chemical Hygiene Plan and Laboratory Safety Manual.
- Provide technical expertise to the laboratory community in the area of laboratory safety and health, and serve as a point of contact to direct inquiries to other appropriate resources if necessary.
- Ensure that guidelines are in place and communicated for particularly hazardous substances regarding proper labeling, handling, use, and storage, selection of proper personal protective equipment, and facilitating the development of standard operating procedures for laboratories using these substances.
- Serve as a resource to review academic research protocols and standard operating procedures developed by Principal Investigators and department personnel for the use, disposal, spill cleanup, and decontamination of hazardous chemicals, and the proper selection and use of personal protective equipment.
- Conduct laboratory safety training sessions for laboratory personnel and upon request, assist laboratory supervisors in developing and conducting hands-on training sessions with employees.
- Review reports of laboratory incidents, accidents, chemical spills, and near-misses and recommend follow up actions w here appropriate.
- In conjunction with Physical Facilities, stay informed of plans for renovations or new laboratory construction projects and serve as a resource to assist with the design and construction process.
- Keep senior administration informed on the progress of continued implementation of the Chemical Hygiene Plan and Laboratory Safety Manual and bring campus wide issues affecting laboratory safety to their attention.

1.2.3 Deans, Directors, and Department Chairpersons

The Deans, Directors, and Department Chairpersons are responsible for laboratory safety within their department(s) and must know and understand University Health & Safety Policies and know and understand the guidelines and requirements of the Laboratory Safety Manual. In addition to the responsibilities outlined within the University Health & Safety Policy, the laboratory safety responsibilities of Deans, Directors, and Department Chairpersons - which can be delegated to other authorized personnel within the department such as a Department Safety Representative (DSR) - are:

- Be familiar with and implement the University Health & Safety Policy within units under their control or designate a person in the department (such as the DSR) with the ***authority*** to carry out these requirements.
- Communicate and implement the University Health and Safety Policy and its requirements to faculty, staff (including temporary employees), visiting scholars, volunteers, and students working in laboratories within their units.
- Assist the Chemical Hygiene Officer with implementation of the Chemical Hygiene Plan and Laboratory Safety Manual.
- Ensure laboratory personnel develop and adhere to proper health and safety protocols.
- Direct individuals under their supervision, including but not limited to Principal Investigators, supervisors, regular and temporary employees, visiting professors, and student employees - to obtain any required safety and health training before working with hazardous chemicals, biohazardous agents, radiation, and/or other physical/mechanical hazards found within their working or learning environments.
- Determine and ensure that safety needs and safety equipment for departments are met (e.g., engineering controls, training, protective equipment) and ensure corrective measures for noncompliance identified in safety audits are corrected promptly.
- Encourage the formation of a college and/or department safety committee(s).
- Keep the DSR, Building Administrator, and Chemical Hygiene Officer informed of plans for renovations or new laboratory construction projects.
- Ensure college and departmental procedures are established and communicated to identify and respond to potential accidents and emergency situations.
- Notify the Chemical Hygiene Officer before a faculty member retires or leaves the University so proper laboratory decommissioning occurs.
- Establish college and departmental priorities, objectives, and targets for laboratory safety and health performance. Obtain assistance and guidance from EH&S when necessary.
- Notify EH&S when a new faculty or PI is hired. EH&S will meet with all new PI's.

1.2.4 Principal Investigators, Faculty, and Laboratory Supervisors

Principal Investigators, faculty, and laboratory supervisors are responsible for laboratory safety in their research or teaching laboratories. In addition to the responsibilities outlined within the University Health

& Safety Policy, the laboratory safety duties of Principal Investigators, faculty, and laboratory supervisors (which can also be delegated to other authorized personnel within the laboratory) are:

- Implement and communicate the University Health & Safety Policies and all other University safety practices and programs, including the guidelines and procedures found within the Laboratory Safety Manual, in laboratories under your supervision or control.
- Establish laboratory priorities, objectives and targets for laboratory safety.
- Communicate roles and responsibilities for individuals within the laboratory relative to environmental health, and safety according to this Laboratory Safety Manual.
- Conduct hazard evaluations for procedures conducted in the laboratory and maintain a file of standard operating procedures documenting those hazards.
- Ensure that specific operating procedures for handling and disposing of hazardous substances used in their laboratories are written, communicated, and followed and ensure laboratory personnel have been trained in these operating procedures and use proper control measures.
- Require all staff members and students under their direction to obtain and maintain required health and safety training.
- Conduct laboratory self-inspections with their laboratory employees or designate someone in the laboratory to conduct these inspections on a regular basis.
- Ensure that all appropriate engineering controls including chemical fume hoods and safety equipment are available and in good working order in their laboratories. This includes notifying EH&S when changes in chemical use may require a re-evaluation of the laboratory ventilation.
- Ensure procedures are established and communicated to identify the potential for, and the appropriate response to accidents and emergency situations.
- Ensure that all incidents and near misses occurring in their laboratories are reported to the Director or Department Chairperson and/or Department Safety Representative and that a written Incident/Accident Report (CS–13) is filed with EH&S for each injured person.
- Ensure laboratory personnel under your supervision know and follow the guidelines and requirements contained within the Laboratory Safety Manual.
- Follow the guidelines identified within this manual as Principal Investigator and laboratory supervisor responsibilities. An abbreviated version of these responsibilities can be found in the appendix.
- Keep the Department Safety Representative, Department Chairperson, and the Chemical Hygiene Officer informed of plans for renovations or new laboratory construction projects.

1.2.5 Laboratory Employees

Laboratory employees are those personnel who conduct their work, are present in the laboratory, and are at risk of possible exposure to hazardous chemicals on a regular or periodic basis. These personnel include laboratory technicians, instructors, researchers, visiting researchers, administrative assistants, graduate assistants, student aides, student employees, and part-time and temporary employees.

In addition to the responsibilities outlined within the University Health & Safety Policy, the laboratory safety duties of laboratory employees are:

- Comply with the University Health & Safety Policy and all other health and safety practices and programs by maintaining class, work, and laboratory areas safe and free from hazards.
- Know the location of the Chemical Hygiene Plan and how to access material safety data sheets.
- Attend required health and safety training as designated by your supervisor.
- Inform a supervisor or instructor of any safety hazards in the workplace, classroom, or laboratory, including reporting any unsafe working conditions, faulty fume hoods, or other non-working emergency safety equipment to the laboratory supervisor.
- Ensure an SDS is present for all new chemicals you purchase and a copy is supplied to EH&S. It is strongly recommended a copy is stored in the lab. Review the SDS's for chemicals you are working with and check with your laboratory supervisor or principal investigator if you have any questions.
- Conduct hazard evaluations with your supervisor for procedures conducted in the laboratory and maintain a file of standard operating procedures documenting those hazards.
- Be familiar with what to do in the event of an emergency situation.
- Participate in laboratory self-inspections.
- Follow the standard operating procedures for your laboratory and incorporate the guidelines and requirements outlined in this Laboratory Safety Manual into everyday practice.
- Notify EH&S when you plan on graduating or leaving the university. A laboratory closeout checklist must be completed.

1.2.6 Building Administrator

Building Administrators serve as an important conduit for information with regard to building wide issues. This information includes reporting and coordinating routine maintenance issues, scheduling building shutdowns, and communicating building wide maintenance and repairs and building system shutdowns to all occupants.

Laboratory safety responsibilities of Building Administrators include:

- Comply with the University Health and Safety policy and all other University health and safety practices and programs by maintaining common building areas safe and free from hazards.
- Attend required health and safety training as designated by your supervisor.
- Keep the DSR, Department Chairperson, and the Chemical Hygiene Officer informed of plans for renovations or new laboratory construction projects, and the laboratory needs of new faculty and staff.
- Ensure that service requests for safety equipment (such as fume hoods and emergency eyewash/showers) and other laboratory equipment are processed in a timely manner.
- Ensure that requests from EH&S related to building-wide laboratory safety issues are addressed promptly.
- Be aw are of building issues that could impact the health and safety of laboratory personnel and contact EH&S at 777-2211 whenever building wide health and safety issues arise in laboratories.
- Be familiar with what to do in the event of an emergency situation.

- Notify EH&S when a laboratory is assigned to a Principal Investigator

1.2.7 Department Safety Representatives

The Department Safety Representative (DSR) serves a very important function in implementing the Chemical Hygiene Plan and Laboratory Safety Manual within the department. The role of the DSR is to assist the director, unit head, and/or department chairperson to meet their responsibilities for safety and compliance.

Laboratory safety responsibilities of DSRs include:

- Comply with the University Health and Safety policy and all other University health and safety practices and programs.
- Request and coordinate assistance from EH&S and other organizations that can provide guidance, training, and other services to assist laboratory personnel.
- Assist directors, unit heads, department chairpersons, supervisors, and individuals within the areas they represent to establish departmental, unit, or facility-wide safety programs, priorities, objectives and targets for safety, health, and environmental performance.
- Assist directors, unit heads, department chairpersons, supervisors, and individuals to identify (with assistance and guidance from EH&S) if the safety needs for the areas they represent are met (e.g., training, protective equipment, acquisition of safety equipment, and corrective measures including noncompliance items identified in safety audits).
- Encourage the formation of, and participate on college, unit, departmental, and/or facility-wide safety committee(s).
- Work with EH&S to stay knowledgeable about safety, health, and environmental services available, the University Health and Safety policies and procedures that apply to, and the health and safety issues that occur within, the areas they represent.
- Communicate to individuals working within the areas they represent about these health and safety policies and procedures, including this Laboratory Safety Manual, and the safety, health, and environmental services available to them.
- Conduct and/or facilitate routine inspections of work areas in the areas they represent. Tools and resources are available from EH&S. Facilitate corrective actions for any issues identified, including bringing issues of noncompliance to the attention of directors, unit heads and department chairpersons.
- Promote safety, health, and environmental training program and workshops (particularly EH&S trainings) throughout the areas they represent. Inform individuals working in areas they represent about the requirement to obtain necessary training as identified by their supervisor and EH&S.
- Serve as a “conduit for information exchange” through facilitation and dissemination of safety, health and environmental information (particularly information sent out by EH&S) to all personnel, including visiting faculty and researchers, and student employees, within the areas they represent.
- Communicate with supervisors in the areas they represent that all incidents and near misses should be reported and that a written Incident/Accident Report (CS-13) is completed.

- Attend EH&S training programs (and other safety, health, and environmental training programs and workshops) to increase and maintain know ledge about safety, health, and environmental issues that are applicable to the areas they represent.
- Be aw are that changes in chemical use in a particular laboratory may require a re-evaluation of the laboratory ventilation.
- Notify EH&S before a faculty member retires or leaves the University or laboratory groups move so proper laboratory decommissioning can occur.

1.2.8 Safety Responsibilities during Leaves/Absences

Whenever a faculty member or lab supervisor will not be present in the laboratory for an extended period of time e.g. during a sabbatical, vacation, or protracted illness, etc., it is their responsibility to identify a colleague to oversee their laboratory operations with respect to safety procedures and requirements.

- The person selected must be familiar with the hazards of the operations occurring in the lab and be empowered to address concerns as they arise. Examples include a fellow faculty member, the Departmental Chemical Hygiene Officer, a full-time research associate or post-doctoral fellow; however, the individual must be a BU employee.
- The faculty member must notify their Department Chair of who will be assuming responsibility for all safety aspects of their laboratory operations.

The Department Chair and faculty member must be in agreement that the selected person has the experience, knowledge and background to assume the responsibilities. The faculty member must communicate the name of this responsible individual to the Departmental Safety Committee and EHS as well as list the name and contact information of the responsible individual on the emergency contact card posted at the laboratory.

2.0 CONTROL MEASURES

The main goals of the OSHA Laboratory Standard and the requirement to develop a Chemical Hygiene Plan are to protect employees from health hazards associated with use of hazardous chemicals in the laboratory and keep exposures below the permissible exposure limits as specified in 29 CFR Part 1910, subpart Z – Toxic and Hazardous Substances and other resources such as NIOSH and ACGIH. In addition to other requirements, the OSHA Lab Standard specifies the Chemical Hygiene Plan include “criteria the employer will use to determine and implement control measures to reduce employee exposure to hazardous chemicals including engineering controls, the use of personal protective equipment and hygiene practices; particular attention shall be given to the selection of control measures for chemicals that are known to be extremely hazardous.” Engineering controls and administrative controls promote a healthy and safe work environment, and meet both the requirements and the intent of the OSHA Laboratory Standard.

2.1 Engineering Controls

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

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

The proper functioning and maintenance of fume hoods and other protective equipment used in the laboratory is the responsibility of a variety of service groups. Physical Facilities, Building Administrators, Department Chairperson, EH&S, and other groups service equipment such as fire extinguishers, emergency eyewash and showers, and mechanical ventilation. Periodic inspections and maintenance by these groups ensure proper functioning and adequate performance of these important pieces of protective equipment.

It is the responsibility of laboratory personnel to immediately report malfunctioning protective equipment, such as fume hoods, or mechanical problems to their Building Administrator or their department contact as soon as they are discovered.

2.1.1 Chemical Fume Hoods

Fume hoods and other capture devices must be used for operations that might result in the release of toxic chemical vapors, fumes, or dusts. Benchtop use of chemicals that present an inhalation hazard is not permitted. Fume hoods must be used when conducting new experiments with unknown consequences from reactions or when the potential for a fire exists.

To obtain optimum performance and achieve the greatest protection when using a fume hood, please adhere to the following:

- Before working in any fume hood, ensure the fume hood is working by checking the tell-tale (green crepe paper or kimwipe hanging from hood sash) and air monitoring device if the hood is equipped with one. DO NOT use an improperly working fume hood. If EH&S or Physical Facilities has posted the hood as being out of service, do not use the fume hood for any reason.
- Keep the fume hood sash lowered at all times to the height recommended by EH&S (as indicated by the inspection sticker). Keeping the hood sash lowered improves the performance of the fume hood, acts as a safety shield during experimental procedures and (for VAV hoods) helps to conserve energy.

- Keep all materials stored in hoods to a minimum. Excess and unnecessary storage and clutter results in decreased hood performance and increases the chances of an accident or spill occurring. Do not use hoods as storage cabinets, especially for long term storage of chemicals and hazardous waste.
- For optimum performance of the fume hood, keep all materials and equipment back at least six (6) inches from the face of the hood and do not block the vents or baffle openings in the back of the hood.
- Keep any lab equipment elevated at least one inch off the work surface of the hood to allow for proper airflow. Use bench stands or items such as blocks of wood, metal test tube racks, or other items that will not react with the chemical(s) in use.
- When working in a fume hood, keep windows and doors closed within the lab and minimize traffic in front of the hood. Minimize rapid movements while working in the hood, including opening and closing the sash. All of these precautions will help to prevent air currents from forming, which can result in hazardous vapors being pulled out of the hood and into laboratory personnel breathing zones.
- Do not use fume hoods to evaporate hazardous waste. Evaporating hazardous waste is illegal.
- For work involving particularly hazardous substances or chemicals that can form toxic vapors, fumes, or dusts, the hood or equipment within the hood may need to be fitted with condensers, traps, or scrubbers in order to prevent the vapors, fumes, and dusts from being released into the environment.
- When pouring flammable liquids, always make sure both containers are electrically interconnected to each other by bonding and grounding in order to prevent the generation of static electricity which can cause the flammable liquid to ignite.
- As with any work involving chemicals, always practice good housekeeping and clean up any chemical spills immediately. Be sure to wash both the working surface and hood sash frequently, and always maintain a clean and dry work surface that is free of clutter.

2.1.1.1 Perchloric Acid Use

The use of heated Perchloric acid requires a special Perchloric acid fume hood with a wash down function. DO NOT heat Perchloric acid in a regular fume hood. If heated Perchloric acid is used in a regular fume hood (without a wash down function), shock sensitive metallic perchlorate crystals can form inside the duct work. This can result in an explosion during maintenance work on the ventilation system. If you suspect your fume hood has perchlorate contamination or would like more information on Perchloric acid fume hoods, contact EH&S at 777-2211.

2.1.1.2 Fume Hood Inspection and Testing Program

EH&S performs free annual testing and inspection of fume hoods on campus. After each inspection, an inspection sticker is affixed to the fume hood. If your fume hood does not have an inspection sticker or if the existing inspection sticker on your fume hood indicates a year or more has passed since the hood was last inspected, please call EH&S at 777-2211.

The fume hood inspection program consists of an initial comprehensive inspection followed by annual standardized inspections for all fume hoods on campus. This initial inspection will provide baseline information including, but not limited to, hood usage, type of hood, room and building information, as well as average face velocity measurements.

Follow -up inspections for proper use and face velocity (airflow) measurements will be performed on an annual basis or upon request by laboratory personnel. Upon completion of each inspection, hoods will be labeled with an inspection sticker indicating face velocity, date inspected, and initials of the inspector. The sticker represents the sash position at which the hood was tested for optimum working height. All inspection information will be recorded and kept on file at the EH&S office.

Fume hood testing and inspection consists of the following:

- The face velocity will be tested for compliance with American National Standards Institute (ANSI) and American Industrial Hygiene Association (AIHA) standard Z9.5-2003.
- The hood will be checked for the correct postings and a tell-tale flow indicator (kimwipe).
- A report will be sent to the Building Administrator documenting the testing and indicating any needed repairs.

Hoods will be classified as acceptable or unacceptable based on the average face velocity measurement and sash height.

- A hood will be considered ***acceptable*** if an average face velocity between 80 and 120 fpm occurs with a sash opening of 18.” The optimum working height is with the hood sash at 9”-12”.
- A hood will be considered ***unacceptable*** if the average face velocity falls outside of these ranges.

If a hood is found to be unacceptable, a warning sign indicating the hood did not pass inspection will be attached in a conspicuous location. The warning sign will include instructions on the proper procedures to have the hood repaired or maintenance service performed.

Under no circumstances should laboratory personnel continue to use a fume hood that has not passed the EH&S inspection and has a warning sign attached, even if the fume hood appears to have airflow. Laboratory personnel must make arrangements with other laboratories with functioning fume hoods if their work requires the use of a fume hood.

EH&S will consult with the Building Administrator and Facilities Management, to ensure a timely repair process.

2.1.1.3 Installation of New Fume Hoods

Installation of a new fume hood requires careful planning and knowledge of the existing building ventilation systems and capabilities. Improperly installed fume hoods or other capture devices can seriously disrupt the existing ventilation system and have a negative impact in the immediate room, other fume hoods, and the ventilation system throughout the building. All fume hoods and other capture devices must be installed by Physical Facilities and in consultation with EH&S.

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

EH&S can provide information regarding the selection, purchase, and inspection requirements for laminar flow clean benches, biosafety cabinets, and portable fume hoods.

2.1.1.4 Removal of Existing Fume Hoods

As with installation of new fume hoods and capture devices, any removal of these devices requires prior consultation with your Building Administrator, Physical Facilities, and EH&S. In addition to ensuring ventilation systems are not affected by removal of fume hoods and capture devices, utility services such as electrical lines, plumbing systems, and water and gas supply lines must be properly disconnected. All fume hood removal must be conducted by Physical Facilities.

There is an additional concern for the presence of asbestos within the fume hood itself, and potentially in any pipe insulation associated with the ductwork and/or mercury in cup sinks. Any asbestos must be properly removed and disposed of by a certified asbestos removal company. Contact EH&S at 777-2211 for more information or questions about asbestos.

2.1.2 Other Capture Devices

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

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

2.1.3 Water Protection in Labs

Laboratory personnel must ensure that any piece of equipment or laboratory apparatus connected to the water supply utilizes backflow protection or is connected to a faucet with a vacuum breaker. The purpose of backflow prevention and vacuum breakers is to prevent water used in an experimental process or with a piece of equipment, from back flowing and contaminating the laboratory's and building's water supply system. Examples of situations that can result from improper backflow protection include chemical contamination and/or temperature extremes (i.e. hot water coming from a drinking fountain).

The two most common water protection problems found in labs are:

1) A tube attached to a faucet without a vacuum breaker

2) Drainage tubing hanging down into the sink.

These tubes can be immersed in wash water when the sink is stopped up and then back flow into the faucet and contaminate the building water supply.

The most common example of back flow prevention found in laboratories is sink faucets equipped with a vacuum breaker. These faucets are easily identifiable from standard (rounded) faucets by the vacuum breaker head at the top of the faucet. If you have questions about whether the laboratory faucet you are planning on using has a vacuum breaker or back flow protection, contact your Building Administrator or EH&S at 777-2211. If your sink faucet does not have a vacuum breaker present, make sure any hoses that you connect to the faucet are short enough to prevent the possibility of water in the sink back flowing up the faucet.

2.2 Personal Protective Equipment

Personal Protective Equipment (PPE) is considered the second line of defense in protecting laboratory personnel against chemical hazards, after the use of engineering controls. PPE is not a substitute for good engineering or administrative controls, or good work practices, but should be used in conjunction with these controls to ensure the safety and health of university employees and students. The OSHA Personal Protective Equipment standard, 29 CFR 1910 Subpart I contains the following requirements:

- Hazard assessment and equipment selection.
- Employee training.
- Record keeping requirements.
- Guidelines for selecting PPE.
- Hazard assessment certification.

More information on PPE can be found in the OSHA Safety and Health topics page on Personal Protective Equipment.

2.2.1 Laboratory Responsibilities for Personal Protective Equipment

Laboratory personnel need to conduct hazard assessments of the specific operations occurring in their laboratories to determine what Personal Protective Equipment (PPE) is necessary to safely carry out the operation. PPE must be made available to laboratory workers to reduce exposures to hazardous chemicals in the lab. Proper PPE includes items such as gloves, eye protection, lab coats, face shields, aprons, boots, hearing protection, etc. PPE must be readily available and most equipment is provided at no cost to the employee.

When deciding on the appropriate PPE to wear when performing any operations or experiments, a number of factors must be taken into consideration such as:

- The chemicals being used, including concentration and quantity.
- The hazards the chemicals pose.
- The routes of exposure for the chemicals.
- The material the PPE is constructed of.
- The permeation and degradation rates specific chemicals will have on the material.
- The length of time the PPE will be in contact with the chemicals.

Careful consideration should be given to the comfort and fit of PPE to ensure that it will be readily used by laboratory personnel.

All personal protective clothing and equipment must be maintained in a sanitary and reliable condition. Only those items that meet NIOSH (National Institute of Occupational Safety and Health) or ANSI (American National Standards Institute) standards should be purchased or accepted for use.

Please Note: Principal Investigators, laboratory supervisors, departments and colleges are free to set policies that establish minimum PPE requirements for personnel working in and entering their laboratories. Be sure to check with your Department Safety Representative to see if there are any department or college specific requirements for PPE.

2.2.1.1 Training for Personal Protective Equipment

Laboratory personnel must be trained in the selection, proper use, limitations, care, and maintenance of PPE. Training requirements can be met in a variety of ways including videos, group training sessions, and handouts. Periodic retraining should be offered to both employees and supervisors as appropriate. Examples of topics to be covered during the training include:

- When PPE must be worn.
- What PPE is necessary to carry out a procedure or experiment.
- How to properly put on, take off, adjust, and wear PPE.
- The proper cleaning, care, maintenance, useful life, limitations, and disposal of PPE.

As with any training sessions, PPE training must be documented, including a description of the information covered during the training session and a copy of the sign-in sheet. Written records must be kept of the names of the persons trained, the type of training provided, and the dates when training occurred. EH&S will maintain records of employees who attend EH&S training sessions.

Information on the specific PPE required to carry out procedures within the laboratory using hazardous chemicals must also be included in the laboratory's Standard Operating Procedures.

Please note: while EH&S can provide information, training, and assistance with training on conducting hazard assessments, and on the selection and use of proper PPE, the ultimate responsibility lies with the Principal Investigator or laboratory supervisor.

It is the responsibility of the Principal Investigator or laboratory supervisor to ensure laboratory staff have received the appropriate training on the selection and use of proper PPE; that proper PPE is available and in good condition; and laboratory personnel use proper PPE when working in laboratories under their supervision.

2.2.2 Eye Protection

Eye protection is one of the most important and easiest forms of PPE to wear. Laboratory personnel should use eye protection for many of the chemical and physical hazards found in laboratories including flying particles, molten metal, acids or caustic liquids, chemical liquids, chemical gases or vapors, or potentially injurious light radiation.

EH&S strongly encourages Principal Investigators and laboratory supervisors to make eye protection a mandatory requirement for all laboratory personnel, including visitors, working in or entering laboratories under their control.

All laboratory employees and visitors should wear protective eye wear while in laboratories where chemicals are being handled or stored, at all times, even when not working directly with chemicals.

Additional information can be found on the OSHA Health and Safety Topics Page for eye and face protection.

2.2.2.1 Eye Protection Selection

All protective eye and face devices must comply with ANSI Z87.1-2020, " American National Standard Practice for Occupational and Educational Eye and Face Protection" and be marked to identify the manufacturer. When choosing proper eye protection, be aware there are a number of different styles of eye wear that serve different functions.

Prescription Safety Eye wear- OSHA regulations require that employees who wears prescription lenses while engaged in operations that involve eye hazards shall wear eye protection that incorporates the prescription in its design, or must wear eye protection that can be worn over the prescription lenses (goggles, face shields, etc.) without disturbing the proper position of the prescription lenses or the protective lenses. Any prescription eyewear purchase must comply with ANSI Z87.1-2020. Note: Contact lenses by themselves are not considered protective eyewear.

Safety Glasses provide eye protection from moderate impact and particles associated with grinding, sawing, scaling, broken glass, and minor chemical splashes, etc. Side protectors are required when there is a hazard from flying objects. Safety glasses are available in prescription form for those persons needing corrective lenses. Safety glasses do not provide adequate protection for processes that involve heavy chemical use such as stirring, pouring, or mixing. In these instances, splash goggles should be used.

Splash Goggles provide adequate eye protection from many hazards, including potential chemical splash hazards, use of concentrated corrosive material, and bulk chemical transfer. Goggles are available with clear or tinted lenses, fog proofing, and vented or non-vented frames.

Be aware that goggles designed for woodworking are not appropriate for working with chemicals. These types of goggles can be identified by the numerous small holes throughout the face piece. In the event of a splash, chemicals could enter into the small holes, and result in a chemical exposure to the face. Ensure the goggles you choose are rated for use with chemicals.

Welding/chippers' Goggles provide protection from sparking, scaling, or splashing metals and harmful light rays. Lenses are impact resistant and are available in graduated lens shades. Chippers' /grinders' goggles provide protection from flying particles. A dual protective eyecup houses impact resistant clear lenses with individual cover plates.

Face Shields provide additional protection of the eyes and face when used in combination with safety glasses or splash goggles. Face shields consist of an adjustable headgear and face shield of tinted or clear lenses or a mesh w ire screen. They should be used in operations when the entire face needs protection and should be worn to protect eyes and face from flying particles, metal sparks, and chemical/biological splashes. Face shields with a mesh w ire screen are not appropriate for use with chemicals. Face shields must ***not*** be used alone and are ***not*** a substitute for appropriate eyewear. Face shields should always be worn in conjunction with a primary form of eye protection such as safety glasses or goggles.

Welding Shields are similar in design to face shields but offer additional protection from infrared or radiant light burns, flying sparks, metal splatter, and slag chips encountered during welding, brazing, soldering, resistance welding, bare or shielded electric arc welding, and oxyacetylene welding and cutting operations.

Equipment fitted with appropriate filter lenses must be used to protect against light radiation. Tinted and shaded lenses are not filter lenses unless they are marked or identified as such.

LASER Eye Protection -A single pair of safety glasses is not available for protection from all laser outputs. The type of eye protection required is dependent on the spectral frequency or specific wavelength of the laser source. If you have questions on the type of eyewear that should be worn with your specific laser, contact the Laser Safety Officer at EH&S at 777-2211. See the LASER Hazards for more laser information.

2.2.3 Hand Protection

Most accidents involving hands and arms can be classified under four main hazard categories: chemicals, abrasions, cuts, and heat/cold. Gloves must be worn whenever significant potential hazards from chemicals, cuts, lacerations, abrasions, punctures, burns, biologicals, or harmful temperature extremes are present.

The proper use of hand protection can help protect from potential chemical and physical hazards. Gloves must be worn when using chemicals that are easily absorbed through the skin and/or particularly hazardous substances (such as select carcinogens, reproductive toxins, and substances with a high degree of acute toxicity).

*** * * Keep in mind there is no one type of glove that offers the best protection against all chemicals or one glove that totally resists degradation and permeation to all chemicals. All gloves must be replaced periodically, depending on the type and concentration of the chemical, performance characteristics of the gloves, conditions and duration of use, hazards present, and the length of time a chemical has been in contact with the glove.**

All glove materials are eventually permeated by chemicals; however, they can be used safely for limited time periods if specific use and other characteristics (i.e., thickness, permeation rate, and time) are known. EH&S can provide assistance with determining the resistance to chemicals of common glove materials and determining the specific type of glove material that should be worn for use with a particular chemical.

2.2.3.1 Selecting the Proper Gloves

Before working with any chemical, always read manufacturer instructions and warnings on chemical container labels and SDS's. Recommended glove types may sometimes be listed in the section for PPE on SDS's. If the recommended glove type is not listed on the SDS, laboratory personnel should consult with the manufacturers’ glove selection charts. These charts typically include commonly used chemicals that have been tested for the different glove types. Keep in mind that different manufacturers use different formulations so check the glove chart of the specific manufacturer for the glove you plan to use.

If the manufacturers’ glove chart does not list the specific chemical you will be using, call the manufacturer and speak with their technical representatives to determine which glove is best suited for your application.

It is important to know that not all chemicals or mixtures have been tested by glove manufacturers. It is especially important in these situations to contact the glove manufacturer directly.

In some cases, you may need to hire a testing laboratory that specializes in determining which glove material will be most resistant to the chemical you are using.

Some general guidelines for glove use include:

- Wear appropriate gloves when the potential for contact with hazardous materials exists. Laboratory personnel should inspect gloves for holes, cracks, or contamination before each use. Any gloves found to be questionable should be discarded immediately.
- Gloves should be replaced periodically, depending on the frequency of use and permeability to the substance(s) handled. Reusable gloves should be rinsed with soap and water and then carefully removed after use. Discard disposable gloves after each use and whenever they become contaminated.
- Due to potential chemical contamination which may not always be visible, remember to remove gloves before leaving the laboratory. Do not w ear gloves while performing common tasks such as answering the phone, grabbing a door handle, using an elevator, etc.

2.2.3.2 Double Gloving

A common practice to use with disposable gloves is “double-gloving”. This is accomplished when two pairs of gloves are worn over each other to provide a double layer of protection. If the outer glove becomes contaminated, starts to degrade, or tears open, the inner glove continues to offer protection until the gloves are removed and replaced.

The best practice is to check outer gloves frequently, watching for signs of degradation (change of color, change of texture, tears, etc.). At the first sign of degradation or contamination, always remove and dispose of the contaminated disposable gloves immediately and double-glove with a new set of gloves. If the inner glove appears to have any contamination or degradation, remove both pairs of gloves, and double glove with a new pair.

Another approach to double gloving is to wear a thin disposable glove (4 mil Nitrile) under a heavier glove (8 mil Nitrile). The outer glove is the primary protective barrier while the under glove retains dexterity and acts as a secondary barrier in the event of degradation or permeation of the chemical through the outer glove. Alternatively, you could wear a heavier (and usually more expensive and durable) 8 mil Nitrile glove as an under glove and wear thinner, disposable 4 mil Nitrile glove as the outer glove (which can help improve dexterity). However, remember to change the thinner outer gloves frequently.

When working with mixtures of chemicals, it may be advisable to double glove with two sets of gloves made from different materials. This method can offer protection in case the outer glove material becomes permeated by one chemical in the mixture, while allowing for enough protection until both gloves can be removed. The type of glove materials selected for this type of application will be based on the specific chemicals used as part of the mixture. Check chemical manufacturers glove selection charts first before choosing which type of glove to use.

To properly remove disposable gloves, grab the cuff of the left glove with the gloved right hand and remove the left glove. While holding the removed left glove in the palm of the gloved right hand, insert a finger under the cuff of the right glove and gently invert the right glove over the removed left glove and dispose of them properly. Be sure to wash your hands thoroughly with soap and water after the gloves have been removed.

2.2.3.3 Types of Gloves

As with protective eyewear, there are a number of different types of gloves that are available for laboratory personnel that serve different functions:

Fabric gloves are made of cotton or fabric blends and are generally used to improve grip when handling slippery objects. They also help insulate hands from mild heat or cold. These gloves are not appropriate for use with chemicals because the fabric can absorb and hold the chemical against a user's hands, resulting in a chemical exposure.

Leather gloves are used to guard against injuries from sparks, scraping against rough surfaces, or cuts from sharp objects like broken glass. They are also used in combination with an insulated liner when working with electricity. These gloves are not appropriate for use with chemicals because the leather can absorb and hold the chemical against a user's hands, resulting in a chemical exposure.

Metal Mesh Gloves are used to protect hands from accidental cuts and scratches. They are most commonly used when working with cutting tools, knives, and other sharp instruments.

Cryogenic Gloves are used to protect hands from extremely cold temperatures. These gloves should be used when handling dry ice and when dispensing or working with liquid nitrogen and other cryogenic liquids.

Chemically Resistant Gloves come in a wide variety of materials. The recommendations given below for the specific glove materials are based on incidental contact. Once the chemical makes contact with the gloved hand, the gloves should be removed and replaced as soon as practical. Often a glove specified for incidental contact is not suitable for extended contact, such as when the gloved hand can become covered or immersed in the chemical in use. Before selecting chemical resistant gloves, consult the glove manufacturers' recommendations or their glove selection charts, or contact EH&S at 777-2211 for more assistance.
Some general guidelines for different glove materials include:

- Natural Rubber Latex*** * * -** Resistant to ketones, alcohols, caustics, and organic acids. See note below.
- Neoprene - Resistant to mineral acids, organic acids, caustics, alcohols, and petroleum solvents.
- Nitrile - Resistant to ketones, alcohols, caustics, and organic acids.
- Norfoil **-** Rated for chemicals considered highly toxic and chemicals that are easily absorbed through the skin. These gloves are chemically resistant to a wide range of materials that readily attack other glove materials. These gloves are not recommended for use with Chloroform. Common brand names include: Silver Shield by North Hand Protection, 4H by Safety4, or New Barrier by Ansell Edmont.
- Polyvinyl chloride (PVC) - Resistant to mineral acids, caustics, organic acids, and alcohols.
- Polyvinyl alcohol (PVA) - Resistant to chlorinated solvents, petroleum solvents, and aromatics.

*** * * A note about latex gloves**
The use of latex gloves, especially thin, disposable exam gloves, for chemical handling is discouraged because latex offers little protection from commonly used chemicals. Latex gloves can degrade severely in seconds or minutes, when used with common lab and shop chemicals.

Latex gloves can also cause an allergic reaction in a percentage of the population due to proteins found in latex. Symptoms can include nasal, eye, or sinus irritation, hives, shortness of breath, coughing, wheezing, or unexplained shock. If any of these symptoms become apparent in personnel w earing latex gloves, discontinue using the gloves and seek medical attention immediately.

The use of latex gloves is only appropriate for:

- Most biological materials.
- Nonhazardous chemicals.
- Clean room requirements.
- Medical or veterinary applications.
- Very dilute, aqueous solutions containing < 1% for most hazardous chemicals or less than 0.1% of a known or suspected human carcinogen.

Staff required to wear latex gloves should receive training on the potential health effects related to latex. Hypoallergenic, non-powdered gloves should be used whenever possible. If a good substitute glove material is available, then use nonlatex gloves. A general purpose substitute for disposable latex gloves are disposable Nitrile gloves.

See the appendix for a list of recommended gloves for specific chemicals, definitions for terms used in glove selection charts, glove materials and characteristics, and a list of useful references.

2.2.4 Lab Coats and Protective Clothing

Protective clothing includes lab coats or other protective garments such as aprons, boots, shoe covers, Tyvek coveralls, and other items. that can be used to protect street clothing from biological or chemical contamination and splashes, as well as providing additional body protection from some physical hazards.

EH&S strongly recommends that Principal Investigators and laboratory supervisors ban the wearing of shorts and skirts in laboratories using hazardous materials (chemical, biological, and radiological) by laboratory personnel (including visitors) working in or entering laboratories under their supervision.

Lab Coats should have the following characteristics:

- Cotton/Poly blend construction
- Knitted or Elastic tight-fitting cuffs
- Snap closure on the front for easy removal in an emergency
- Flame resistance if required by a hazard assessment

Laboratory personnel who are planning experiments that may require special protective clothing or have questions regarding the best protective clothing should contact EH&S at 777-2211 for assistance.

2.2.5 Respiratory Protection

Respiratory protection includes disposable respirators (such as N95 filtering facepieces, commonly referred to as “dust masks.” air purifying, and atmosphere supplying respirators. Respirators are generally not recommended for laboratory workers. Engineering controls, such as dilution ventilation, fume hoods, and other devices, which capture and remove vapors, fumes, and gases from the breathing zone of the user are preferred over the use of respirators. There are certain exceptions to this general rule, such as the changing out of cylinders of toxic gases and emergency response to chemical spills.

The use of all types of respiratory protection at Binghamton is governed by OSHA standards and the Binghamton EH&S Respiratory Protection Program. **A laboratory worker at Binghamton University may not purchase a respirator and bring it to their lab for personal use without prior consultation with EH&S.**

The following are situations where respiratory protection would be appropriate for laboratory workers (after consultation with EH&S):

- The use of disposable respirators (e.g., N95 filtering facepieces/dust masks) for weighing powdery or dusty materials. Note: Most disposable respirators do not offer protection against chemical vapors and fumes; they are for use of nuisance dust only. The use of disposable respirators may or may not be regulated by OSHA depending upon the circumstances of use. In order to determine if OSHA regulations apply, please contact EH&S at 777-2211 to schedule a hazard assessment prior to using a disposable respirator.
- The use of large volumes of certain hazardous chemicals, such as formaldehyde in a room where dilution ventilation or capture devices will not offer adequate protection.
- Changing out cylinders of hazardous gases (Additional training is required).
- To reduce exposure to some chemicals which certain individuals may be or become sensitive.
- When mixing chemicals that may result in more hazardous vapors from the combination of the chemicals versus the exposure to each chemical alone or when the potential for an unknown exposure exists. However, laboratory staff should try to conduct such experiments in a fume hood.

Please note, as a measure of coworker protection, when weighing out dusty materials or powders, consider waiting until other coworkers have left the room to prevent possible exposure. Be sure to thoroughly clean up and decontaminate working surfaces.

There are some situations in which the use of a respirator is prohibited:

- When the air in a laboratory is severely contaminated and immediately dangerous to life and health (IDLH).
- When the air in a room does not have enough oxygen to support life (less than 19.5%).
- When dangerous vapors are present that have inadequate warning properties (such as odor) should the respirator fail.
- When the air contaminants can penetrate or damage skin and eyes unless other suitable protection is worn.

2.2.5.1 Respiratory Protection Program

EH&S has an established program for the use of respirators on campus. The program is designed for those University personnel who, during their normal duties are, or could be, exposed to hazardous substances or atmospheres that may affect their health and safety.

The Binghamton University Respiratory Protection Program includes the following:

- You will receive a medical evaluation by United Health Services (UHS) to ensure you are physically fit to w ear a respirator. Wearing any type of respirator puts stress on the body.
- You will be given a fit test by EH&S personnel to determine which size respirator fits you best. Due to differences in the sizes and shapes of faces, there is no one respirator that fits everyone.
- You will be shown how to properly put on and take off the respirator, and how to check to make sure it is functioning properly.
- You will be shown how to properly clean and care for your respirator, including proper maintenance.
- You will be shown how to choose the right respirator or respirator cartridge for the specific processes and types of chemicals you will be using. NOTE: As with chemical protective gloves, there is no one universal respirator cartridge that can be used with every chemical.

For more information about the use of respirators at Binghamton, call EH&S at 777-221. If you are approved for the use of a respirator after meeting the requirements of the OSHA Standard and the Binghamton EH&S Respiratory Protection Program, you will be provided with a respirator.

2.2.6 Hearing Protection

Hearing protective devices includes earplugs, earmuffs, or similar devices designed to protect your hearing. In situations where occupational noise exposures exceed permissible levels and cannot be reduced through engineering or other controls, hearing protective devices must be worn. The Binghamton University Hearing Conservation Program protects employees who, during their normal duties, experience an occupational noise exposure as defined by the Occupational Safety and Health Administration (OSHA) General Industry Standard " Occupational Exposure to Noise" Part 1910.95 and the Hearing Conservation Amendment. If you have questions about noise exposure, would like to request workplace monitoring, or for more information about the Binghamton University Hearing Conservation Program, contact EH&S at 777-2211.

Additional information can be obtained from the OSHA Health and Safety Topics page for Noise and Hearing Conservation.

2.2.7 Foot Protection

Laboratory personnel (and other personnel) must wear foot protection at all times in laboratories, laboratory support areas, and other areas with chemical, biological and physical hazards. Laboratory personnel should not wear sandals or similar types of perforated or open toes shoes when working with or around hazardous chemicals. This is due to potential exposure to toxic chemicals and the potential associated with physical hazards such as dropping pieces of equipment or broken glass. In general, shoes should be comfortable, and leather shoes are preferable to cloth shoes due to better chemical resistance of leather. Leather shoes also tend to absorb fewer chemicals than cloth shoes. However, leather shoes are not designed for long term exposure to direct contact with chemicals. In such instances, chemically resistant rubber boots are necessary.

EH&S strongly encourages Principal Investigators and laboratory supervisors to require the use of closed toed shoes for all laboratory personnel, including visitors, working in or entering laboratories and laboratory support areas under their supervision.

In some cases, the use of steel-toed shoes may be appropriate when heavy equipment or other items are involved. Chemically resistant boots or shoe covers may be required when working with large quantities of chemicals and the potential exists for large spills to occur.

2.3 Standard Operating Procedures

The OSHA Laboratory Standard requires that Chemical Hygiene Plans include specific elements and measures to ensure employee protection in the laboratory. One such requirement is Standard Operating Procedures (SOPs) "relevant to safety and health considerations to be followed when laboratory work involves the use of hazardous chemicals."

SOPs can be stand-alone documents or supplemental information included as part of research notebooks, experiment documentation, or research proposals. The requirement for SOPs is to ensure a process is in place to document and addresses relevant health and safety issues as part of every experiment.

At a minimum, SOPs should include details such as:

- The chemicals involved and their hazards.
- Special hazards and circumstances.
- Use of engineering controls (such as fume hoods).
- Required PPE.
- Spill response measures.
- Waste disposal procedures.
- Decontamination procedures.
- Description of how to perform the experiment or operation.

While the OSHA Laboratory Standard specifies the requirement for SOPs for work involving hazardous chemicals, laboratories should also develop SOPs for use with any piece of equipment or operation that may pose any physical hazards. Examples include:

- Safe use and considerations of LASERs.
- Use of cryogenic liquids and fill procedures.
- Connecting regulators to gas cylinders and cylinder change outs.
- Use of equipment with high voltage.

SOPs do not need to be lengthy and it is acceptable to point laboratory personnel to other sources of information. Some examples of what to include as part of SOPs are:

> *"To use this piece of equipment, see page 4 in the operator's manual (located in file cabinet #4)."*
>
> *"The chemical and physical hazards of this chemical can be found in the SDS – located in the SDS binder. Read the SDS before using this chemical."*
>
> *"When using chemical X, wear safety goggles, nitrile gloves, and a lab coat."*

It is the responsibility of the Principal Investigator and laboratory supervisor to ensure written SOPs incorporating health and safety considerations are developed for work involving the use of hazardous chemicals in laboratories under their supervision and that PPE and engineering controls are adequate to prevent overexposure. In addition, Principal Investigators and laboratory supervisors must ensure that personnel working in laboratories under their supervision have been trained on those SOPs. EH&S can assist with these SOPs.

2.4 Administrative Controls

Administrative controls include policies and procedures that result in providing proper guidance for safe laboratory work practices and set the standard for behavior within the laboratory. Once developed, administrative controls must be implemented and adhered to by all personnel working in the laboratory.

Colleges and departments are responsible for developing policies and written guidelines to ensure laboratory workers are protected against exposure to hazardous chemicals as outlined in the OSHA Laboratory Standard and physical hazards that may be present, including the development of a written Chemical Hygiene Plan or adoption of this Laboratory Safety Manual.

It is the responsibility of the Principal Investigator and laboratory supervisor to ensure that personnel working in laboratories under their supervision are informed and follow laboratory specific, departmental, and campus wide policies and procedures related to laboratory safety – such as the guidelines and requirements covered in this Laboratory Safety Manual.

* * * In addition to meeting regulatory requirements identified within this Laboratory Safety Manual, colleges and departments are strongly encouraged to incorporate the recommendations and guidelines identified within this manual. While this Laboratory Safety Manual provides the minimum requirements and recommendations to meet the intent of the OSHA Laboratory Standard, colleges, departments, Principal Investigators, and laboratory supervisors have the authority to implement more stringent policies within laboratories under their supervision and are encouraged to do so.

2.4.1 Procedural Controls

Procedural controls incorporate best management practices for working in a laboratory. These practices serve not only to protect the health and safety of personnel in the lab, but are a common sense way of increasing productivity in a laboratory. Through implementation of good practices, laboratories can expect an increase in the efficient use of valuable lab space, in the reliability of experiments due to less potential contamination, and an increase in the awareness of health and safety issues by laboratory personnel.

Following the practices outlined in this Lab Safety Manual should also result in a decrease in the number of accidents, injuries, and spills. This will result in a decrease in the overall liability for the Principal Investigator, laboratory supervisor, and the University. Procedural controls are fundamental to instilling safe work behavior and helping to create a culture of safety within the laboratory environment.

2.4.2 Housekeeping

Housekeeping refers to the general condition and appearance of a laboratory and includes:

- Keeping all areas of the lab free of clutter, trash, extraneous equipment, and unused chemical containers. Areas within the lab that should be addressed include benches, hoods, refrigerators, cabinets, chemical storage cabinets, sinks, trash cans, etc.
- Cleaning up all chemicals spills immediately, regardless if the chemical is hazardous or not. When cleaning up a chemical spill, look for any splashes on nearby equipment, cabinets, doors, and counter tops. For more information on cleaning up spills, see the Chemical Spill Procedures section.
- Keeping areas around emergency equipment clean and free of clutter. This includes items such as eyewash/emergency showers, electric power panels, fire extinguishers, and spill cleanup supplies.
- Keeping exits and work areas clear of obstacles and tripping hazards. NYS Fire Code requires 3 feet of clearance.
- When storing items overhead, keep heavier and bulkier items closer to the floor. New York State (NYS) Building Code prohibits the storage of combustible material (such as paper, boxes, plastics, etc.) within two feet of the ceiling in unsprinklered rooms and within 18” of the crown of a sprinkler head in sprinklered rooms.

Good housekeeping has obvious health and safety benefits and can have a positive effect on laboratory personnel who work in a clean environment. During an inspection by a state or federal regulatory agency, the general condition of the laboratory observed in the first few minutes of the inspection (the housekeeping of the lab) can have a significant impact (positive or negative) on the rest of the inspection process.

It is the responsibility of Principal Investigators and laboratory supervisors to ensure laboratories under their supervision are maintained in a clean and orderly manner and personnel working in the lab practice good housekeeping.

2.4.3 Personal Hygiene

Good chemical hygiene practices include the use of personal protective equipment (PPE) and good personal hygiene habits. Although PPE can offer a barrier of protection against chemicals and biological materials, good personal hygiene habits are essential to prevent chemical exposure, even when using PPE. Some general guidelines that should always be followed include:

- Do not eat, drink, chew gum, or apply cosmetics in a lab.

- Do not store food or drink in refrigerators that are used to store chemicals.
- Do not start siphon or pipette by mouth. This can result in ingestion of chemicals or inhalation of chemical vapors. Always use a pipette aid or suction bulb to start a siphon.
- Always confine long hair, loose clothing, and jewelry.
- Wear a lab coat when working with hazardous materials.
- Shorts and sandals should never be worn in a research lab.
- Remove laboratory coats, gloves, and other PPE immediately when chemical contamination occurs. Failure to do so could result in chemical exposure to yourself or others.
- After removing contaminated PPE, be sure to wash any affected skin with soap and water for at least 15 minutes.
- Always remove lab coats, scrubs, gloves, and other PPE before leaving the lab. Do not wear lab coats, scrubs, or other PPE (especially gloves) in areas outside the lab, particularly in areas where food and drink are served, or other public areas.
- Always wash hands with soap and water after removing gloves and before leaving the lab or using items such as the phone, turning doorknobs, or using an elevator.
- Contaminated laboratory clothing should not be taken home for cleaning. EH&S recommends the use of commercial laundry services or disposable lab coats. Contact EH&S at 777-2211 for recommendations.
- Binghamton University is a smoke free campus. Smoking is prohibited in all work areas.

2.4.4 Eating, Drinking, and Applying Cosmetics in the Lab

Chemical exposure can occur through ingestion of food or drink contaminated with chemicals. This type of contamination can occur when food or drinks are brought into a lab or when food or drinks are stored in refrigerators, freezers, or cabinets with chemicals. When this occurs, it is possible for the food or drink to absorb chemical vapors and lead to a chemical exposure when the food or drink is consumed. Eating or drinking in areas exposed to toxic materials is prohibited by the OSHA Sanitation standard, 29 CFR 1910.141(g)(2).

A similar principle of potential chemical exposure holds true with regard to the application of cosmetics (make-up, hand lotion, etc. in a laboratory setting when hazardous chemicals are being used. In this instance, the cosmetics have the ability of absorbing chemical vapors, dusts, and mists from the air and when applied to the skin result in skin exposure to chemicals.

To prevent exposure to hazardous chemicals through ingestion, do not eat, drink, chew gum, or apply cosmetics in areas w here hazardous chemicals are used.

Wash your hands thoroughly after using any chemicals or other laboratory materials, even if you were wearing gloves, and especially before eating or drinking.

To help promote awareness, refrigerators and freezers should be properly labeled:

- Refrigerators for the storage of food should be labeled, “Food Only, No Chemicals” or “No Chemicals or Samples”.

- Refrigerators used for the storage of chemicals should be labeled “Chemicals Only, No Food”.

Keep in mind that some chemical exposure can result in immediate effects (acute exposure) while other effects may not be seen for some time despite repeated exposure (chronic exposure). Consuming food or drink or applying cosmetics in the lab can result in both types of exposure.

2.4.5 Working Alone

Whenever possible, laboratory personnel should avoid working alone, especially when experiments involve hazardous substances and procedures. Laboratories should establish specific guidelines and standard operating procedures specifying when working alone is not allowed and develop notification procedures when working alone occurs. All work to be performed by someone working alone, and the monitoring system that is established, must be approved in advance by the Principal Investigator or laboratory supervisor. Check with your DSR to see if your department has specific requirements for working alone.

If a laboratory person determines it is necessary to work alone, consideration should be given to notifying someone else in the area – in an adjacent room, another lab on the same floor, or a lab on a different floor. It is recommended that a “buddy system” be established for regular, routine checks on personnel working alone, such as every 15 – 30 minutes, to ensure no accidents have occurred. This could be accomplished by physically walking to the room where the lab worker is or through the use of a phone. If the person working alone is doing highly hazardous work, then the person checking on the lab worker should not enter same room. A system of visual checks should be established to indicate there are no problems or to determine if help is needed.

In the event of an emergency that requires the buddy to leave prior to the completion of an experiment involving highly hazardous chemicals, the buddy should notify Binghamton University Police at 777-2222 of the name, location, and end time of the experiment involved. The buddy should also notify the person conducting the experiment. The person conducting the experiment should notify Binghamton Police upon completion of the experiment. **Under no circumstances should Binghamton University Police be used in place of a “lab buddy.”**

Examples of activities where working alone would be permissible include:

- Office work such as writing papers, calculations, computer work, and reading.
- Housekeeping activities such as general cleaning, reorganization of supplies or equipment, etc., as long as no moving of large quantities of chemicals is involved.
- Assembly or modification of laboratory apparatus when no chemical, electrical, or other physical hazards are present.
- Routine lab functions which are part of a standard operating procedure which has been demonstrated to be safe and not involve hazardous materials.

Examples of activities where working using a “buddy system” should be considered include:

- Experiments involving toxic or otherwise hazardous chemicals, especially poison inhalation hazards.
- Experiments involving high-pressure equipment.

- Experiments involving large quantities of cryogenic materials.
- Experiments involving work with unstable (explosives) materials.
- Experiments involving Class 3b or 4 Lasers.
- Transfer of large quantities of flammable materials, acids, bases, and other hazardous materials.
- Changing out compressed gas cylinders containing hazardous materials.

It is the responsibility of Principal Investigators and laboratory supervisors to ensure procedures for working alone are developed and followed by personnel working in laboratories under their supervision.

2.4.6 Unattended Operations

Whenever it is necessary to have unattended operations occur in a lab, it is important to ensure safeguards are put into place in the event of an emergency. Laboratory personnel are strongly encouraged to adhere to the following guidelines when it is necessary to carry out unattended operations.

For unattended operations involving highly hazardous materials, a light should be left on and an appropriate warning/explanation sign should be placed on the laboratory door, or in a conspicuous place that could be easily seen without putting someone else in danger in the event of an emergency. The warning sign should list the following information:

- The nature of the experiment in progress.
- The chemicals in use.
- Hazards present (electrical, heat, etc.)
- The name of the person conducting the experiment and a contact number. A secondary name and contact number is also recommended.

When setting up an experiment that will be left unattended, take into account potential incidents that could occur if something went wrong. For example:

- Use secondary containment such as trays to contain any spills that may occur.
- Use safety shields and keep the hood sash down low to contain chemicals and glass in case an explosion occurs.
- Remove any chemicals or equipment that are not necessary for the experiment or items that could potentially react with the chemicals or other materials being used in the experiment.
- Whenever possible, use automatic shutoff devices to prevent accidents such as loss of cooling water shutoff, overtemperature shut off, etc.
- Use emergency power outlets for those pieces of equipment that could be negatively affected in the event electric service is interrupted.

It is the responsibility of Principal Investigators and laboratory supervisors to ensure procedures for unattended operations are developed and followed by personnel working in laboratories under their supervision.

2.4.7 Access to Laboratories

Access to Binghamton University laboratories, workshops and other work areas housing hazardous materials or machinery is restricted to Binghamton University faculty, staff, students, or other persons on official business.

2.4.7.1 Visitors and Children in Labs

Due to potential hazards and liability issues, other persons, in particular children under the age of 16 are not permitted in hazardous work areas, with the exception of University-sanctioned activity, *e.g.,* tours, open houses, or other University related business as authorized by the Principal Investigator or laboratory supervisor. In these instances, all children under the age of 16 must be under careful and continuous supervision. Check with your DSR to see if your department has specific procedures or policies in place for visitors.

2.4.7.2 Visiting Scientists and Other Similar Users

There are potential risks associated with allowing access to labs and equipment by visiting scientists. These risks include: theft or questions of ownership for intellectual property, bodily injury, and property damage. Departments should verify that all users of the lab have the required safety and health training prior to allowing access to the lab and/or specialized equipment. It is the user's responsibility to have or obtain the appropriate training.

It is the responsibility of the Department Chairperson, Principal Investigators, and laboratory supervisors to restrict access of visitors and children to areas under their supervision when potential health and physical hazards exist.

2.4.8 Chemical Purchasing

Before ordering new chemicals, search your existing inventories and use chemicals currently in stock. An accurate and up-to-date chemical inventory can minimize purchase of chemicals already on hand and can facilitate acquisition of Safety Data Sheets (SDS).

If it is necessary to purchase new chemicals, laboratory personnel should order the smallest size necessary to carry out the experiment. Avoid ordering extra quantities because the chemical "might be needed in the future" as this only contributes to chemical limits and may add to disposal costs.

Some chemical purchases may require special approval or permits, such as those chemicals that are Drug Enforcement Agency (DEA) or Alcohol, Tobacco, and Firearms (ATF) listed substances. DEA List 1 and 2 chemicals may require additional signatures from within the department. DEA Scheduled chemicals MUST be ordered through instructions outlined in the *Controlled Substances in Research Policy*. Select Agents must have prior approval from the Biosafety Officer. Consider contacting EHS for a consultation before purchasing particularly hazardous substances. There are also building and fire codes that restrict the amount of flammable materials that can be stored in any one room, floor, and building at a time. For more information, contact EH&S at 777-2211.

2.4.9 Ordering New Equipment

Whenever large pieces of equipment are planned to be purchased and installed in laboratories, especially equipment that is required to be hooked up to building utility services such as electric, water, or gas, laboratory personnel must first consult with Physical Facilities and EH&S to ensure the building has the necessary resources to support the new equipment. Lab personnel **should not** assume they can purchase equipment first and then expect the building to be able to handle the service requirements later. By preplanning and communicating well in advance, potential issues can be identified ahead of time. This will help make this process smoother

As with installation of fume hoods, certain pieces of equipment require special installation due to their potential impact on the rest of the building ventilation system and utilities, and cannot be hooked up by laboratory personnel or private contractors without first consulting with Physical Facilities and EH&S. Laboratory personnel are strongly encouraged to be proactive and consult with the appropriate departments ahead of time.

Laboratory personnel are strongly encouraged, as responsible campus members, to give consideration to purchasing "Energy Star" energy efficient pieces of equipment to help conserve natural resources and long-term operating costs. When discussing purchases of equipment with vendors and equipment manufacturers, ask about "Energy Star" alternatives they carry.

2.4.10 Service Requests

In the event of a maintenance issue or if repairs are needed to equipment, laboratory personnel should first consult with their Building Administrator, who can then submit the appropriate paperwork with Physical Facilities Customer Service to have repairs initiated. Please note that due to NYS building codes and liability issues, laboratory personnel must not try to repair utility services (such as electrical, plumbing, or gas issues) themselves. These repairs must be handled by qualified personnel only.

Whenever maintenance workers will be working on your hood system or in your laboratory, please remove all chemicals, laboratory apparatus, and equipment from the area requiring maintenance work. Ensure the work area is clean and inform the maintenance workers of any potential hazards present in the vicinity either verbally or by leaving a sign with the appropriate information.

2.4.11 Changes in Lab Occupancy

Changes in laboratory occupancies can occur when faculty retire, new faculty come to campus, new lab staff are hired, students graduate or leave, or when facility renovations take place. When changes in lab occupancy occur, it is important to address any potential issues BEFORE the occupants leave.

Failure to address the change in occupancy can result in:

- Old, unlabeled chemicals, samples, or hazardous waste being left behind in refrigerators, freezers, and cabinets.
- Valuable furniture or equipment being moved or thrown away.
- Unknown chemical spills or contamination being present.

These issues can result in costly remediation efforts and wasted resources for both the department and the University.

If you are planning to leave your laboratory or if you know of a research group or students that are planning to leave, there are a few simple steps that can be followed to ensure a smooth transition:

- Complete Lab Close Out, Transfer, Temporary Shutdown Procedures
- Notify your department chairperson, lab supervisor, and DSR well in advance of the planned move.
- Ensure all chemical containers are properly labeled with full chemical name
- Properly dispose of any hazardous and chemical waste left in the laboratory.
- Ensure all chemical spills and contamination have been cleaned up.

2.4.12 Ventilation Rates

As part of energy conservation measures, ventilation rates for laboratories are determined based on the occupancy and type of research being conducted. Whenever the function of a room changes, it is very important to notify EH&S at 777-2211. EH&S will then verify if the ventilation rate for a given room is appropriate for the type of research being conducted.

2.4.14 Laboratory Self Inspections

An important part of any laboratory safety program is implementation of laboratory self-inspections. Laboratory self-inspections provide a number of useful benefits and further help to create a culture of safety within the lab. Benefits of self-inspections include:

- Raising the level of awareness of laboratory personnel and determining the level of compliance with state and federal regulations.
- Identifying and addressing any potential issues before an inspection by a state or federal regulatory agency.
- Providing an opportunity for lab specific training by identifying potential issues within the lab and then training lab personnel.
- Serving as a regular health and safety check of laboratory facilities.
- Serving as an outlet for faculty, staff, and student concerns.

EH&S recommends the following frequency for laboratory self-inspections:

- On a daily basis, lab personnel should maintain good housekeeping within their lab.
- Informal weekly lab walkthroughs.
- Ideally, formal once per month lab self-inspections should occur. These could include participation of laboratory staff, DSRs, and/or safety committee members, and use of a laboratory inspection checklist.
- At least once per semester lab personnel should perform a formal lab self-inspection.

EH&S can train laboratory personnel to properly conduct a lab inspection using the EH&S self-inspection checklist.

The benefits of conducting inspections of laboratories on a regular basis cannot be overstated. In addition to providing for a healthier and safer work environment, lab inspections can reduce legal liability by identifying potential issues, and training lab personnel to look for and correct potential issues.

2.4.15 Laboratory Security

Laboratories need to take specific actions in order to provide security against theft of highly hazardous materials, valuable equipment, and to ensure compliance with state and federal regulations. EH&S encourages each unit (college, department, and research group) to review and develop procedures to ensure the security of all hazardous materials in their area of responsibility.

Many laboratories already implement various means of security, including required locking up of controlled substances, syringes and needles, and radioactive materials. EH&S recommends you review and assess the hazardous materials in your laboratory and consider security to protect those materials. The intent is to minimize the risk of theft, especially targeting the five-minute window when the lab is left unattended.
*** * * One easy way to increase security is to make sure that your laboratory door is locked whenever the lab is left unattended, even for a few minutes.**

2.4.15.1 Security Guidelines

The following are guidelines designed to minimize opportunities for intentional removal of any hazardous materials from your laboratory:

- <u>Recognize that laboratory security is related to, but different from laboratory safety</u>. Security is preventing intrusion into the laboratory and the theft of equipment or materials from the lab.
- <u>Develop a site-specific security policy</u>. Assess your laboratory area for hazardous materials and particular security issues. Develop and implement lab security procedures for your lab group and train lab group members on security procedures and assign responsibilities.
- <u>Control access to areas where hazardous chemicals are used and stored</u>. Limit laboratory access to only those individuals who need to be in the lab and restrict off-hours access only to individuals authorized by the Principal Investigator.
- Be sure to lock freezers, refrigerators, storage cabinets, and other containers where stocks of biological agents, hazardous chemicals, or radioactive materials are stored when they are not in direct view of workers (for example, when located in unattended storage areas).
- Do not leave hazardous materials unattended or unsecured at any time. Most importantly, close and lock laboratory doors when no one is present.
- Note: If staff work alone, and use the buddy system with someone outside of the research group, allowing access for that individual will need to be addressed prior to the initiation of working alone.
- <u>Know who is in the laboratory area at any given time</u>. Consider using a logbook for staff to sign in and out each day or use carded access devices. Consider having all lab staff wear

identification tags. If you don't recognize someone who appears to be wandering in laboratory areas call University Police at 777-2222 or 911 from any university phone.

- Secure your highly hazardous materials. Use a log to sign hazardous materials in and out of secure storage. Take periodic inventory of all highly hazardous chemicals, biological agents/toxins, and controlled substances (this is required for use of radioactive materials). This could be as simple as frequently looking at your chemical containers to be sure that none are missing. Laboratories are required to maintain a chemical inventory. Report any missing inventory to University Police (777-222) immediately.
- Know what materials are being ordered and brought into the laboratory area. Visually screen packages before bringing them into your lab. Packages containing potentially infectious materials should be opened in a biological safety cabinet or other appropriate containment device. Know what materials are being removed from the laboratory area and consider tracking the use and disposal of hazardous materials.
- Develop an emergency plan and protocols for reporting incidents. Department Heads should have policies and procedures in place for the reporting and investigation of incidents or possible incidents, such as undocumented visitors, missing chemicals, or unusual or threatening phone calls. Review protocols and emergency plans and update as necessary. Be sure to include the lab's emergency contact information on your emergency information sheet, located on or near your laboratory door.
- Be aware of the classes of security risk hazardous chemicals. Laboratory researchers should be aware of the highly hazardous materials or other special materials of concern. The Centers for Disease Control and Prevention maintains lists of biological diseases and chemical agents.
- Pay special attention to the following:
    - Open labs
    - Unrestricted access to toxic chemicals
    - Unlocked support rooms
    - Toxic gas security
    - Unsecured biological materials and waste
    - Access to controlled substances
    - Changes in chemical inventory
    - Storeroom security
    - Chemical waste collection areas

Many of the laboratory supply catalogs carry information and products such as locks, lock boxes, and other security devices for chemical storage in laboratories. For more information, you can contact EH&S for assistance (777-2211) and/or consult with the University Lock Shop (777-2226) about security devices.

2.4.16 Energy Conservation in Laboratories

Laboratories are known to be energy intensive facilities, consuming many times the energy use of the average non-lab academic buildings. Laboratories use large quantities of heated and cooled, one-pass air for ventilation and fume hoods; electricity to operate fans, lighting, and specialized lab equipment; and large quantities of water and process chilled water. Some laboratory facilities also use substantial quantities of natural gas.

Many improvements to facility design, including the computerized control of lab buildings, have led to substantial energy savings in recently constructed lab buildings. However, many of these energy saving improvements are only fully effective if people working in labs are also involved in the energy conservation efforts. There are a number of things that YOU can do to reduce the overall consumption of energy in YOUR laboratory:

1 Turn off the lights when you leave during the day and at the end of every day, especially if your lights do not have a setback (turn themselves off after a few minutes).
2 Whenever possible, turn off all electrical equipment when not in use, especially before you leave for the day.
3 Use timers to turn pieces of equipment on and off automatically.
4 Turn off your computer's monitor when not in use. If for some reason you can't turn your computer off, then turn on your computer's energy saving features. This feature will put your computer and monitor to "sleep" after 10 minutes and cut power use nearly to zero.
5 Keep the sash closed on your fume hood, especially if you have a Variable Air Volume (VAV) type fume hood. This promotes both energy conservation and safety. A typical five-foot fume hood uses $3500 per year in heating and cooling costs. Keeping your VAV hood sash closed can cut the air volume and cost by two thirds!
6 Rooms that are too hot or too cool may be due to faulty thermostats or other controls that are malfunctioning or have drifted from set points, resulting in wasted energy as well as uncomfortable conditions for you. If you experience these problems, contact your Building Administrator for assistance.
7 Report drips of water from sink taps, chilled water connections or Reverse Osmosis (RO) faucets.
8 Buy energy efficient equipment. Look for the Energy Star logo or other statements that an electrical device is designed to be energy efficient.
9 When purchasing natural gas powered or consuming devices, buy equipment that uses an electronic ignition instead of a pilot light. Pilot lights waste over 20 percent of the gas used in the United States.
10 Use shades and blinds as provided to help keep your space cool on sunny days. Shade can reduce the amount of cooling required in a south or west facing room by over 30%.

Reducing energy consumption not only conserves precious natural resources, but also reduces energy costs for the University, which results in more funds being available for other endeavors. Additional information on selecting energy efficient products can be obtained at the EPA Pollution Prevention website for Green products and the Energy Star website. Additional information on energy conservation for both work and home can be found on the Department of Energy's website: Energy Efficiency and Renewable Energy.

3.0 EMERGENCY PREPAREDNESS

IN CASE OF AN EMERGENCY:
CALL 911 from any campus phone or dial 777-2222 from any cell or off campus phone to reach Binghamton University Police.

Emergencies can occur at any time, without warning. Careful planning, with an emphasis on safety, can help members of the Binghamton community handle crises and emergencies with appropriate responses, and could save lives. Every member of the Binghamton community shares responsibility for emergency preparedness.

Building Administrators are responsible for ensuring that their buildings have emergency plans in place, and that all persons – including faculty, staff and students – are familiar with those emergency plans. Building Administrators are also responsible for assigning emergency preparedness and response duties to appropriate staff members.

3.1 Emergency Evacuation Procedures

Evacuation is required every time the fire alarm sounds, an evacuation announcement is made, or a university official orders you to evacuate. When an evacuation occurs, building occupants should exit immediately, putting their department's evacuation plan into effect. After the building has been evacuated, occupants must wait for an "All Clear" from University Police or EH&S before re-entry.

3.1.1 General Evacuation Procedures

- Turn equipment off if it is safe to do so.
- Quickly shutdown any hazardous operations or processes and render them safe.
- Notify others in the area of the alarm if they did not hear it while you are evacuating yourself.
- Take jackets or other clothing needed for protection from the weather, and your keys
- Close windows and doors as you leave, but do not lock the doors.
- Leave room lights on.
- Exit the room.

3.1.2 Evacuation of Persons with Disabilities

Be aware that faculty, staff and students with "hidden" disabilities (arthritis, cardiac conditions, back problems, learning disabilities, etc.) may also need individual assistance. Use the following list to assist both helpers and disabled persons. Use a "buddy system" naming who is responsible for whom.

If you are unable to leave the building due to a physical disability:

- Go to the nearest area where there are no hazards.
- Dial 911 from a campus telephone or, using a cell phone, dial 777-2222 to call University Police.

- Be sure to give the room number so they can send help to you.
- If possible, signal out the window to on-site emergency responders.
- One person may remain with you if they wish to assist you.
- To exit the building, walk to the nearest safe exit route (do not run). Do not use elevators to exit.
- Move away from the building, report to the designated evacuation point and meet with other persons from the building. Wait at evacuation point for directions.
- Account for faculty, staff and students and sign in at the evacuation point. Report any missing or trapped people to the emergency responders. Keep existing groups together.

Assisting Visually Impaired Persons

- Announce the type of emergency.
- Offer your arm for guidance.
- Tell the person where you are going, and any obstacles you encounter.
- When you reach safety, ask if further help is needed.

Assisting People with Hearing Limitations

- Turn lights on/off to gain the person's attention, or indicate directions with gestures, or write a note with evacuation directions.

Assisting People Using Crutches, Canes, or Walkers

- Evacuate these individuals as injured persons.
- Assist and accompany to evacuation site if possible, or use a sturdy chair (or one with wheels) to move the person, or help carry the individual.

Assisting Wheel Chair Users

- Non-ambulatory persons' needs and preferences vary.
- Individuals at ground floor locations may exit without help.
- Others may have minimal ability to move – lifting may be dangerous.
- Some non-ambulatory persons have respiratory complications.
- Remove them from smoke and vapors immediately.
- Most wheelchairs are too heavy to take down stairs.
- Consult with the person to determine best carry options. • Reunite the person with the chair as soon as it is safe to do so.

3.2 Emergency Procedures

Emergencies can include both fire and non-fire emergencies. Non-fire emergencies can include:

- Loss of electricity, heat, AC, water or other essential utilities.
- Failure of mechanical equipment such as HVAC systems and emergency generators.

- Flooding, tornadoes, earthquakes, or other natural disasters.
- Nearby chemical releases of hazardous materials to the environment.
- Terrorist actions or civil unrest.

3.2.1 Laboratory Emergency Shutdown Procedures for Non-Fire Emergencies

Each laboratory facility should develop a non-fire emergency plan or incorporate non-fire emergencies into a master emergency response plan. Employees must be trained on the content of the plan and how to respond in a non-fire emergency. Binghamton EH&S has devised a set of simple steps for the shutdown of labs in non-fire emergency situations. These and other steps, based on the requirements of the facility, should be included in the emergency response plan of each facility. This list is by no means complete, but it gives laboratory personnel simple steps to ensure a safe lab shutdown.

- Close fume hood sashes.
- Be certain caps are on all bottles of chemicals.
- Turn off all non-essential electrical devices. Leave refrigerators and freezers on and make sure the doors are closed. Check the disconnects of large LASERs, radio frequency generators, etc. It may be necessary to check to ensure that essential equipment is plugged in to the power receptacles supplied by the emergency generator (usually orange or red).
- Turn off all gas cylinders at the tank valves. Note: If a low flow of an inert gas is being used to "blanket" a reactive compound or mixture, then the lab worker may want to leave the flow of gas on. This should be part of a pre-approved, written, posted standard operating procedure for this material or process.
- Check all cryogenic vacuum traps (Nitrogen, Carbon dioxide, and solvent). The evaporation of trapped materials may cause dangerous conditions. Check all containers of cryogenic liquids to ensure that they are vented to prevent the buildup of internal pressure.
- Check all pressure, temperature, air, or moisture sensitive materials and equipment. This includes vacuum work, distillations, glove boxes used for airless/moisture less reactions, and all reactions in progress. Terminate all reactions that are in progress, based on the known scope of the emergency.
- If experimental animals are in use, special precautions may need to be taken to secure those areas such as emergency power, alternative ventilation, etc.
- All non-essential staff/students must leave the building. Depending on the nature of the emergency, some staff may need to stay behind to facilitate the start-up of essential equipment once the lab is reopened.
- It is important to remember that some equipment does not shut down automatically – such as large cryogenic magnets, sources of radioactivity, and other pieces of equipment. Be sure to check any special operating procedures for your equipment before an emergency occurs.

3.2.2 Medical Emergency Procedures

- Protect the victim from further injury or harm by removing any persistent threat to the victim or by removing the victim to a safe place if needed, however do not move the victim unnecessarily. Do not delay in obtaining trained medical assistance if it is safe to do so.

- Notify UPD of the location, nature and extent of the injury by calling 911 or 777-2222 from a cell phone or off campus or using a Blue Light or Emergency Telephone. Always call from a safe location.
- Provide first aid until help arrives if you have appropriate training and equipment, and it is safe to do so.
- Send someone outside to escort emergency responders to the appropriate location, if possible.

3.2.3 Fire or Explosion Emergency Procedures

- Alert people in the immediate area of the fire and evacuate the room.
- Confine the fire by closing doors as you leave the room.
- Activate the building fire alarm system by pulling the handle on a fire alarm box.
- Notify UPD of the location and size of the fire by calling 911 from a campus phone, or 777-2222 from a cell phone or off campus phone, or using a Blue Light or Emergency Telephone. Always call from a safe location.
- Evacuate the building using the established Emergency Evacuation Procedure.

3.2.3.1 Fire Extinguishers

- All fire extinguishers are inspected monthly and maintained by EH&S.
- Laboratory personnel should perform regular visual checks (***minimum on a monthly basis***) to ensure fire extinguishers present in their labs are fully charged. For those fire extinguishers with a readout dial, labs only need to ensure the indicator arrow on the readout dial is within the green zone. If the indicator arrow is on either side of the green zone, call EH&S at 777-2211 to have the fire extinguisher replaced.
- Any fire extinguisher that has been used at all, even if it wasn't fully discharged, needs to be reported to EH&S so a replacement fire extinguisher can be provided. You can also obtain training in using a fire extinguisher by contacting EH&S at 777-2211.

3.2.4 Power Outage Procedures

- Assess the extent of the outage in the area.
- Report the outage to Binghamton University Customer Service Center at 777-2226.
- Assist other building occupants to move to safe locations. Loss of power to fume hoods may require the evacuation of laboratories and surrounding areas.
- Evaluate the Departments work areas for hazards created by a power outage. Secure hazardous materials. Take actions to preserve human and animal safety and health. Take actions to preserve research.
- Turn off and/or unplug non-essential electrical equipment, computer equipment and appliances. Keep refrigerators and freezers closed throughout the outage to help keep contents cold.

3.3 Chemical Spill Procedures

When a chemical spill occurs, it is necessary to take prompt and appropriate action. The type of response to a spill will depend on the quantity of the chemical spilled and the severity of the hazards associated with the chemical. The first action to take is to alert others in your lab or work area that a spill has occurred. Then you must determine if you can safely clean up the spill yourself.

Many chemical spills can be safely cleaned up by laboratory staff without the help of EH&S. Attempt to clean-up small spills only if you are trained and have the proper spill clean-up materials available. Note: The following advice is intended for spills that occur within a University building. A release to the outside environment may to require the University file a report with the Environmental Protection Agency and/or the Department of Environmental Conservation. Calling University Police will initiate this determination by the Department of Environmental Health and Safety.

3.3.1 Small Spills

A spill is considered small if the criteria below are met:

Physical:

- The spill is a small quantity of a known chemical.
- No gases or vapors are present that require respiratory protection.

Equipment:

- You have the materials and equipment needed to clean up the spill.
- You have the necessary proper personal protective (PPE) equipment available.

Personal:

- You understand the hazards posed by the spilled chemical.
- You know how to clean up the spill.
- You feel comfortable cleaning up the spill.

3.3.1.1 Small Spill Cleanup Procedures

1) Notify other people in the area that a spill has occurred. Prevent others from coming in contact with the spill (i.e. walking through the spilled chemical). Your first priority is to always protect yourself and others.
2) Put on the Proper Personal Protective Equipment (PPE) such as goggles, gloves, etc. before beginning cleanup. Do not expose yourself to the chemical.
3) Stop the source of the spill if possible, and if safe to do so.
4) Try to prevent spilled chemicals from entering waterways by building a dike around access points (sink, cup sinks, and floor drains inside and storm drains outside) with absorbent material if you can safely do so.
5) Use the appropriate absorbent material for liquid spills (detailed in the following section).

6) Slowly add absorbent material on and around the spill and allow the chemical to absorb. Apply enough absorbent to completely cover the spilled liquid.
7) Sweep up the absorbed spill from the outside towards the middle.
8) Scoop up and deposit in a leak-proof container.
9) For absorbed hazardous chemicals, label the container and dispose of through the hazardous waste management program.
10) Wash the contaminated surface with soapy water. If the spilled chemical is toxic, collect the rinse water for proper disposal.
11) Report the spill to your supervisor.
12) Restock any spill cleanup supplies that you may have used from any spill kits.

3.3.1.2 Spill Absorbent Materials

Note: *The following materials are EH&S recommended spill absorbent materials. They are NOT appropriate for every possible chemical spill – when in doubt, contact EH&S at 777-2211 for advice.*

For acid spills (except Hydrofluoric acid):

- Sodium carbonate
- Sodium bicarbonate (baking soda)
- Calcium carbonate
- Calcium bicarbonate
- Do not use absorbent clay for acid spills

For Hydrofluoric acid (HF) spills:

- Use Calcium carbonate or Calcium bicarbonate to tightly bind the fluoride ion.

For liquid base spills:

- Use Sodium bicarbonate powder to neutralize the spill

For oil spills:

- Use speedi-dri or oil spill pads

For most aqueous solutions:

- Use clay absorbent (speedi-dri)

For most organic liquid spills:

- Use ground clay absorbent (speedi-dri). If the liquid is flammable, be sure to use an excess of speedi-dri.

For oxidizing liquids:

- Use absorbent clay, vermiculite, or some other nonreactive absorbent material. Do not use speedi-dri or paper towels. Note: Most nitrate solutions are not sufficiently oxidizing for this requirement.

For mercury spills:

- Do not dispose of mercury or mercury contaminated spill debris in the regular trash or down the drain.
- Use the provided mercury spill kits in the spill bucket to clean up mercury spills.
- If you need help collecting Mercury from a spill, contact EH&S 777-2211.

3.3.1.3 Spill Kits

While commercially available spill kits are available from a number of safety supply vendors, laboratory personnel can assemble their own spill kits to properly clean up chemicals specific to their laboratory. Whether commercially purchased, made in-house, or provide by EH&S, every lab is required to have and maintain a spill bucket.

A useful spill kit can be assembled using a 2.5 or 5-gallon bucket containing the following absorbent materials. Stock only the absorbents appropriate for your space. Each container of absorbent must be labeled as to what it contains and what type of spills it can be used for.

Spill kit absorbent material:

- 1-5 lbs. of clay absorbent material (speedi-dri) – for most aqueous and organic liquid spills.
- 1-5 lbs. of clay absorbent clay (speedi-dri) - for oil spills.
- 1-5 lbs. of Sodium bicarbonate - for liquid acid spills.
- 1-5 lbs. of Calcium carbonate or Calcium bicarbonate - for HF spills.
- 1-5 lbs. of citric acid – for base spills.

Equipment in the spill kit could include:

- Whisk broom and dust pan (available at home improvement stores)
- Sponge
- pH paper
- Small and large Ziploc bags – for collection of spill cleanup material or to enclose leaking bottles/containers.
- Safety goggles
- Nitrile gloves
- Hazardous waste labels and tags

The spill kit should be clearly labeled "SPILL KIT", with a list of the contents posted on or in the kit. This list should include information about restocking the kit after use and where to obtain restocking materials. Laboratory personnel must also be properly trained on:

- How to determine if they can or should clean up the spill, or if they should call 911 or EH&S at 777-2211.
- Where the spill kit will be kept within the laboratory.
- What items are in the kit and where replacement items can be obtained.
- How to use the items in the kit properly
- How to clean up the different types of chemical spills.

- How to dispose of spill cleanup material.

Environmental Health and Safety can provide assistance in assembling spill kits for laboratories and can offer training on cleaning up small spills. More information can be obtained by contacting Environmental Health and Safety at 777-2211.

3.3.2 Major Spills

A spill is considered Major if any of the criteria below are met:

Physical:

- The spill is **any quantity** of an unknown chemical.
- The spill is a **large** quantity of a known chemical
- Gases or vapors **may be** present that require respiratory protection.

Equipment:

- You **do not** have the materials and equipment needed to clean up the spill.
- You **do not** have the necessary proper personal protective (PPE) equipment available.

Personal:

- You **do not** understand the hazards posed by the spilled chemical.
- You **do not** know how to clean up the spill.
- You **do not** feel comfortable cleaning up the spill.

EH&S is activated to assist with spill cleanup whenever Binghamton University Police are notified of a spill by calling 911 from a campus phone or 777-2222 from a cell phone.

3.3.2.1 Major Spill Cleanup Procedures

When a spill occurs that you are not capable of handling:

- Alert people in the immediate area of the spill and evacuate the room.
- If an explosion hazard is present, do not unplug, or turn electrical equipment on or off – doing so can result in a spark and ignition source.
- Confine the hazard by closing doors as you leave the room.
- Use eyewash or safety showers as needed to rinse spilled chemicals off others or yourself.
- Evacuate nearby rooms that may be affected. If the hazard will affect the entire building, evacuate the building by pulling the fire alarm.
- Notify Binghamton University Police from a safe location by calling 911, using a campus Emergency Telephone, or dial 777-2222 from a cell phone.

Be prepared to provide Binghamton University Police with the following information:

- Where the spill occurred (building and room number).

- If there are there any injuries and if medical attention is needed.
- The identity of the spilled material(s) - be prepared to spell out the chemical names.
- The approximate amount of material spilled.
- How the spill occurred (if you know)
- Any immediate actions you took.
- Who first observed the spill and the approximate time it occurred.
- Where you will meet emergency responders, or provide a call back number (if available).

Once outside, notify emergency responders of the location, nature and size of the spill. Isolate contaminated persons.

3.4 Emergency Eyewash and Showers

All laboratories using hazardous chemicals, particularly corrosive chemicals, must have access to an eyewash and/or an emergency shower as per the OSHA standard 29 CFR 1910.151 – Medical Services and First Aid. The ANSI Standard Z358.1-2014 - Emergency Eyewash and Shower Equipment, provides additional guidance, stating that emergency eyewash and/or emergency showers must be readily accessible, free of obstructions and within 10 seconds from the hazard. The ANSI standard also outlines specific requirements related to flow requirements, use of tempered water, inspection and testing frequencies, and training of laboratory personnel in the proper use of this important piece of emergency equipment.

Due to the flow requirements outlined in the ANSI standard, hand held bottles **do not** qualify as approved eyewashes. Hand held eyewash bottles are acceptable to use in conjunction with an eyewash, such as sink mounted or portable units.

Plumbed eyewash units and emergency showers should ideally have a tempering valve in place to prevent temperature extremes to the eyes or body. If you have questions about where eyewashes and emergency showers should be located, or which models meet ANSI standards, contact EH&S at 777-2211.

3.4.1 Testing and Inspection of Emergency Eyewash and Showers

The ANSI Standard provides guidance stating that plumbed emergency eyewash and safety showers should be activated **weekly** to verify proper operation and inspected annually. Regular activation (weekly flushing) ensures the units are operating properly, helps to keep the units free of clutter, and helps prevent the growth of bacteria within the plumbing lines, which can cause eye infections.

It is the responsibility of laboratory personnel to activate (flush) units on a weekly basis. It is recommended to allow the water to run long enough to flush the stagnant water from the unit, generally around 10 seconds. EH&S strongly encourages laboratories to post an "Eyewash Weekly Testing Log" near the eyewash to keep track and document that weekly activation is occurring.

Laboratories are responsible for ensuring access to eyewashes and emergency showers is kept free of clutter and ensuring the eyewash nozzle dust covers are kept in place. If nozzle dust covers are not kept on the eyewash nozzles, dust or other particles can clog the nozzles and result in poor or no water flow. This can also result in dust or other particles being forced into the eyes when the eyewash is used.

If you discover your emergency shower or eyewash is not functioning properly, contact your Building Administrator to request an emergency work order.

EH&S performs free annual inspections of eyewashes and emergency showers. EH&S will test units for compliance with ANSI Z358.1-2014 including:

- Test the water flow for proper quantity, spray pattern, and good water quality.
- Ensure the unit is not obstructed.
- Ensure water is tepid as described in the ANSI Standard
- Ensure valves are working properly.
- Ensure signs are posted.
- Ensure the unit is free of corrosion.

As with installation of new fume hoods, all new eyewashes and emergency showers must be installed in consultation with Physical Facilities and EH&S.

In addition to ensuring proper installation of your new eyewash or emergency shower, by consulting with EH&S on new installations, your new eyewash or emergency shower will be added to our inventory to be included in our free annual inspection and testing program.

3.4.2 Using Emergency Eyewash and Showers

In the event of an emergency (chemical spill or splash) where an eyewash is needed, please adhere to the following procedures:

1. If you get a chemical in your eyes, yell for help if someone else is in the lab.
2. Immediately go to the nearest eyewash and push the activation handle all the way on.
3. Put your eyes or other exposed area in the stream of water and begin flushing.
4. Open your eyelids with your fingers and roll your eyeballs around for maximum irrigation of the eyes.
5. Keep flushing for at least 15 minutes or until help arrives. The importance of flushing the eyes first for at least 15 minutes cannot be overstated!
6. If you are alone, call 911 after you have finished flushing your eyes for at least 15 minutes.
7. Seek medical attention.

8. Complete an accident report.

If someone else in the lab needs to use an eyewash, assist them to the eyewash, activate the eyewash for them, and help them get started flushing their eyes using the procedures above and then call **911** from a campus phone or **777-2222** from a cell phone. After calling for help, go back to assist the person using the eyewash and continue flushing for 15 minutes or until help arrives, and have the person seek medical attention.

Emergency Showers:

1. If you get chemical contamination on your skin resulting from an accident, yell for help if someone else is in the lab.
2. Immediately go to the nearest emergency shower and pull the activation handle.
3. Once under the stream of water, begin removing your clothing to wash off all chemicals.
4. Keep flushing for at least 15 minutes or until help arrives. The importance of flushing for at least 15 minutes cannot be overstated! If you spill Hydrofluoric acid on yourself, follow the special Hydrofluoric acid first aid in section 3.4.3.
5. If you are alone, call 911 after you have finished flushing for at least 15 minutes.
6. Seek medical attention.
7. Complete an accident report.

If someone else in the lab needs to use an emergency shower (and it is safe for you to do so), assist them to the emergency shower, activate the shower for them, and help them get started flushing using the procedures above. Then call **911** from a campus phone or **777-2222** from a cell phone. After calling for help, go back to assist the person using the shower and continue flushing for 15 minutes or until help arrives and have the person seek medical attention.

NOTE: Although an emergency is no time for modesty, if a person is too modest and reluctant to use the emergency shower, you can assist them by using a lab coat or other piece of clothing or barrier to help ease their mind while they undress under the shower. If you are assisting someone else, you should wear gloves to avoid contaminating yourself.

When using an emergency shower, do not be concerned about damage from flooding. The important thing to remember is to keep flushing for 15 minutes. If there is a large quantity of chemical spilled or washed off, please contact EH&S at
777-2211 to see if the rinse needs to be collected as hazardous waste.

3.4.3 Hydrofluoric Acid First Aid

For splash:

1) YELL FOR HELP! – Stay calm
2) Go IMMEDIATELY to a shower (or sink) and wash contaminated area with water
3) Remove contaminated clothing while washing

4) Wash until all acid is removed from surface (limit washing to 5 minutes if calcium gluconate is available, otherwise wash until help arrives).
5) Dry area quickly and apply calcium gluconate gel to affected area and massage into skin (wear gloves). Do this until medical help arrives.
6) If HF is under nails, try to scrub the calcium gluconate underneath
***If you are alone dial 911 at this point

If in eyes: Hold eyes open and rinse in eyewash until help arrives – Do not use calcium gluconate gel in the eyes

If inhalation: Get victim to fresh air. If a first responder is there they should administer oxygen

HF burn victims must always get medical treatment

3.5 Accident Reporting

All accidents and injuries, no matter how minor, are required to be reported to University officials through the accident/injury reporting system. The supervisor of an injured employee, the department head, or a designated individual within the department must complete all sections of Accident form (CS-13) within **24 hours** after the injury is first reported.

It is the responsibility of the Principal Investigator and laboratory supervisor to ensure all accidents and injuries are reported to University officials through the use of the Binghamton University injury reporting system.

3.6 Medical Consultations

When a chemical exposure occurs, medical consultations and medical examinations will be made available to laboratory workers who work with hazardous chemicals as required. All work related medical examinations and consultations will be performed by or under the direct supervision of a licensed physician and will be provided at no cost to the employee without loss of pay, and at a reasonable time.

The opportunity to receive medical attention, including any follow up examinations, will be provided to employees who work with hazardous chemicals under the following circumstances:

- Whenever an employee develops signs or symptoms associated with a hazardous chemical to which the employee may have been exposed in the laboratory.
- Where airborne exposure monitoring reveals an exposure level routinely above the action level (or in the absence of an Action Level, the Permissible Exposure Limit) for an OSHA regulated substance for which there are exposure monitoring and medical surveillance requirements. Action Level means the airborne concentration of a specific chemical, identified by OSHA, and calculated as an 8-hour time weighted average (TWA).

- Whenever an event such as a spill, leak, explosion or other occurrence takes place and results in the likelihood of a hazardous exposure. Upon such an event, the affected employee shall be provided an opportunity for a medical consultation. The consultation shall be for the purpose of determining the need for a medical examination. 74 More information on action levels and Permissible Exposure Limits can be found on the OSHA Health and Safety topics page – Permissible Exposure Limits.

3.6.1 Information Provided to the Physician

The physician shall be provided with the following information:

- The identity of the hazardous chemical(s) to which the employee may have been exposed. Such information can be found in the Safety Data Sheet (SDS) for the chemical(s). If you do not have a copy please contact EH&S at 777-2211
- A description of the conditions under which the exposure occurred including quantitative exposure data, if available.
- A description of the signs and symptoms of exposure that the employee is experiencing, if any.

3.6.2 The Physician's Written Opinion

The physician's written opinion for the consultation or examination shall include:

- The results of the medical examination and any associated tests.
- Any medical condition that may be revealed in the course of the examination, which may place the employee at increased risk as a result of exposure to a hazardous workplace.
- A statement that the employee has been informed by the physician of the results of the consultation or medical examination and any medical condition that may require further examination or treatment.
- The written opinion shall not reveal specific findings of diagnoses unrelated to the occupational exposure.

All records of medical consultations, examinations, tests, or written opinions shall be maintained at facility in accordance with 29 CFR 1910.1020 - Access to employee exposure and medical records. Exposure monitoring records of contaminate levels in laboratories will be maintained by EH&S (777-2211).

4.0 EMPLOYEE INFORMATION AND TRAINING

Federal and state laws and Binghamton University policy require all laboratory workers to receive laboratory safety training and be informed of the potential health and safety risks that may be present in their workplace. Documentation must be maintained to demonstrate that such training was provided and received.

In order to assist laboratory personnel compliance with this requirement, laboratory safety training must be obtained either through EH&S or documented as having been received from an alternative source. Laboratory personnel who attend EH&S training classes will have documentation maintained by EH&S.

Laboratory personnel who have not attended the EH&S Laboratory Safety Training program must submit documentation of training received from alternative sources for verification by EH&S.

The OSHA Laboratory Standard requires employers to provide employees with information and training to ensure they are apprised of the hazards of chemicals present in their work area. The Laboratory Standard states that such information shall be provided at the time of an employee's initial assignment to a work area where hazardous chemicals are present and prior to assignments involving new exposure situations.

As per the OSHA Laboratory Standard, information that must be provided to employees includes:

- The contents of the Laboratory Standard and its appendices (Appendix A and Appendix B) shall be made available to employees.
- The location and availability of the employer's Chemical Hygiene Plan (in the EH&S office, located in the Health Services Building).
- The permissible exposure limits for OSHA regulated substances or recommended exposure limits for other hazardous chemicals where there is no applicable OSHA standard (available through the SDS for the substance).
- Signs and symptoms associated with exposures to hazardous chemicals used in the laboratory.
- The location and availability of identified reference materials listing the hazards, safe handling, storage and disposal of hazardous chemicals found in the laboratory including, but not limited to, SDS's received from the chemical supplier.

The Laboratory Standard states this training shall include:

- Methods and observations that may be used to detect the presence or release of a hazardous chemical.
- The physical and health hazards of chemicals in the work area.
- The measures employees can take to protect themselves from these hazards, including specific procedures the employer has implemented to protect employees from exposure to hazardous chemicals, such as appropriate work practices, emergency procedures, and PPE to be used.

The employee shall be trained on the applicable details of the employer's written Chemical Hygiene Plan.

It is the responsibility of Principal Investigators and laboratory supervisors to ensure personnel working in laboratories under their supervision have been provided with the proper training, have received information about the hazards in the laboratory they may encounter, and have been informed about ways they can protect themselves.

4.1 Training Options

Principal Investigators and laboratory supervisors have a number of options available to them to ensure laboratory employees under their supervision have received proper training. These options include:

- Training programs provided by EH&S
- Training programs provided by outside vendors

- In-house training programs (provided by the Principal Investigator or laboratory supervisor)
- Training manuals and booklets
- Training videos
- Web-based training modules

The keys to any good training program are:

- The instructor providing the training is technically qualified to provide training on the particular subject.
- The training program(s) address the hazards present in the laboratory and describe ways employees can protect themselves.
- The training program and attendance must be documented using a sign-in sheet and these records must be readily available and accessible upon request.

Please note that one training class is usually not comprehensive enough to cover all of the hazards found within a laboratory. Principal Investigators and laboratory supervisors may find that it is necessary to use a combination of the options available to ensure their employees are properly trained.

EH&S Training Programs

EH&S offers a number of training programs which you can request. EH&S can come to your building or laboratory and provide the training program for your laboratory group. All EH&S provided training programs and attendance sheets are kept on file at the EH&S office.

Outside Vendor Training Programs

Principal Investigators and laboratory supervisors can provide training programs to their employees through contracts with outside training companies or product vendors. A number of vendors are willing to provide free training programs upon request. If using an outside company or vendor, be sure to ask for documentation including: training content, date of training, copies of handouts, and the sign-in sheet. All of this documentation must be kept on file.

In-House Training Programs

In-house training can include department provided training, and training by Principal Investigators and laboratory supervisors. Training sessions can be stand-alone classes, on-the-job training, or short trainings incorporated as part of a laboratory group meeting. The key is to make sure the training is documented with a sign-in sheet.

Training Manuals and Booklets

Principal Investigators and laboratory supervisors can utilize training manuals, booklets, webpage downloads, etc., as part of an ongoing training program by simply having laboratory staff review the material, be given an opportunity to ask any questions, and sign off that they read <u>and</u> understood the material. All training material must be retained as part of training records.

Training Videos

Principal Investigators and laboratory supervisors can make use of videos to supplement training of their employees. As with any training, it is important to document the training took place by using a sign-in sheet. When videos are used, the training sign-in sheet should have the date, time, location, and name and running time of the video, in addition to signatures of those people who watched the video.

5.0 SAFE CHEMICAL USE

Laboratory personnel can safely handle and use chemicals. To ensure this, topics include: minimizing exposure to chemicals, proper training, understanding chemical hazards, proper labeling, proper storage and segregation, and proper transport.

5.1 Minimize Exposure to Chemicals

The best way laboratory personnel can protect themselves from chemical hazards is to minimize their exposure to them. In order to minimize chemical exposure:

- Substitute less hazardous chemicals in experiments whenever possible.
- Always use the smallest possible quantity of chemical for all experiments. Consider microscale experiments and activities.
- Minimize chemical exposures to all potential routes of entry - inhalation, ingestion, skin and eye absorption, and injection through proper use of engineering controls and personal protective equipment.
- Be sure to select the proper PPE and regularly inspect it for contamination, leaks, cracks, and holes. Pay particular attention to gloves.
- Do not pipette or apply suction by mouth.
- Do not smell or taste chemicals. When it is necessary to identify a chemical's odor, lab personnel should hold the chemical container away from their face and gently waft their hand over the container without inhaling large quantities of chemical vapor.
- Do not underestimate the risk of exposure to chemicals - even for substances of no known significant hazard.
- In order to identify potential hazards, laboratory personnel should plan their experiments in advance. These plans should include the specific measures that will be taken to minimize exposure to all chemicals to be used, the proper positioning of equipment, and the organization of dry runs.
- Chemicals that are particularly hazardous substances require prior approval from your supervisor and special precautions to be taken.
- When working with mixtures of chemicals, laboratory personnel should assume the mixture to be more toxic than the most toxic component in the mixture.
- Consider all substances of unknown toxicity to be toxic until proven otherwise.
- Contact EH&S at 777-2211 to request exposure monitoring to ensure the Permissible Exposure Limits (PELs) of OSHA and the current Threshold Limit Values (TLVs) of the American Conference of Governmental Industrial Hygienists are not exceeded.

- Promptly clean up all chemicals spills whether the chemical is considered hazardous or nonhazardous. When cleaning up spills, remember to clean up any splashes that may have occurred on the sides of cabinets and doors in the immediate area.
- When working in cold rooms, keep all toxic and flammable substances tightly closed as cold rooms have recirculated atmospheres.
- Be aware of the potential asphyxiation hazard when using cryogenic materials and compressed gases in confined areas such as cold rooms and environmental chambers. If necessary, install an oxygen monitor/oxygen deficiency alarm and/or toxic gas monitor before working with these materials in confined areas. Contact EH&S at 777-2211 for more assistance.
- Do not eat, drink, chew gum, or apply cosmetics in areas where hazardous chemicals are being used.
- Keep all food and drink out of refrigerators and freezers used to store chemicals. Refrigerators used to store chemicals should be labeled as "Chemicals Only – No Food". Refrigerators used to store food should be labeled as "Food Only – No Chemicals".
- Always wash hands with soap and water after handling chemicals and especially before leaving the lab and eating – even if gloves were worn during chemical handling.
- Always remove personal protective equipment, such as gloves and lab coats, before leaving the lab.
- Do not attempt to scale up experiments until after you have run the experiment according to published protocols and you are thoroughly familiar with the potential hazards. When scaling up an experiment – change only one variable at a time, i.e. don't change the heat source, the volumes, and the glassware all at once. It is also advisable to let one of your other lab group members check your setup prior to each run.

5.2 Understanding Chemical Hazards

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

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

According to OSHA, physical hazard means "a chemical for which there is scientifically valid evidence that it is a combustible liquid, a compressed gas, explosive, flammable, an organic peroxide, an oxidizer, pyrophoric, unstable (reactive) or water-reactive." Separate sections on physical hazards will be covered in later in this manual.

5.2.1 Chemical Hazard Information

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

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

In addition to required health and safety training as per the OSHA Lab Standard and the University Health and Safety Policy, other sources of information on chemical and physical hazards include:

- This Laboratory Safety Manual
- Training videos
- Other department’s safety manuals
- Material Safety Data Sheets (SDS’s)
- Websites
- EH&S Training Programs
- Departmental Safety Committees
- Container labels
- Laboratory Standard Operating Procedures

5.2.2 Safety Data Sheets

Safety Data Sheets (SDS’s) are an important part of any laboratory safety program to communicate information to chemical users. SDS’s provide useful information such as:

- The identity of the chemical substance.
- Physical and chemical characteristics.
- Physical and health hazards.
- Primary routes of entry.
- OSHA Permissible Exposure Limits (PELs).
- Carcinogenic and reproductive health status.
- Precautions for safe handling and use (including PPE).
- Spill response procedures.
- Emergency and first aid questions.
- Date the SDS was prepared.

Any chemical shipment received should be accompanied by an SDS (unless one has been shipped with a previous order). If you do not receive an SDS with your shipment, check the chemical manufacturers website first (or call the manufacturer directly), or check the web, or contact EH&S at 777-2211 to request assistance.

If you have questions on how to read SDS's, or questions about the terminology or data used in SDS's, contact EH&S at 777-2211 for more information. Additional information, including how to read an SDS, can be found in the SDS FAQ and a glossary of terms used on SDS's can be found in the "Hyperglossary". Information on the National Fire Protection Association - NFPA diamond and the Hazardous Materials Information Guide and Hazardous Materials Information System – HMIG and HMIS is also available.

It is the responsibility of Principal Investigators and laboratory supervisors to ensure that staff and students working in laboratories under their supervision have obtained required health and safety training and have access to SDS's (and other sources of information) for all hazardous chemicals used in laboratories under their supervision.

SDS's must be accessible at all times. Access to SDS's via paper copies or electronic access through the internet. EH&S maintains links to a number of SDS websites and other sites with chemical health and safety information.

EH&S strongly encourages paper copies of SDS's be kept in the laboratory. Having SDS websites bookmarked is acceptable as long as all employees in the workplace know where to find the SDS and are trained on the use of computers to access SDS's. If a laboratory chooses to use electronic access, EH&S recommends the SDS website link be posted on the computer or in another conspicuous location. Some departments maintain binders with SDS's.

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

EH&S encourages a person working in a laboratory should be able to produce an SDS for any hazardous chemical found in the lab within five minutes.

5.2.3 SDS's and Newly Synthesized Chemicals

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

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

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

AND

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

OR

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

OR

- The newly created chemical or intermediate compound is going to be provided to another research group at Binghamton University.

Additional information on developing SDS's can be found in the SDS FAQ. A blank SDS form (OSHA Form 174) can be found on the OSHA website. A description of how to fill out an SDS can be found in the appendix.

5.3 Routes of Chemical Entry

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

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

5.3.1 Inhalation

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

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

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

5.3.2 Ingestion

Chemical exposure through ingestion occurs by absorption of chemicals through the digestive tract. Ingestion of chemicals can occur directly and indirectly. Direct ingestion can occur by accidently eating or drinking a chemical; with proper housekeeping and labeling, this is less likely to occur.

A higher probability of chemical exposure can occur by way of indirect ingestion. This can occur when food or drink is brought into a chemical laboratory. The food or drink can absorb chemical contaminants (vapors or dusts) in the air and result in a chemical exposure when the food or drink is consumed. This can also occur when food or drink is stored with chemicals, such as in a refrigerator.

Ingestion can occur when a laboratory worker who handles chemicals does not wear gloves or practice good personal hygiene, such as frequent hand washing, and then leaves the laboratory to eat, drink, or smoke. In all cases, a chemical exposure can result, although the effects of chronic exposure may not manifest itself until years later.

Symptoms of chemical exposure through ingestion include metallic or other strange tastes in the mouth; stomach discomfort; vomiting; problems swallowing; and a general ill feeling. **If you think you may have accidentally ingested a chemical, seek medical attention immediately and/or call the Poison Control Center at 1-(800) 222-1222 or University Police at 911 from a campus phone or (607) 777-2222 from a cell phone or off campus phone.**

After seeking medical attention, complete an accident report.

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

5.3.3 Injection

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

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

When cleaning up broken glass or other sharp items, always try to use a broom, scoop or dustpan, or devices such as pliers, before using your hands to pick up broken pieces. If you have to use your hands, wear leather gloves.

For other items that can cause cuts or puncture wounds, such as needles and razor blades, never leave these items out in the open where someone could come into contact with them. EH&S recommends using a device such as a piece of Styrofoam or similar item to secure them for later use. For disposal, use an appropriate "sharps" container. Containers can be purchased from Science Stores.

If you receive a cut or injection from a chemically contaminated item, gently try to remove the object and immediately rinse under water to flush the wound and remove any chemical contamination. Administer first aid and seek medical attention if necessary and complete an accident report.

5.3.4 Eye and Skin Absorption

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

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

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

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

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

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

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

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

5.3.5 Chemical Exposure Limits

The OSHA Laboratory Standard requires that laboratory employee exposure of OSHA Regulated Substances does not exceed the Permissible Exposure Limits as specified in 29 CFR Part 1910, subpart K.

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

Another measure of exposure limits are Threshold Limit Values (TLV) which are recommended occupational exposure limits published by the American Conference of Governmental Industrial Hygienists (ACGIH). Similar to PELs, TLVs are the average concentration of a chemical that a worker can be exposed to over an 8-hour workday, 5 days per week, over a lifetime without observing ill effects. TLVs also have Ceiling (C) limits, which are the maximum concentration a worker can be exposed to at any given time. The ACGIH has established TLVs for over 800 chemicals.

One of difference between PELs and TLVs is that TLVs are advisory guidelines only and are not legally enforceable. Both PELs and TLVs can be found in SDS's. Another good resource for information is the National Institute for Occupational Health and Safety (NIOSH).

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

5.3.6 Chemical Exposure Monitoring

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

Exposure monitoring is the determination of the airborne concentration of a hazardous material in the work environment. Exposure monitoring data is compared to existing OSHA and ACGIH exposure guidelines and is often used to make recommendations concerning engineering controls, work practices, and PPE.

If you think you may be receiving a chemical exposure in excess of OSHA exposure limits, such as feeling symptoms commonly associated with exposure to hazardous materials, or work with any of the chemicals listed below, contact EH&S at 777-2211 and our staff can sample to monitor for any potential exposures.

In some cases, OSHA substance specific standards actually require that the employer conduct initial exposure monitoring. Chemicals that fall into this category include:

- Formaldehyde
- Vinyl chloride
- Methylene chloride
- Benzene
- Ethylene oxide

Other substances that have exposure monitoring requirements include:

- Lead
- Cadmium
- Silica

5.3.7 Toxicity

Toxicity refers to the ability of a chemical to cause harmful effects to the body. There are a number of factors that influence the toxic effects of chemicals on the body. These include, but are not limited to:

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

5.3.7.1 Toxic Effects

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

Acute toxicity is generally thought of as a single, short-term exposure where effects appear immediately and the effects are often reversible. An example of acute toxicity relates to the over consumption of alcohol and subsequent hangovers.

Chronic toxicity is generally thought of as frequent exposures where effects may be delayed (even for years), and the effects are generally irreversible. Chronic toxicity can also result in acute exposures, with long term chronic effects. An example of chronic toxicity is cigarette smoking and lung cancer.

5.3.7.2 Evaluating Toxicity Data

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

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

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

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

Toxicity Class	**Animal LD50**	**Probable Lethal Dose for 70 kg Person (150 lbs.)**	**Example**
Super Toxic	Less than 5 mg/kg	A taste (7 drops or less)	Botulinum toxin
Extremely Toxic	5 - 50 mg/kg	< 1 teaspoonful	Arsenic trioxide, Strychnine
Very Toxic	50 - 500 mg/kg	< 1 ounce	Phenol, Caffeine

Moderately Toxic	0.5 - 5 g/kg	< 1 pint	Aspirin, Sodium chloride
Slightly Toxic	5 - 15 g/kg	< 1 quart	Ethyl alcohol, Acetone

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

5.4 Chemical Hazards

Chemicals can be broken down into hazard classes and exhibit both physical and health hazards. It is important to keep in mind, that chemicals can exhibit more than one hazard or combinations of several hazards. It is also important to note several factors can have influence the hazards of chemicals:

- Concentration of the chemical.
- Physical state of the chemical (solid, liquid, gas).
- Physical processes involved in using the chemical (cutting, grinding, heating, cooling, etc.).
- Chemical processes involved in using the chemical (mixing with other chemicals, purification, distillation, etc.)
- Other processes (improper storage, addition of moisture, storage in sunlight, refrigeration, etc.).

All of these factors can influence how a chemical will behave and the hazards the chemical presents. It is important to note here that SDS's and other chemical resources provide information related to the specific hazards a chemical possesses in addition to any special storage, handling, and use requirements.

The following sections describe general information and safety precautions about specific hazard classes. The chemical hazards listed are based on the Department of Transportation (DOT) hazard class system (which will be discussed in the Chemical Segregation section and where appropriate, will be noted as such). A general description of the hazards of various chemical functional groups can be found in the appendix.

It is important to note that the following sections are general guidelines. Laboratory personnel should always review SDS's and other resources FIRST, before working with any chemical.

5.4.1 Explosives

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

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

If you ever come across any chemical that you suspect could be potentially shock sensitive and/or explosive, do not attempt to move the container. Some of these compounds are shock, heat, and friction sensitive. Contact EH&S at 777-2211 immediately.

Explosives can result in damage to surrounding materials (hoods, glassware, windows, people, etc.), generation of toxic gases, and fires. If you plan to conduct an experiment where the potential for an explosion exists, first ask yourself the question; "Is there another chemical that could be substituted in the experiment that does not have an explosion potential?"

If you must use a chemical that is potentially explosive, or for those compounds that you know are explosive, (even low powered explosives) you must first obtain prior approval from the Principal Investigator to use such chemicals. After obtaining prior approval from your Principal Investigator, thoroughly read the SDS's and any other chemical resources related to the potentially explosive compound(s) to ensure potential incidents are minimized.

Whenever setting up experiments using potentially explosive compounds:

- Always use the smallest quantity of the chemical possible.
- Always conduct the experiment within a fume hood and use in conjunction with a properly rated safety shield.
- Be sure to remove any unnecessary equipment and other chemicals (particularly highly toxic and flammables) away from the immediate work area.
- Be sure to notify other people in the laboratory what experiment is being conducted, what the potential hazards are, and when the experiment will be run.
- Do not use metal or wooden devices when stirring, cutting, scraping, etc. with potentially explosive compounds. Non-sparking plastic devices should be used instead.
- Ensure other safety devices such as high temperature controls, water overflow devices, etc., are used in combination to help minimize any potential incidents.
- Properly dispose of any hazardous waste and note on the hazardous waste tag any special precautions that may need to be taken if the chemical is potentially explosive.
- Always wear appropriate PPE, including the correct gloves, lab coat or apron, safety goggles used in conjunction with a face shield, and explosion-proof shields when working with potentially explosive chemicals.
- For storage purposes, always date chemical containers when received and opened. Pay particular attention to those compounds that must remain moist or wet so they do not become explosive (ex. Picric acid, 2,4-Dinitrophenyl hydrazine, etc.). Pay particular attention to any potentially explosive compounds that appear to exhibit the following signs of contamination:
- Deterioration of the outside of the container.
- Crystalline growth in or outside the container.
  - Discoloration of the chemical.

If you discover a potentially explosive compound that exhibits any of these signs of contamination, contact EH&S at 777-2211 for more assistance.

Examples of explosive and potentially explosive chemicals include:

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

5.4.2 Flammable and Combustible Liquids

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

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

The OSHA Laboratory Standard defines a combustible liquid as any liquid having a flashpoint at or above 100 degrees F (37.8 degrees C), but below 200 degrees F (93.3 degrees C), except any mixture having components with flashpoints of 200 degrees F (93.3 degrees C), or higher, the total volume of which make up 99% or more of the total volume of the mixture.

OSHA further breaks down flammables into Class I liquids, and combustibles into Class II and Class III liquids. Please note this classification is different than the criteria used for DOT classification. This distinction is important because allowable container sizes and storage amounts are based on the particular OSHA Class of the flammable liquid.

Classification	**Flash Point**	**Boiling Point**
Flammable Liquid		
Class IA	< 73 degrees F	< 100 degrees F
Class IB	< 73 degrees F	> = 100 degrees F
Class IC	> = 73 degrees F, < 100 degrees F	> 100 degrees F
Combustible Liquid		

Class II	> = 100 degrees F, < 140 degrees F	--
Class IIIA	> = 140 degrees F, < 200 degrees F	--
Class IIIB	> = 200 degrees F	--

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

Flammable and combustible liquids are a common type of chemicals used at Binghamton University and are an important component in a number of laboratory processes. In addition to the flammable hazard, some flammable liquids also may possess other hazards such as being toxic and/or corrosive.

When using flammable liquids, keep containers away from open flames; it is best to use heating sources such as steam baths, water baths, oil baths, and heating mantels. Never use a heat gun to heat a flammable liquid. Any areas using flammables should have a fire extinguisher present. If a fire extinguisher is not present, contact EH&S at 777-2211 for more assistance.

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

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

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

5.4.2.1 Flammable Storage in Refrigerators/Freezers

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

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

For most laboratory applications, a flammable storage refrigerator/freezer is acceptable. However, some operations may require an explosion-proof refrigerator/freezer. Flammable storage refrigerators can be expensive. If a laboratory cannot purchase a flammable storage refrigerator for their own use, EH&S strongly encourages departments and laboratory groups on each floor to consider purchasing a communal flammable storage refrigerator for the proper and safe storage of flammable liquids.

5.4.2.2 Flammable Storage Cabinets

The requirements for use of flammable storage cabinets are determined by the classification of the flammable liquids, the quantities kept on hand, the building construction (fire wall ratings), and the floor of the building the flammables are being stored on. As a general rule, if you have more than 10 gallons of flammable liquids, including materials in use, you should store the flammable liquids in a properly rated flammable liquid storage cabinet. All flammable liquids not in use should be kept in the flammable liquid storage cabinet. For stand-alone flammable cabinets (as opposed to cabinets underneath fume hoods), there are vent holes on each side of the cabinet (called bung holes) that must have the metal bungs screwed into place for the cabinet to maintain its fire rating.

Venting of flammable cabinets is NOT required, however, if a flammable cabinet is vented, it must be vented properly according to the manufacturer's specifications and NFPA 30. Typically, proper flammable cabinet ventilation requires that air be supplied to the cabinet and the air be taken away via non-combustible pipes. If you are planning on venting your flammable storage cabinet, please contact EH&S at 777-2211 for more information.

5.4.3 Flammable Solids

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

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

- Flammable Solids – Class 4.1
- Spontaneously Combustible – Class 4.2
- Dangerous When Wet – Class 4.3

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

5.4.3.1 Spontaneously Combustible

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

5.4.3.2 Dangerous When Wet

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

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

If you are using dangerous when wet compounds and do not have a Class D fire extinguisher present, contact EH&S at 777-2211 for assistance.

5.4.4 Oxidizers and Organic Peroxides

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

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

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

In order to have a fire, you need:

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

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

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

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

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

If you suspect your oxidizer or organic peroxide has been contaminated (evident by discoloration of the chemical, or if there is crystalline growth in the container or around the cap), then dispose of the chemical as hazardous waste or contact EH&S at 777-2211. Indicate on the hazardous waste tag that the chemical is an oxidizer or organic peroxide and that you suspect contamination.

5.4.4.1 Peroxide Forming Compounds

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

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

1) Each peroxide forming chemical container MUST be dated when received and opened. A list of common peroxide forming chemicals can be found in the appendix. Those compounds in the appendix designated as Class III should be disposed of within 3 months of opening and those compounds in the appendix designated as Class I and Class II should be disposed of within 12 months of opening.
2) Each peroxide forming chemical container must be tested for peroxides when opened and at least every 3 months thereafter. The results of the peroxide test and the test date must be marked on the outside of the container.
3) Peroxide test strips can be purchased from Science Stores or from a safety supply vendor. References such as Prudent Practices in the Laboratory and the American Chemical Society booklet Safety in Academic Chemistry Laboratories outline ways to test for peroxides and ways to remove them if discovered. When using the test strips, if the strip turns blue, peroxides are present. Light blue test results may be acceptable for use. Containers with darker blue test results must be deactivated or disposed of. You can test older test strips for efficacy with a dilute solution of hydrogen peroxide.
4) Due to sunlight's ability to promote formation of peroxides, all peroxidizable compounds should be stored away from heat and sunlight.
5) Peroxide forming chemicals should not be refrigerated at or below the temperature at which the peroxide forming compound freezes or precipitates as these forms of peroxides are especially sensitive to shock and heat. Refrigeration does not prevent peroxide formation.
6) As with any hazardous chemical, but particularly with peroxide forming chemicals, the amount of chemical purchased and stored should be kept to an absolute minimum. Only order the amount of chemical needed for the immediate experiment.
7) Ensure containers of peroxide forming chemicals are tightly sealed after each use and consider adding a blanket of an inert gas, such as Nitrogen, to the container to help slow peroxide formation.
8) A number of peroxide forming chemicals can be purchased with inhibitors added. Unless absolutely necessary for the research, labs should never purchase uninhibited peroxide formers.
9) Before distilling any peroxide forming chemicals, always test the chemical first with peroxide test strips to ensure there are no peroxides present. Never distill peroxide forming chemicals to dryness. Leave at least 10-20% still bottoms to help prevent possible explosions.

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

* * * Compounds that are suspected of having very high peroxide levels because of age, unusual viscosity, discoloration, or crystal formation should be considered extremely dangerous. If you discover a container that meets this description, DO NOT attempt to open or move the container. Notify other people in the lab about the potential explosion hazard and notify EH&S at 777-2211 immediately.

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

The appendix contains a listing of common peroxide forming chemicals. Please note this list is not all-inclusive There are numerous other chemicals that can form peroxides. Be sure to read chemical container labels, SDS's, and other chemical references.

5.4.5 Poisons

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

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

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

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

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

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

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

- What are the routes of entry into the body for the poison (inhalation, ingestion, injection, or skin absorption)?
- What are the signs and symptoms of potential chemical exposure?
- What proper PPE is required (type of glove, safety glasses vs. splash goggles, face shield, etc.)?
- Does the chemical require any special antidote?
- What emergency procedures must be followed?

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

If you think you may have received an exposure to a poisonous substance, or may have accidentally ingested a chemical, seek medical attention immediately and/or call the Poison Control Center at 1-(800) 222-1222 or University Police at 911 from a campus phone or (607) 777-2222 from a cell phone or off campus phone. If possible, bring a copy of the SDS with you. Upon completion of seeking medical attention, complete an accident report.

5.4.6 Corrosives

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

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

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

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

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

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

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

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

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

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

5.4.6.1 Perchloric Acid

Perchloric acid is a strong oxidizing acid that can react violently with organic materials. Perchloric acid can also explode if concentrated above 72%. For any work involving heated perchloric acid (such as in perchloric acid digestions), work must be conducted in a special Perchloric acid fume hood with a wash down function. If heated Perchloric acid is used in a standard fume hood, the hot perchloric acid vapors can react with the metal in the hood ductwork to form shock sensitive metallic perchlorates.

When working with perchloric acid, remove all organic materials, such as solvents, from the immediate work area. Due to the potential danger of perchloric acid, if possible, try to use alternate techniques that do not involve the use of perchloric acid. If you must use perchloric acid in your experiments, purchase the smallest size container necessary.

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

5.4.6.2 Hydrofluoric Acid

Hydrofluoric acid (HF) is a most hazardous chemical. Small exposures to HF can be fatal if not treated properly. The critical minutes immediately after an exposure can have a great effect on the chances of a victim's survival.

HF is a gas that is dissolved in water to form hydrofluoric acid. The concentration can vary from very low such as in store bought products up to the most concentrated 70% form (anhydrous). Common lab use is around 48%. The liquid is colorless, non-flammable and has a pungent odor. The OSHA permissible exposure limit is 3 ppm, but concentrations should be kept as low as possible.

HF is actually a weak acid by definition and not as corrosive as strong acids such as hydrochloric (HCl), however, corrosivity is the least hazardous aspect of HF. The toxicity of HF is the main concern.

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

Due to the serious hazard of working with HF, the following requirements and must be followed:

- All users of HF must receive training from their supervisor or PI and provide EH&S with proof of training prior to working with Hydrofluoric Acid.
- A Standard Operating Procedure (SOP) must be written for the process in which HF is used. This SOP should be posted or readily available near the designated area where HF use will occur.
- HF should only be used in a designated fume hood and the fume hood should be identified by posting a HF Designated Area sign.
- First Aid - An HF first aid kit must be available that includes 2.5% calcium gluconate gel. The calcium gluconate gel can be obtained through EH&S and should be replaced with new stock annually. The Hydrofluoric Acid First Aid sign should be posted in a prominent place where the calcium gluconate gel is located.
- Spill Kits - An HF spill kit must be available with calcium compounds such as calcium carbonate, calcium sulfate or calcium hydroxide. Sodium bicarbonate should never be used since it does not bind the fluoride ion and can generate toxic aerosols.

- Prior approval - Before anyone uses HF they must have prior approval from the Principal investigator. The names of lab personnel authorized to use HF should be maintained by the PI. The form shall state that they are familiar with the following:
    - Has read the SDS for HF
    - Has read the HF SOP developed by the lab
    - Has read the hydrofluoric acid section in this Lab Safety Manual
    - Is aware of the designated area for HF use
    - Knows the first aid procedure in case of an HF exposure
    - Knows what to do in case of an HF spill

- Personal Protective Equipment (PPE) – The following PPE is required for HF use:
    - Rubber or plastic apron
    - Plastic arm coverings
    - Gloves
        - Incidental use - double glove with heavy nitrile exam gloves and re-glove if any exposure to the gloves
        - Extended use – heavy neoprene or butyl over nitrile or silver shield gloves
    - Splash goggles in conjunction with a fume hood sash
    - Closed toed shoes
    - Long pants and a long sleeve shirt with a reasonably high neck (no low cut)

The following are safe practice guidelines when working with HF:

- Never work alone with HF. Use the buddy system.
- Use a plastic tray while working with HF for containment in case of a spill.
- Keep containers of HF closed. HF can etch the glass sash of a hood and make it hard to see through.
- An SDS for HF must be available.
- All containers of HF must be clearly labeled. EH&S recommends using labels which state the hazards of HF for all non-original containers.
- The stock HF should be stored in plastic secondary containment and the cabinet should be labeled. HF should be stored in lower cabinets near the floor.
- Wash gloves off with water before removing them.

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

- Safety Data Sheets
- Technical data sheets
- Recommended medical treatment for HF exposure
- HF properties charts
- Online training

5.5 Chemical Labeling

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

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

5.5.1 Non-Original Containers

Non-original containers (secondary use containers or working containers) such as wash bottles, squirt bottles, temporary storage containers, beakers, flasks, bottles, vials, etc. or any container that a chemical from an original container is transferred into, must be properly labeled. Write out the full chemical name and any hazards associated with that chemical. Laboratory personnel are strongly encouraged to use commercially available pre-labeled containers (such as squirt bottles) for chemicals that used frequently. Labs can also choose to label chemical containers in other ways such as:

1) EH&S labeling sticker

EH&S strongly encourages laboratories to take advantage of our FREE labeling stickers found in Science Stores for hazardous chemicals in non-original containers. These are especially helpful for containers that are used for the same purpose repeatedly or are used slowly over time.

2) Abbreviations – Structures and Formulas

Use of abbreviations such as structures, formulas, or acronyms is acceptable. However, if you use abbreviations, you must post a “key” to the abbreviations in a visible location (preferably close to the chemicals and/or by the door). The “key” must contain the abbreviation and the name of the chemical. Including the hazards of the chemical on the “key” is also useful information. The abbreviation key must be readily available upon request by visitors, emergency responders, and state and federal regulatory agencies such as EPA, OSHA, or New York State Office of Fire Prevention inspectors.

3) Small Containers and Sample Storage

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

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

4) Number, Letter, and Color Codes

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

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

5.5.2 Labeling Requirements

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

- All chemical containers (both hazardous and non-hazardous) MUST be labeled. Chemical names must be written out in English. If a label is starting to fall off a chemical container or is becoming degraded, the container needs to be relabeled (using tape, permanent marker, EH&S chemical labeling sticker.) or the chemical needs to be transferred to another properly labeled container.

- If abbreviations such as formulas, structures, or acronyms are used, a “key” to the abbreviations must be hung up in a conspicuous location.
- All personnel working in the laboratory must be fully trained on how to label chemicals using the system and how to understand the labeling system. Training must occur when a new person begins working in the laboratory, when new chemicals are introduced, and should occur on a regular basis (annually at a minimum).

5.6 Chemical Storage

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

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

5.6.1 General Storage Guidelines

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

- All chemical containers MUST be labeled. Labels should include the name of the chemical constituent(s) and any hazards present. Be sure to check chemical containers regularly and replace any labels that are deteriorating or falling off or relabel before the chemical becomes an unknown.
- Every chemical should have an identified storage place and should be returned to that location after use.
- The storage of chemicals on bench tops should be kept to a minimum to prevent clutter and spills, and to allow for adequate working space.

- Chemical storage in fume hoods should be kept to a minimum and limited to the experiment being conducted. Excess storage of chemical containers in hoods can interfere with airflow, reduce working space, and increase the risk of a spill, fire, or explosion.
- For chemical storage cabinets, larger chemical bottles should be stored toward the back and smaller bottles should be stored up front where they are more visible. Chemical bottles should be turned with the labels facing out so they can be easily read.
- Chemicals should not be stored on the floor due to the potential for a bottle to be knocked over and result in a spill. If it is necessary to store bottles on the floor, the bottles should be placed in secondary containment, such as trays, and the bottles should be placed away from aisle spaces.
- For multiples of the same chemical, older containers should be stored in front of newer chemicals and containers with the least amount of chemical should be stored in front of full containers. This allows older chemicals to get used up first and helps to minimize the number of chemical containers in a storage area.
- Do not store chemicals in direct sunlight or next to heat sources.
- Laboratories should strive to keep only the minimum quantity of chemicals necessary. When ordering new chemicals, laboratories should only order enough stock needed for the experiment or the quantity that will get used up within a reasonable amount of time.
- Liquid chemical containers should be stored in secondary containment, such as trays, to minimize the potential for bottle breakage and for spills.
- Always segregate and store chemicals according to compatibility and hazard classes.
- Chemical containers should be dated when they arrive and should be checked regularly and disposed of when they pass their expiration date. **Please Note**: Due to the potential explosion hazard, peroxide forming chemicals are required to be tested and dated.
- Flammable liquids in excess of quantities for specific flammability classes must be stored in approved flammable liquid storage cabinets.
- Do not store acids in flammable liquid storage cabinets. This can result in serious degradation of the storage cabinet and the containers inside. Corrosive chemicals should be stored in corrosion resistant cabinets. Exceptions to this rule are organic acids, such as acetic acid, lactic acid, and formic acid, which are considered flammable/combustible and corrosive and can be stored in flammable or corrosive storage cabinets.
- Do not store corrosive or other chemicals that can be injurious to the eyes above eye level. In general, and where practical, no chemicals should be stored above eye level.

- Do not store flammable liquids in standard (non-explosion proof) refrigerators or freezers. Due to the potential explosion hazard, only store flammables in refrigerators or freezers approved by the manufacturer for storage of flammables.
- Highly toxic chemicals such as inorganic cyanides should be stored in locked storage cabinets. Always keep the quantities of highly toxic chemicals to an absolute minimum. See the Particularly Hazardous Substances section.
- Be aware of any special antidotes or medical treatment that may be required for some chemicals (such as cyanides and hydrofluoric acid).
- Always keep spill kits and other spill control equipment on hand in areas where chemicals are used. Ensure all personnel working in the lab have been properly trained on the location and use of the spill kit.
- For reagent shelves, use shelves with anti-roll lips to prevent bottles from falling off. This can also be accomplished using heavy gauge twine or wire to create a lip on the shelf.

5.7 Transporting Chemicals

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

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

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

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

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

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

- Do not transport chemicals in your personal vehicle.

- Transportation of hazardous materials such as chemicals (unless in the original shipping package), compressed gasses, and cryogenic liquids should be avoided through or above areas where food is served/consumed or places of gathering when other routes are available. In instances where no other routes are available users should take extreme caution and/or use a spotter.

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

5.8 Chemical Segregation

Chemicals should be stored according to compatibility and hazard classes. DO NOT store chemicals alphabetically, by carbon number, or by physical state, etc., EH&S recommends that you segregate all chemicals by DOT hazard class first. For assistance contact EH&S at 777-2211.

The potential hazards of storing incompatible chemicals together, include:

- Generation of heat.
- Possible fires and explosion.
- Generation of toxic and/or flammable gases and vapors.
- Formation of toxic compounds.
- Formation of shock and/or friction sensitive compounds.
- Violent polymerization.

The benefits of chemical segregation by hazard class include:

- Safer chemical storage.
- Understanding the hazards a chemical exhibits will increase your knowledge about the chemical.
- Identifying potentially explosive chemicals.
- Identifying multiple containers of the same chemical.

There are a number of segregation schemes recommended in the literature by government agencies, chemical manufacturers, safety supply companies, and other universities. EH&S recommends segregation of chemicals using a modified version of the Department of Transportation (DOT) Hazard Class System. While this modified DOT system results in most common chemicals being segregated properly, there is no one system that solves all problems. The modified DOT system is less complicated than other segregation schemes and the information to make decisions of which hazard classes to use can easily be found in SDS's, container labels, container markings and stickers, and other resources.

Please note that DOT hazard classes segregate chemicals according to the hazards posed during transportation and not necessarily based on health hazards. Keep in mind that chemicals do not always fall neatly into one hazard class and can pose multiple hazards – including both physical and health hazards (such as flammable liquid, corrosive or flammable liquid, poison).

When making decisions on how to segregate, keep the following in mind:

- Physical hazards of the chemical.
- Health hazards of the chemical.
- The chemical form (solid, liquid or gas).
- Concentration of the chemical.

Segregation of different chemical hazard classes (such as acids and bases) can occur in the same cabinet as long as there is some form of physical separation, such as using trays with high sides or deep trays. Never store oxidizers and flammables in the same cabinet. Also, do not store compounds such as inorganic cyanides and acids in the same cabinet.

Once chemicals have been separated, ensure everyone in the lab knows the process and what system is being used. Clearly identify where chemicals in each hazard class will be stored by labeling cabinets with signs. These can be purchased from a safety supply company or you can create your own.

If would like assistance with segregating your chemicals, contact EH&S at 777-2211. EH&S also offers a training class on Chemical Segregation.

For more information on reading chemical container labels see the following manufacturer's webpages:

- Fisher Scientific labels
- JT Baker labels
- Mallinckrodt labels
- Sigma labels

Examples of incompatible chemicals can be found in the appendix.

5.8.1 EH&S Modified DOT Hazard Class System

The basic DOT hazard classes and hazard class numbers are:

DOT Hazard Class Number	Hazard Class
Class 1	Explosives
Class 2	Compressed gases
Class 3	Flammable liquids
Class 4	Flammable solids
Class 5	Oxidizers
Class 6	Poisons
Class 7	Radioactive materials
Class 8	Corrosives
Class 9	Store with Class 6

The DOT hazard class numbers can be found on hazard class labels, in SDS's (under the "Transportation Information Section"), on container labels, and in other reference texts. An explanation of the DOT Hazard Class system can be found in the Pipeline and Hazardous Materials Safety Administration section of the DOT Training Modules.

The EH&S chemical segregation scheme modifies the DOT system by breaking down hazard classes into subcategories. A handout on the EH&S Chemical Segregation Scheme can be found in the appendix.

6.0 PARTICULARLY HAZARDOUS SUBSTANCES

The OSHA Laboratory Standard requires as part of the Chemical Hygiene Plan that provisions for additional employee protection be included for work involving particularly hazardous substances. These substances include "select carcinogens", reproductive toxins, and substances which have a high degree of acute toxicity. Each of these categories will be discussed in detail in later sections. The OSHA Laboratory Standard states for work involving particularly hazardous substances, specific consideration be given to the following provisions where appropriate:

- Establishment of a designated area.
- Use of containment devices such as fume hoods or glove boxes.
- Procedures for safe removal of contaminated waste.
- Decontamination procedures.

EH&S can provide information on working with particularly hazardous substances. General guidelines and recommendations for the safe handling, use, and control of hazardous chemicals and particularly hazardous substances can be found in SDS's and other references such as Prudent Practices in the Laboratory and Safety in Academic Chemical Laboratories.

6.1.1 Establishment of a Designated Area

For work involving particularly hazardous substances, laboratories should establish a designated area where particularly hazardous substances can be used. In some cases, a designated area could be an entire room in a suite of rooms, or it could mean one particular fume hood within a laboratory. Designate one area that everyone in the laboratory is aware that particularly hazardous substances can be used.

Principal Investigators and laboratory supervisors may want to restrict use of a particularly hazardous substance to a fume hood, glove box or other containment device. This information should be included as part of the laboratory's SOPs and covered during in-lab training.

Establishing a designated area not only provides better employee protection, but can help minimize the area where potential contamination of particularly hazardous substances could occur. If a designated area is established, a sign should be hung up (on a fume hood for example) indicating the area is designated for use with particularly hazardous substances. Most designated areas will have special PPE requirements and/or special waste and spill cleanup procedures as well. These and other special precautions should be included within the lab's SOPs.

6.1.2 Safe Removal of Contaminated Materials and Waste

Some particularly hazardous substances may require special procedures for safe disposal of both waste and/or contaminated materials. When in doubt, contact EH&S at hazwaste@binghamton.edu or 777-2211 to determine proper disposal procedures. Once these disposal procedures have been identified, they should be included as part of the laboratory's SOPs and everyone working in the lab should be trained on those procedures.

6.1.3 Decontamination Procedures

Some particularly hazardous substances may require special decontamination or deactivation procedures (such as diaminobenzidine waste or ethidium bromide) for safe handling. Review SDS's and other reference materials when working with particularly hazardous substances to identify if special decontamination procedures are required. If they are required, this information should be included in all laboratory's SOPs and appropriate training needs to be provided to laboratory personnel who work with these chemicals.

6.2 Guidelines for Working with Particularly Hazardous Substances

Laboratory staff should always practice good housekeeping, use engineering controls, wear proper PPE, develop and follow SOPs, and receive appropriate training when working with any chemicals. The following special guidelines should be adhered to when working with particularly hazardous substances:

- Substitute less hazardous chemicals if possible to avoid working with particularly hazardous substances and to keep potential exposure to a minimum.
- Always obtain prior approval from the Principal Investigator before ordering any particularly hazardous substances.
- Plan your experiment out in advance, including layout of apparatus and chemical and waste containers that are necessary.
- Before working with any particularly hazardous substance, review chemical resources for any special decontamination/deactivation procedures and ensure you have the appropriate spill cleanup materials and absorbent on hand.
- Ensure that you have the appropriate PPE, particularly gloves (check glove selection charts or call EH&S at 777-2211).
- Always use the minimum quantities of chemicals necessary for the experiment. If possible, try adding buffer directly to the original container and making dilutions directly.
- If possible, purchase premade solutions to avoid handling powders. If you have to use powders, it is best to weigh them in a fume hood. If it is necessary to weigh outside of a fume hood (because some particles may be too light and would pose more of a hazard due to turbulent airflow) wear a dust mask when weighing the chemical. It is advisable to surround the weighing area with wetted paper towels to facilitate cleanup.
- As a measure of coworker protection when weighing out dusty materials or powders, consider waiting until other coworkers have left the room to prevent possible exposure. Thoroughly clean up and decontaminate working surfaces.
- Use secondary containment, such as trays, to conduct your experiment in and for storage of particularly hazardous substances.
- Particularly hazardous substances should be stored by themselves in clearly marked trays or containers indicating what the hazard is i.e. “Carcinogens,” Reproductive Toxins”, etc.
- Always practice good personal hygiene, especially frequent hand washing, even if wearing gloves.
- If it is necessary to use a vacuum for cleaning particularly hazardous substances, only High Efficiency Particulate Air (HEPA) filters are recommended for best capture and protection. Be aware that after cleaning up chemical powders, the vacuum bag and its contents may have to be disposed of as hazardous waste.
- Ensure information related to the experiment is included within any SOPs.

6.3 Prior Approval

The OSHA Laboratory Standard requires Chemical Hygiene Plans to include information on “the circumstances under which a particular laboratory operation, procedure or activity shall require prior approval”, including “provisions for additional employee protection for work with particularly hazardous substances” such as "select carcinogens," reproductive toxins, and substances which have a high degree of acute toxicity.

Prior approval ensures that laboratory workers have received the proper training on the hazards of particularly hazardous substances or with new equipment, and that safety considerations have been taken into account BEFORE a new experiment begins.

While EH&S can provide assistance in identifying circumstances when there should be prior approval before implementation of a particular laboratory operation, the ultimate responsibility for establishing prior approval procedures resides with the Principal Investigator or laboratory supervisor.

Principal Investigators or laboratory supervisors must identify operations or experiments that involve particularly hazardous substances (such as select carcinogens, reproductive toxins, and substances which have a high degree of acute toxicity) and highly hazardous operations or equipment that require prior approval. They must establish guidelines, procedures, and approval process that would be required. This information should be documented in the laboratory's or department's SOPs. Additionally, Principal Investigators and laboratory supervisors are strongly encouraged to have written documentation, such as "Prior Approval" forms that are completed and signed by the laboratory worker, and the Principal Investigator or laboratory supervisor and kept on file.

Examples where Principal Investigators or laboratory supervisors should consider requiring laboratory workers to obtain prior approval include:

- Experiments that require the use of particularly hazardous substances such as select carcinogens, reproductive toxins, and substances that have a high degree of acute toxicity, highly toxic gases, cryogenic materials and other highly hazardous chemicals or experiments involving radioactive materials, high powered lasers, etc.
- Where a significant change is planned for the amount of chemicals to be used for a routine experiment (such as an increase of 10% or greater) in the quantity of chemicals normally used.
- When a new piece of equipment is brought into the lab that requires special training in.
- When a laboratory worker is planning on working alone on an experiment that involves highly hazardous chemicals or operations.

6.3.1 Campus Prior Approval

There are some circumstances where prior approval from a campus research related committee is required before beginning an operation or activity. These include:

- Research using live vertebrate animals – contact the Institutional Animal Care and Use Committee or campus Bio Safety Officer at 777-2211.
- Recombinant DNA use – contact the Institutional Biosafety Committee or the Bio Safety Officer at 777-2211.
- Use of Radioactive Materials – contact the Radiation Safety Officer (RSO) at 777-2211
- Use of Human Subjects - contact the Institutional Review Board (IRB).
- High Powered Lasers- contact the Laser Safety Officer (LSO) at 607-777-2211 or ehs@binghamton.edu

6.4 Select Carcinogens

A carcinogen is any substance or agent that is capable of causing cancer – the abnormal or uncontrolled growth of new cells in any part of the body in humans or animals. Most carcinogens are chronic toxins with long latency periods that can cause damage after repeated or long duration exposures and often do not have immediately apparent harmful effects.

The OSHA Lab Standard defines a "select carcinogen" as any substance which meets one of the following criteria:

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

With regard to mixtures, OSHA requires that a mixture "shall be assumed to present a carcinogenic hazard if it contains a component in concentrations of **0.1% or greater**, which is considered to be carcinogenic." When working with carcinogens, laboratory staff should adhere to Guidelines for Working with Particularly Hazardous Substances.

Note that the potential for carcinogens to result in cancer can also be dependent on other factors such as:

- Cigarette smoking
- Alcohol consumption
- Consumption of high fat diet
- Geographic location – industrial areas and UV light exposure
- Therapeutic drugs
- Inherited conditions

More information on carcinogens, including numerous useful links can be found on the OSHA Safety and Health Topics for Carcinogens webpage.

6.5 Reproductive Toxins

The OSHA Lab Standard defines a reproductive toxin as a chemical "which affects the reproductive capabilities including chromosomal damage (mutations) and effects on fetuses (teratogenesis)".

A number of reproductive toxins are chronic toxins that cause damage after repeated or long duration exposures and can have long latency periods. Women of childbearing potential should be especially careful when handling reproductive toxins. Pregnant women and women intending to become pregnant, or men seeking to have children, should seek the advice of their physician before working with known or suspected reproductive toxins.

More information on reproductive toxins, can be found on the OSHA Safety and Health Topics for Reproductive Hazards webpage.

6.6 Acute Toxins

OSHA defines a chemical as highly toxic if it falls within any of the following categories:

(a) A chemical that has a median lethal dose (LD50) of 50 milligrams or less per kilogram of body weight when administered orally to albino rats weighing between 200 and 300 grams each.

(b) A chemical that has a median lethal dose (LD50) of 200 milligrams or less per kilogram of body weight when administered by continuous contact for 24 hours (or less if death occurs within 24 hours) with the bare skin of albino rabbits weighing between two and three kilograms each.

(c) A chemical that has a median lethal concentration (LC50) in air of 200 parts per million by volume or less of gas or vapor, or 2 milligrams per liter or less of mist, fume, or dust, when administered by continuous inhalation for one hour (or less if death occurs within one hour) to albino rats weighing between 200 and 300 grams each.

Information on determining whether or not a chemical meets one of these definitions can be found in SDS's and other chemical references.

Work involving the use of acute toxins should adhere to the Guidelines for Working with Particularly Hazardous Substances. Additional guidelines for working with acute toxins include:

- Consider storing highly toxic materials in a locked storage cabinet.
- Be aware of any special antidotes that may be required in case of accidental exposure (hydrofluoric acid and inorganic cyanides for example).
- Pay particular attention to the selection of gloves and other personal protective equipment.
- Do not work with highly toxic chemicals outside of a fume hood, glove box or ventilated enclosure.

More information on acute toxins can be found on the OSHA Safety and Health Topics for Hazardous and Toxic Substances webpage.

7.0 HAZARDOUS CHEMICAL WASTE DISPOSAL

Hazardous chemical waste storage and disposal is regulated by the U.S. Environmental Protection Agency (EPA). In New York State, the Department of Environmental Conservation (DEC) regulates chemical waste management activities. All University chemical waste is subject to inspection and enforcement actions by the EPA and/or the DEC.

EH&S provides the following chemical waste compliance services:

- Management of University hazardous waste storage areas.
- Collection of chemical waste from laboratories.
- General compliance assistance.
- Work space consultations.

7.1 Hazardous Chemical Waste Container Requirements

Within your work area, the following practices must be followed for proper management of hazardous waste:

1) Determine if your unwanted materials pose a significant risk requiring management as hazardous waste.
2) Determine if chemical deactivation or drain disposal is an option.
3) Label containers of hazardous chemical wastes with the identity of the chemical(s) **AND** the words "Hazardous Waste" or label with a Binghamton University Hazardous Waste label available from Science Stores.
4) Keep containers of hazardous chemical wastes closed at all times when they are not in use.
5) Store the hazardous waste containers within the room in which they are generated.

Recommended practices that should be followed:

- Always maintain a neat and orderly workplace.
- Use secondary containment bins or trays to store your chemical waste containers.
- Store your waste containers in a designated place.

It is the responsibility of the Principal Investigator and laboratory supervisor to ensure that personnel working in laboratories under their supervision are familiar with and follow hazardous chemical waste container requirements.

7.2 Hazardous Waste Pickup Procedures

To have your hazardous waste picked up by EH&S, please follow this procedure:

1) Place an EH&S Hazardous Waste label on each container.
    a. Labels are available from the science store located in the basement of Science 2 or
    b. By sending an email to hazwaste@binghamton.edu

2) Fill out the waste label and list all of the ingredients (no trade names or chemical formulas, please). Do not put a date on the tag until you are ready to dispose of the waste through EH&S.

3) Send an email to hazwaste@binghamton.edu requesting a waste pickup with an inventory of the waste you have.

4) EH&S will collect the waste during the next schedule waste pickup (Hazardous Waste Schedule).

The following types of materials have different requirements for disposal:

- Biohazardous materials
- Construction debris (such as asbestos and lead)
- Electronic waste
- Radioactive materials
- Used oils
- Universal waste (fluorescent bulbs, batteries)

If you need further information, refer to the Hazardous Waste Guide, call EH&S at 777-2211, or e-mail hazwaste@binghamton.edu.

8.0 HAZARDOUS MATERIAL SHIPPING

The transport of hazardous materials is regulated by the U.S. Department of Transportation (DOT) and the International Civil Aviation Organization. An additional regulatory body formed by the airlines is called the International Air Transport Association (IATA); however, their regulations are only enforceable by the airlines. All University transportation (including shipping) of hazardous materials off University owned property is subject to DOT enforcement.

8.1 Regulated Hazardous Materials

The following materials are regulated as hazardous material for transportation:

- Compressed gases
- Corrosives
- Explosives

- Flammable liquids and solids
- Infectious substances (animals and humans only)
- Oxidizers
- Toxic solids and liquids
- Radioactive materials

It is the responsibility of the Principal Investigator or laboratory supervisor to ensure any employee working under their supervision who prepares hazardous materials for disposal has received proper training.

For questions, contact EH&S at 777-2211 or visit our webpage at ehs.binghamton.edu.

9.0 PESTICIDES

A pesticide is defined as a substance or mixture of substances intended for preventing, destroying, repelling or mitigating any pest, or intended for use as a plant regulator, defoliant or desiccant.

The definition of pesticides may be determined by any of the following:

1) EPA Registered Pesticides (the EPA registration number can be found on the manufacturer's label).

2) Those experimental chemicals for which a pesticide effect has been determined.

All university personnel (including faculty members, staff members, students, and any other university-affiliated individuals) who label, store, use, transport, dispose of, or clean up spills of pesticides are responsible for adhering to federal and state regulations.

It is essential that teaching, research, and ground maintenance involving pesticide use be conducted properly and legally for the protection of the pesticide applicator, other employees, staff, students, public health, and the environment.

The responsibility for ensuring that all work with pesticides at Binghamton is conducted properly and legally rests on the individual user.

For more information on pesticides see the Physical Facilities website.

9.1 Pesticide Certification

Binghamton University requires that all individuals handling pesticides as a part of university programs must be a NYS certified pesticide applicator unless they qualify for an exemption.

9.1.1 Exemptions from Pesticide Certification

As per state and federal regulations, some exemptions exist for pesticide certification requirements. These exemptions include:

1) Licensed veterinarians, as well as licensed veterinary technicians, interns, residents, and veterinary students working under the direct supervision of a veterinarian in a veterinary facility are exempt from the certification requirement when engaged in the use of general use pesticides.
2) Small laboratory quantities of pesticides used for analysis and treatment of samples in a laboratory and in an environmentally nondispersive manner (e.g., microgram or gram quantities used inside a fume hood, mixed into media, etc.) are exempt from policy requirements. As with all other chemical use in the laboratory, use of laboratory quantity pesticides is regulated by the OSHA Laboratory Standard and other appropriate rules and regulations.
3) Testing of materials for pesticide efficacy, toxicity, or other properties could also be exempted - for clarifications refer to the federal regulation: 40 CFR part 172.3.
4) Teaching/demonstration of pesticide application(s), as well as recommendation of pesticide application or use is exempted from the certification requirements. However, the individual engaged in such activities is responsible for ensuring that these activities are compliant with federal, state, and local pesticide laws and regulations.

When using pesticides in a non-dispersive manner in a laboratory setting, an individual must follow the safety rules outlined in the Binghamton University Laboratory Safety Manual.

10.0 BIOHAZARDS

Complete information on the Biosafety Program at Binghamton can be found on the EH&S Biological Safety webpage.

10.1 Institutional Biosafety Committee

The Institutional Biosafety Committee (IBC) reviews research and teaching activities involving the use of recombinant DNA, infectious and pathogenic agents, select agents and toxins, and gene therapy.

A completed application must be submitted to the IBC to initiate a review. Reviews ensure that all work involving materials and activities described above and the facilities used to conduct such work are in compliance with guidance and regulations put forth by external agencies (e.g. NIH, CDC, OSHA, etc.) and applicable University policies.

View the Binghamton University IBC Policy and Procedures at:

https://www.binghamton.edu/research/division-offices/research-compliance/institutional-biosafety.html

10.1.1 Recombinant DNA

Binghamton University requires that all recombinant DNA work done at the University by employees or affiliates be registered with the IBC, **EVEN IF IT IS EXEMPT** from the NIH Guidelines. Recombinant DNA is defined as:

1) Molecules that are constructed outside living cells by joining natural or synthetic DNA segments to DNA molecules that can replicate in a living cell.

OR

2) DNA molecules that result from the replication of those described above.

10.1.2 Infectious and Pathogenic Agents

Infectious/pathogenic agents to humans, classified in the following categories: Risk Group 2, 3, and 4 bacterial, fungal, parasitic, viral, rickettsial, chlamydial, and prion agents.

See the following links for information regarding the classification of infectious agents:

- National Institutes of Health (NIH)
- Centers for Disease Control and Prevention (CDC)
- American Biological Safety Association (ABSA)

10.1.3 Select Biological Agents and Toxins

Select agents and toxins are biological agents and toxins that have the potential to pose a severe threat to public health and safety, and animal or plant health. The possession and use of these agents is highly regulated. More information can be found at the CDC Select Agent Program and USDA Agricultural Select Agent Program. If you wish to work with these agents, you must first notify and register with EH&S. Unregistered possession and use can result in significant fines and jail time.

Other agents that have the potential for causing disease in animals or plants are regulated by the Animal Plant Health Inspection Service (APHIS) of the United States Department of Agriculture (USDA). APHIS has published a list of regulated plant pests and your research must be reviewed if you are working with or in possession of any of these plant pathogens/pests.

10.2 Animal Use

It is a violation of federal regulations to carry out studies using vertebrate animals without an approved animal use protocol or to maintain animals after expiration of a previously approved protocol. Federal regulations mandate the establishment of an Institutional Animal Care and Use Committee (IACUC) to provide guidance, to oversee the animal care and use program, and to ensure compliance with applicable laws, regulations, and policies. The IACUC oversees the animal use program as mandated by the United States Public Health Service Policy and Animal Welfare Act. Principal Investigators must complete a Protocol Form for the Use of Live Vertebrate Animals whenever vertebrate animals will be used for research, teaching, or testing.

Federal regulations and standards stipulate that personnel must be trained so they are qualified to perform research on animals. Binghamton University is given the responsibility for providing training to perform research on animals, and as the self-regulating unit of the institution for animal research, the IACUC must ensure that personnel are qualified to perform the procedures proposed in animals as part of the review process. For more information, contact the IACUC administrator.

Lastly, all persons having direct or indirect contact with animals used in research and teaching must be included in the Laboratory Animal Research Occupation Health and Safety (LAR OHS) program. The LAR OHS has responsibility for establishing institutional occupational health and safety policy and procedures for animal users and other individuals having contact with animals used in research and teaching.

10.3 Human Subjects

The institution's official Institutional Review Board (IRB), is responsible for all research projects which involves human subject. All research projects that use human subjects -- regardless of the source of funding -- must be reviewed and approved by the IRB before the investigator may commence with the study. Research investigators may ***not*** make the final determination of exemption from applicable Federal regulations or provisions of Binghamton’s Assurance. Only the IRB Administrator or a committee member can designate a research project as “exempt.”

The ultimate responsibility for treatment of human research subjects, however, rests with the principal investigator. Principal investigator's informed participation in this process helps to ensure a positive, ethical, and responsible climate for scholarly research at Binghamton University.

All BU investigators, as well as research staff, undergraduate and graduate students who will be working with human subjects or the data collected on human subjects ***must*** complete training in the use of human subjects ***before*** applications are submitted for review to the Institutional Review Board (IRB).

10.4 Shipping Biological Materials

Shipping certain biological materials such as human or animal infectious agents or diagnostic/clinical samples - collectively referred to as dangerous goods - involves certain risks and incurs many potential liabilities. If you offer for transport, or transport dangerous goods, or cause dangerous goods to be transported, you must be a trained individual. **There are NO exceptions.** The trained shipper is responsible for properly classifying, identifying, packaging, marking, labeling, and documenting shipments for transport by air or ground. Training and compliance with the regulations are not optional; they are the legal requirements under the U.S Department of Transportation.

Categories of regulated materials include:

- Infectious substances: Substances known or reasonably expected to contain pathogens. Pathogens are defined as microorganisms, including bacteria, viruses, rickettsia, parasites, fungi, and other agents such as prions, which can cause disease in humans and/or animals. This category also includes diagnostic or clinical (patient) specimens.
    - Plant and insect pathogens, and microorganisms that are not pathogenic to humans or animals are excluded from dangerous goods regulations. However, permits issued by the US Department of Agriculture/Animal Plant Health Inspection Service (USDA/APHIS) may still be required even if transportation regulations do not apply.

- Biological Products: Products derived from living organisms that are used for prevention, treatment, or diagnosis of disease in humans or animals. They can include finished or unfinished products such as vaccines. If products are known or reasonably believed to contain infectious substances, the products must be shipped as such.

- Genetically modified microorganisms and organisms: Microorganisms and organisms in which genetic material has been purposely altered and meets the definition of an infectious substance, or can genetically modify other organisms, or are known to be dangerous to the environment, animals, or humans. Some genetically modified organisms that produce pharmaceutical or industrial products may be regulated by agencies such as USDA or Food and Drug Administration.

Contact EH&S at 777-2211 for training inquires and alternative shipping options.

10.4.1 Permits for the Import and Export of Biological Materials

Permits issued by federal agencies such as the US Department of Agriculture or Centers for Disease Control and Prevention are required to import disease causing agents for humans, animals, vectors, plant pests, and animal and plant products. The Department of Commerce controls the export of certain microorganisms and toxins.

Agents Regulated by the Centers for Disease Control and Prevention for Import
Agents of human disease and any materials, including live animals or insects which may contain them. Examples include:

- Any infectious agent known or suspected to cause disease in man.
- Unsterilized specimens of human and animal tissues (such as blood, body discharges, fluids, excretions or similar material) containing an infectious agent.
- Any animal known or suspected of being infected with an organism capable of causing disease transmissible to man. Importation of live turtles of less than 4 inches in shell length and all nonhuman primates requires an importation permit issued by the Division of Quarantine.
- All live bats require an import permit from the CDC and the U.S. Department of Interior, Fish and Wildlife Services.
- All live fleas, flies, lice, mites, mosquitoes, or ticks, regardless of infection status, including adult forms, as well as eggs, larvae, pupae, and nymph stages. Additionally, any other living insect or arthropod, known or suspected of being infected with any disease transmissible to man.
- Any snail species capable of transmitting a human pathogen.

For more information or to download a permit application, see the CDC Import Permit Program.

Agents Regulated by the United States Department of Agriculture/Animal and
Plant Health Inspection Service for Import and Interstate Transport Import and interstate transport of materials that could potentially harm U.S.
agricultural products including livestock, poultry, and crops. Examples include:

Animal-related materials that require an APHIS Import Permit include:

- Live animals, animal semen, and animal embryos from horses, birds, dogs, sheep, cattle, and fish.
- Foreign import or interstate transfer of infectious agents (bacteria, viruses, protozoa, and fungi) of animals, and vectors that might contain these infectious agents.

- Materials derived from animals or exposed to animal-source material including:
    - Animal tissues
    - Blood, cells or cell lines of livestock or poultry origin
    - RNA/DNA extracts ○ Hormones or enzymes
    - Monoclonal antibodies for in-vivo use in non-human species
    - Certain polyclonal antibodies, antisera, and bulk shipments of test kit reagents
- Various other animal materials such as dairy (except butter and cheese), and meat products (e.g., meat pies, prepared foods) from countries with livestock diseases exotic to the U.S.

Certain items do not need a USDA import permit, but will be reviewed at the port of entry by USDA inspectors.

Plant-related materials that are subject to Import and/or Interstate restrictions include:

- Bees and bee related articles
- Biological control organisms
- Butterflies and moths
- Earthworms
- Fruits and vegetables
- Noxious weeds and parasitic plants
- Plants and plant products
- Plant pests
- Snails and slugs
- Soil
- Wood products

Genetically modified organisms (GMOs)

The Biotechnology Regulatory Services regulates the field testing (confined release into the environment), interstate movement, and importation of genetically engineered organisms through the permit and notification processes. Included are:

- Genetically engineered plants and microorganisms
- Transgenic arthropods

GMOs that are not controlled or regulated may still be held at customs. Include a courtesy letter in the shipment.

Department of Commerce

An export license may be required when exporting certain infectious agents of human, plant, and animal diseases, including genetic material, toxins, and products which might be used for culture of large amounts of agents. Consult the Commerce Department’s Export Control page.

U.S. Fish and Wildlife

A permit may be required to import/export non-agricultural animal and plant species. These can include: CITES (Convention on International Trade in Endangered Species) plants and wildlife, migratory and wild birds, marine mammals, endangered and threatened species.

Food and Drug Administration

Food (exception of most meat and poultry - these are regulated by the USDA), drugs, biologics, cosmetics, medical devices, and electronic products that emit radiation, being imported or offered for import into the United States are regulated by the Food and Drug Administration.

10.5 Biological Safety Cabinets

Biological Safety Cabinets (BSC) are engineering devices that reduce the risk of working with biohazardous and infectious microorganisms. Cabinets are also used for maintaining aseptic conditions when working with cell cultures. BSCs utilize High Efficiency Particulate Air (HEPA) filters in the supply air and exhaust systems to create a nearly sterile work environment. Thus, BSCs provide personnel, environmental, and product protection when appropriate practices and procedures are followed.

Contact the Biological Safety Officer at EH&S at 777-2211 to determine the appropriate cabinet for your applications and space. BSCs may be purchased from a variety of vendors including, but not limited to:

- Baker
- Labconco
- NuAire
- Thermo Forma
- Envirco

10.5.1 Biological Safety Cabinet Certifications

All biological safety cabinets must be certified to ensure proper operation. Certification is recommended:

- Before a cabinet is put into service.
- After a cabinet has been repaired or relocated.
- After a filter has been replaced.
- At least annually.

This certification must be performed by a certified contractor. Please coordinate with the Research Compliance Office to find a vendor to complete your certification.

Please note: EH&S does not certify biological safety cabinets.

It is the responsibility of the Principal Investigator or laboratory supervisor to ensure biological safety cabinets within laboratories under their supervision are certified annually.

10.5.2 BSC Work Practices and Procedures

The proper use of biological safety cabinets (BSC) can complement good microbiological practices, and result in effective containment and control of biohazardous and infectious agents. These general guidelines should be followed:

- Locate the BSC "deep" in the laboratory away from air currents produced by ventilation inlets, opening/closing of the laboratory door(s), and away from areas of heavy traffic. If possible, close laboratory doors, limiting entry and egress, and walking traffic during operation. Air currents and movements create turbulence that disrupts the protective envelope of the cabinet. Additionally, other nearby laboratory equipment such as centrifuges, vacuum pumps, etc. can affect the performance of the BSC. Cabinets should not be located directly opposite of each other or opposite a chemical fume hood, as laminar airflow will be hindered.
- Observe the magnehelic gauge and note its relative position each time you operate the BSC. The magnehelic gauge measures the pressure drop across the HEPA filters, and thus indicates filter load and integrity. A significant increase or decrease in the pressure over a short period of time may indicate clogging or leaking of the filter.
- Plan and prepare for your work in the cabinet by having a checklist of materials needed, and place those materials in the BSC before commencing work. This reduces the number of disruptions and arm movements across the air barrier of the cabinet, thereby preserving the protective envelope and containment properties. Slow movement of arms in and out of the cabinet will reduce the risk for potential contamination.

10.5.3 BSC Operational Procedures

1) Operate the cabinet blowers for at least five minutes before beginning work to allow the cabinet to purge or remove particulates from the cabinet.

2) Disinfect and ready the work area. Wipe the work surface, interior walls, and interior surface of the window with a suitable disinfectant such as 70% ethanol, or quaternary ammonium compound, and keep wet for at least 5 -10 minutes.

3) Assemble material. Introduce only those items that are required to perform the procedures and arrange the items such that work "flows" from the least to the most contaminated item. Avoid having to reach for supplies or discard items outside of the cabinet. Consequently, place pipette discard trays (containing disinfectant), biohazard bags, sharps containers, etc. inside the BSC to

the most contaminated side. Limited motion in and out of the cabinet preserves the protective envelope, and prevents the release of infectious materials outside of the BSC.

4) Don protective clothing. Wear laboratory coats or solid front gowns over street clothing, and long-cuffed latex or other appropriate gloves (e.g., nitrile, vinyl). The cuffs of the gloves should be pulled up and over the cuffs of the coat sleeves.

5) Avoid rapid movements inside the cabinet, and perform procedures slowly to avoid disrupting the containment properties of the cabinet.

6) Do not block the front grille with papers, equipment, etc. as this may cause air to enter the workspace instead of flowing through the front grille and to the HEPA filter. Raise arms slightly, and perform operations in the middle third area of the work surface. Likewise, do not block the rear exhaust grille with any operations or equipment.

7) Avoid using open flames inside the cabinet as this can create turbulence and disrupt the pattern of air, and compromise the safety of the operator and affect product protection (i.e., cause contamination). Flames can also damage the interior of the cabinet and the HEPA filters, and in certain circumstances, cause explosions (especially when flammable materials such as ethanol are present). Reevaluate your procedures to determine if sterilization is required (e.g., it is not necessary to flame the necks of flasks). Use devices such as electric furnaces to sterilize any tools, or use disposable, sterile instruments. Lastly, if a burner is necessary, use a touch plate device that provides a flame on demand, and place it to the rear of the cabinet.

8) Connect suction or aspirator flasks to an overflow collection flask that contains a disinfectant (the aspirated materials can then be discarded down the sanitary sewer). Couple the flasks to an inline hydrophobic or HEPA filter designed to protect the vacuum system.

9) When the work is completed, remove all items within the cabinet. Do not use the interior of the BSC as a storage area since stray organisms may become “trapped” and contaminate the cabinet. Clean all the interior surfaces of the cabinet with a suitable disinfectant. Let the blowers operate for at least five minutes with no activity inside the cabinet, to purge the BSC of contaminants.

10) Investigators should remove their gowns and gloves and thoroughly wash their hands with soap and water before exiting the laboratory.

10.5.4 Use of Ultraviolet Lights in the BSC

Ultraviolet lights are a common accessory of many BSCs. These lamps are regarded as biocidal devices “protecting” the operator from exposure to infectious agents, and experimental materials from contamination. However, the actual effectiveness of UV light in providing this “sterile” environment is unclear. Additionally, there are potential occupational hazards that carry significant risks (e.g., serious eye and skin injury) associated with the use and misuse of these lamps. Ultraviolet lamps must be periodically tested to ensure that the energy output is adequate to kill microorganisms. The radiation output should be at least 40 microwatts/cm^2 at 254 nm when measured with a UV flux meter placed in the center of the work surface. Dust that accumulates on the surface of the lamps (UV light is unable to penetrate through dust or other materials), can affect the output performance of the lamps. Microorganisms adhering to floating dust particles or other fixed objects are also "protected" and unaffected by UV illumination.

The effective life spans of the lamps are relatively short and the bulbs are expensive to replace. However, ultraviolet damage to the eyes and skin can occur well after the output of the lamps has dropped below the biocidal level. As a result, EH&S does not recommend the use of UV lights to maintain a clean working environment. Instead, a more effective strategy to reduce or eliminate contamination utilizes well-practiced microbiological procedures, good aseptic techniques, operational procedures as outlined in this manual, and thorough decontamination procedures before and after BSC use.

10.5.5 Types of Biological Safety Cabinets

Biological safety cabinets are divided into 3 classifications: Class I and Class II cabinets, and the total containment Class III cabinets. Class II cabinets are the most common type of cabinet used on campus.

- <u>Class I:</u> The Class I biological safety cabinet is designed to provide personnel and environmental protection only. Unfiltered air is directed through the front opening, across the work area and out through the HEPA filter on top. This cabinet is conventionally used with a full width open front, or can be used with an attached armhole front panel with or without attached rubber gloves. Although Class I cabinets are simple and economical, and radioisotopes and some toxic chemicals can be used (if the exhaust is ducted to the outside), filtered air is not provided over the work area. These cabinets <u>do not</u> protect your materials from contaminants introduced from the environment or the operator.

- <u>Class II:</u> A Class II cabinet meets the requirements for the protection of product, personnel, and the environment. The capacity to protect materials within the cabinet is provided by the flow of HEPA-filtered air over the work surface. There are four subtypes of Class II cabinets based on the construction, inflow air velocities, and exhaust systems. These cabinets can be used to manipulate low to moderate risk agents.

    - <u>Class IIA1</u>: Air, at a face velocity of 75 lfpm, is drawn into the front grille of the cabinet away from the work surface. HEPA filtered air is directed downward over the work area. As the air approaches the work surface, the blower part of the air is directed through the front grille and the remainder through the rear grille. From a common plenum, approximately 70% of the air is recirculated to the work zone through a HEPA filter and about 30% is exhausted to the room through another HEPA filter. This cabinet is unsuitable for work that involves radioactive materials and toxic chemicals because of the buildup of vapors in the air recirculated within the cabinet and exhausted out into the laboratory.

- Class IIA2: This cabinet has a face velocity of 100 lfpm. About 70% of the air directed over the work surface is recirculated through a HEPA supply filter, and about 30% is exhausted through a HEPA exhaust filter. Exhaust air can be directed to the room or to a facility exhaust system. Minute amounts of toxic chemicals and trace amounts of radioisotopes can be used within the hood (if used with facility exhaust), although activities should be conducted toward the rear of the cabinet.

- Class IIB1: This cabinet has a face velocity of 100 lfpm. In contrast to the A2 cabinet, approximately 70% of the circulated air passes through a HEPA exhaust filter, whereas the remaining 30% of the air is recirculated to the work area through a HEPA supply filter.

- Class IIB2: These are total exhaust cabinets (no recirculation of air within the work area), and are widely used in toxicology laboratories and similar applications where chemical effluent is present and clean air is essential. Room air enters through a blower/motor in the top of the cabinet and passes through a HEPA supply filter into the work area as laminar unidirectional airflow. Descending air is pulled through the base of the cabinet through the perforated front and rear grilles. All of the air is pulled into a dedicated, hard-ducted exhaust system. Small quantities of toxic chemicals and radioisotopes can be used within the hood. The exhaust of a large volume of conditioned room air makes this cabinet very expensive to operate. Additionally, the cabinet must be running continuously so as not to interfere with room exhaust.

10.6 Biohazardous Waste (Regulated Medical Waste)

In New York State, the Department of Health (DOH) defines biohazardous or regulated medical waste (RMW) as “waste which is generated in the diagnosis, treatment or immunization of human beings or animals, in research pertaining thereto, or in production and testing of biologicals”. This includes:

- Cultures and stocks of agents infectious to humans (including human, primate, and mammalian cell lines), associated biologicals (e.g., serums, vaccines), and culture dishes and devices used to transfer, inoculate or mix cultures (e.g., Petri dishes, vials, flasks, inoculation loops, disposable gloves).

- Human pathological wastes including tissue, organs, and body parts, and specimens of body fluids and their containers.

- Human blood and blood products.

- Sharps such as syringes and needles, razor blades, scalpels, blood vials, etc.

- Animal wastes including carcasses, body parts, body fluids, blood, or bedding originating from animals known to be contaminated with (zoonotic organisms) or intentionally inoculated with infectious agents.

Please reference the regulated medical waste web page for disposal procedures. All RMW generated on campus within LAR & Science III is self-transported in covered secondary containers to the regulated medical waste accumulation facility.

10.6.1 Hypodermic Syringes and Needles

All users of hypodermic syringes and needles must comply with New York State Department of Health regulations, and are responsible for appropriate procurement, storage, and distribution.

- All non-medical and non-veterinary use of syringes and needles (e.g., teaching, research) require a Department of Health Certificate of Need. Generally, individual academic departments at Binghamton possess Certificates that cover all members within the respective department (please consult with your administrative assistant or department chair).
- The Principal Investigator or supervisor of the laboratory or work area should assign an individual (i.e., custodian) who is responsible for the storage, security, and maintaining records of purchases and distribution.
- Individual users are responsible for securing hypodermic syringes and needles not in use in a locked drawer or cabinet, and maintaining a written log of use and distribution.
- Follow the guidelines for disposal in one of the waste segregation and disposal tables.

11.0 RADIATION HAZARDS

Ionizing radiation is a form of energy. Unlike some other types of energy, such as heat (infrared radiation) or visible light, the human body cannot sense exposure to ionizing radiation. Nonetheless, absorption of ionizing radiation energy by body tissues can cause changes to the chemical makeup of living cells.

The type and thickness of material needed to make an effective barrier or shield around a source of ionizing radiation varies a great deal depending on the type of ionizing radiation. Beta radiation is a stream of tiny charged electrons that can be stopped by a thin layer of plastic, glass, wood, metal and most other common materials. X-rays and Gamma rays are very similar to sunlight in that they are not particles, just electromagnetic waves. While sunlight will pass through only a few materials, such as window glass, X-rays and Gamma rays penetrate easily through most materials. However, they can be blocked by a sufficient thickness of material such as lead.

Ionizing radiation is also similar to other forms of radiation in that the intensity of the radiation exposure decreases very quickly as you move away from the radiation source. Just as moving a short distance closer to or farther from a fireplace causes a large change in how warm you feel; keeping just a few feet away from where someone is handling radioactive material will reduce eliminate your exposure.

11.1 Where Ionizing Radiation is Used

Small amounts of radioactive material are used and stored in laboratory rooms around the campus. Some of the material is contained in small sealed capsules. Examples of these "sealed sources" include test sources for radiation detectors and ionization detectors in gas chromatographs. Most often radioactive material is found in small vials of radioactively labeled chemicals in solution. These labeled chemicals are widely used in research. With very few exceptions, only very small amounts of radioactive material are used and levels of radiation exposure are quite low.

Ionizing radiation can also be produced by certain electrical equipment, including X-ray machines and particle accelerators. Radiation levels produced by this equipment are also very low because of shielding.

You can tell if a room contains a source of ionizing radiation because each entrance is plainly marked by warning labels. Within the room, additional labels and warning tape will be found on each piece of radiation producing equipment and on all areas used to work with or store radioactive material.

11.2 Potential Hazards

Like any form of energy, ionizing radiation can be harmful if a person is exposed to an excessive amount. Exposure to ionizing radiation causes chemical damage to body tissues and can be harmful. Just as with exposure to any toxic chemical, the human body can tolerate exposure to ionizing radiation up to a point without producing any immediate injury. However, just as with toxic chemicals, high levels of exposure can cause serious injuries including skin burns, hair loss, internal bleeding, anemia and immune system suppression. In addition, exposure to high levels of ionizing radiation has been proven to cause an increased lifetime risk of cancer.

11.2.1 How to Protect Yourself

Responsibility for protecting themselves, co-workers and others from exposure to ionizing radiation is delegated by the Radiation Safety Committee to the Principal Investigator or area supervisor and to each of the individual users. Appropriate safety requirements, that are specific to each use and location, are written into each approval granted by the Committee. Every user is trained in radiation safety principles and on the specific safety requirements of their operations before they are allowed to begin working with radioactive material.

Other individuals in these areas, who are not trained to use radioactive material or radiation producing equipment, need to follow the safety procedures established for those working with ionizing radiation. Primarily this means:

1. Never operate equipment that produces ionizing radiation.

2. Never handle items or containers that are labeled with radioactive material warnings or that are within areas marked as storage or use areas for radioactive material.

11.3 Control of Ionizing Radiation

All use of material or equipment that produces ionizing radiation requires prior approval by the Binghamton University Radiation Safety Committee. This group of faculty and staff members set policies and personally review each operation to ensure safety and compliance with state and federal regulations. The University Radiation Safety Officer provides training and other services to help individuals work safely. In addition, the committee performs routine inspections of all use areas and require corrections of all violations of radiation safety requirements. Detailed information on the university radiation safety program is available through the Radiation Safety Officer.

The information presented here is only a brief overview. If you have questions or concerns about the use of ionizing radiation where you work, you are entitled to answers and information. The Principal Investigator, area supervisor or any authorized user is willing and able to help you and you should feel free to speak with them. If you need additional assistance or have any other questions, please contact EH&S at 777-2211.

11.4 Radioactive Waste Disposal

Radioactive material cannot be disposed of in the regular trash. For proper disposal procedures please contact the Radiation Safety Officer at ehs@binghamton.edu or 607-777-2211.

*****NOTE: This material is supplementary to the Radiation Safety Manual*****

12.0 LASER HAZARDS

Binghamton University has a Laser Safety Program designed to establish guidelines to protect students and employees from the potential hazards associated with laser devices and systems used to conduct laboratory, educational, or research activities. To achieve this goal, EH&S recognizes the American National Standard for the Safe Use of Lasers, ANSI Z136.1-2000 and New York Department of Labor's Part 50, LASER Regulation.

For additional information regarding laser safety please contact EH&S at 777-2211. Additional information can be found on the OSHA Safety and Health topics webpage for laser hazards.

13.0 PHYSICAL HAZARDS

In addition to the chemical hazards found in laboratories, there are also physical hazards that can be encountered by laboratory staff regularly. Good awareness of these hazards, preplanning, use of personal protective equipment and following basic safety rules can go a long way in preventing accidents.

13.1 Electrical Safety

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

Electric shock normally occurs in one of three ways. The person must be in contact with ground and must contact:

- Both wires of the electric circuit, or
- One wire of the energized circuit and the ground, or
- A metallic part that has become energized by being in contact with an energized wire.

The severity of the shock received when a person becomes a part of an electric circuit is affected by three primary factors:

- The amount of current flowing through the body (measured in amperes).
- The path of the current through the body.
- The length of time the body is part of the circuit.

Other factors that may affect the severity of shock are the frequency of the current, the phase of the heart cycle when shock occurs, and the general health of the person prior to shock.

EFFECTS OF ELECTRIC CURRENT IN THE BODY

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

The effects of an electrical shock can range from a barely perceptible tingle to immediate cardiac arrest. Although there are no absolute limits or even known values that show the exact injury from any given amperage, the table above shows the general relationship between the degree of injury and the amount of amperage for a 60-cycle hand-to-foot path of one second's duration of shock.

As this table illustrates, a difference of less than 100 milliamperes exists between a current that is barely perceptible and one that can kill. Muscular contraction caused by stimulation may not allow the victim to free himself/herself from the circuit, and the increased duration of exposure increases the dangers to the shock victim. For example, a current of 100 milliamperes for 3 seconds is equivalent to a current of 900 milliamperes applied for 0.03 seconds in causing fibrillation. The so-called low voltages can be extremely dangerous because, all other factors being equal, the degree of injury is proportional to the length of time the body is in the circuit. Simply put, low voltage does not mean low hazard.

In the event of an accident involving electricity, if the individual is down or unconscious, or not breathing: **CALL Binghamton University Police at 911 (777-2222 from a cell phone or off campus phone) immediately.** If an individual must be physically removed from an electrical source, it is always best to eliminate the power source first (i.e. switch off the circuit breaker) but time, or circumstance may not allow this option. Be sure to use a nonconductive item such as a dry board. Failure to think and react properly could make you an additional victim. If the individual is not breathing and you have been trained in CPR, have someone call Binghamton University Police and begin CPR IMMEDIATELY!

13.1.2 Common Electrical Hazards and Preventative Steps

Many common electrical hazards can be easily identified before a serious problem arises.

- Read and follow all equipment operating instructions for proper use. Ask yourself, "Do I have the skills, knowledge, tools, and experience to do this work safely?"

- Do not attempt electrical repairs unless you are a qualified electrical technician assigned to perform electrical work by your supervisor. Qualified individuals must receive training in safety related work practices and procedures, be able to recognize specific hazards associated with electrical energy, and be trained to understand the relationship between electrical hazards and possible injury. Fixed wiring may only be repaired or modified by Physical Facilities.

- All electrical devices fabricated for experimental purposes must meet state and University construction and grounding requirements. Extension cords, power strips, and other purchased electrical equipment must be Underwriters Laboratories (UL) listed.

- Remove all jewelry before working with electricity. This includes rings, watches, bracelets, and necklaces.

- Determine appropriate personal protective equipment (PPE) based on potential hazards present. Always wear safety glasses and electrically insulated gloves when working on live circuits. Before use, inspect safety glasses and gloves for signs of wear and tear or other damage.

- Use insulated tools and testing equipment to work on electrical equipment. Use power tools that are double-insulated or that have Ground Fault Circuit Interrupters protecting the circuit. Do not use aluminum ladders while working with electricity; choose either wood or fiberglass.

- The accidental or unexpected starting of electrical equipment can cause severe injury or death. Before any inspections or repairs are made, the current must be turned off at the switch box and the switch padlocked or tagged out in the off position. At the same time, the switch or controls of the machine or the other equipment being locked out of service should be securely tagged to show which equipment or circuits are being worked on. Test the equipment to make sure there is no residual energy before attempting to work on the circuit. Employees must follow the Binghamton University lock-out/tag-out procedures which can be found on the EH&S website.

- If you need additional power supply, the best solution is to have additional outlets installed by Physical Facilities. Do not use extension cords or power strips as a substitute for permanent wiring.

- Extension cords and power strips may be used on a temporary basis only. Extension cords can only be used for portable tools or equipment and must be unplugged after use. Do not use extension cords for fixed equipment such as computers, refrigerators/freezers, etc.; use a power strip in these cases. In general, the use of power strips is preferred over use of extension cords.

- Power strips must have a built-in overload protection (circuit breaker) and must not be connected to another power strip or extension cord (commonly referred to as daisy chained or piggy-backed). As mentioned above, extension cords and power strips are not a substitute for permanent wiring.

- Ensure any power strips or extension cords Underwriters Laboratory (UL) listed. Make sure the extension cord thickness is at least as big as the electrical cord for the tool. For more information on extension cords, see the Consumer Product Safety Commission - Extension Cords Fact Sheet (CPSC Document #16).

- Inspect all electrical and extension cords for wear and tear. Pay particular attention near the plug and where the cord connects to the piece of equipment. If you discover a frayed electrical cord, contact your Building Administrator for assistance. Do not use equipment with worn or damaged power cords, plugs, switches, receptacles, or cracked casings. Running electrical cords under doors or rugs, through windows, or through holes in walls is not allowed at Binghamton University.

- Never store flammable liquids near electrical equipment, even temporarily.

- Keep work areas clean and dry. Cluttered work areas and benches invite accidents and injuries. Good housekeeping and a well-planned layout of temporary wiring will reduce the dangers of fire, shock, and tripping hazards.

- Common scenarios that may indicate an electrical problem include: flickering lights; warm switches or receptacles; burning odors; sparking sounds when cords are moved; loose connections; frayed, cracked, or broken wires. If you notice any of these problems, have a qualified electrician address the issue immediately.

- Access to electrical panels must be unobstructed; a minimum of 3' of clearance is required in front of every electrical panel. Each panel must be labeled. Contact your Building Administrator for assistance if an electrical hazard is present

- When performing laboratory inspections, verify the location of the power panel and to open the door to ensure any breakers that are missing have breaker caps in its place. If no breaker is present and no breaker cap is covering the hole, contact your Building Administrator for assistance.

- Avoid operating or working with electrical equipment in a wet or damp environment. If you must work in a wet or damp environment, be sure your outlets or circuit breakers are Ground Fault Circuit Interrupter (GFCI) protected. Temporary GFCI plug adapters can also be used, but are not a substitute for GFCI outlets or circuit breakers.

- Fuses, circuit breakers, and Ground-Fault Circuit Interrupters are three well-known examples of circuit protection devices.

    - Fuses and circuit breakers are over-current devices that are placed in circuits to monitor the amount of current that the circuit will carry. They automatically open or break the circuit when the amount of the current flow becomes excessive and therefore unsafe. Fuses are designed to melt when too much current flows through them. Circuit breakers, are designed to trip open the circuit by electro-mechanical means.

    - Fuses and circuit breakers are intended primarily for the protection of conductors and equipment. They prevent overheating of wires and components that might otherwise create hazards for operators.

    - The Ground Fault Circuit Interrupter (GFCI) is designed to shut off electric power within as little as 1/40 of a second, thereby protecting the person, not just the equipment. A fixed or portable GFCI should be used in high-risk areas such as wet locations and construction sites.

For additional information, see the following resources:

1) OSHA Pamphlet 3075
2) 29 CFR 1910.303 through 29 CFR 1910.335
3) National Fire Protection Association (NFPA) 70E

13.1.3 Safe Use of Electrophoresis Equipment

Electrophoresis units present several possible hazards including electrical, chemical, and radiological hazards. All of these hazards need to be addressed before using the unit. EH&S has prepared these guidelines to assist researchers in safely operating electrophoresis units.

1) Proper Equipment Set-Up

Place electrophoresis units and their power supplies so that the on/off switch is easy to reach and the power-indicator lights are visible. Locate the equipment where it will not be easy to knock or trip over.

Because electrophoresis work involves handling conductive liquids around electricity, power supplies should be protected by Ground Fault Circuit Interrupters (GFCIs). You can identify GFCIs by their "test" and "reset" buttons. An adapter type, which plugs into a standard outlet and does not require installation by an electrician, can be purchased at local hardware stores.

2) Addressing Electrical Hazards

Electrophoresis units use very high voltage (approximately 2000 volts) and potentially hazardous current (80 milliamps or more). This high power output has the potential to cause a fatal electrical shock if not properly handled.

Routinely inspect electrophoresis units and their power supplies to ensure they are working properly. Power supplies should be inspected to ensure that all switches and lights are in proper working condition, that power cords and leads are undamaged and properly insulated, and that "Danger--High Voltage" warning signs are in place on the power supply and buffer tanks.

Inspect the buffer tanks for cracks or leaks, exposed connectors, or missing covers. If your units have such hazards, replace the units with new models that have these safety features built in.

3) Training and Work Procedures

Principal Investigators are responsible for providing instruction on the safe use of electrophoresis units to those in the laboratory who work with them. The instruction should cover the operating procedures written by the manufacturer or laboratory, as well as the associated hazards, the correct personal protective equipment, and applicable emergency procedures. As with all safety training, this instruction should be documented. Employees must wear all appropriate personal protective equipment when working with electrophoresis units, including lab coats, gloves, and eye protection.

Do not leave electrophoresis units unattended for long periods of time since unauthorized persons may accidentally come in contact with the unit, or the buffer tank liquid may evaporate, resulting in a risk of fire.

Laboratories that perform electrophoresis work during off hours should consider using a "buddy system" to ensure that emergency services can be notified if someone is injured or exposed. It is also recommended that laboratory personnel be trained in CPR and First Aid.

13.2 Machine Guarding

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

Moving machine parts have the potential for causing severe injuries such as crushed fingers or hands, amputations, burns, or blindness.
Safeguards are essential to protect workers from such injuries.

Requirements for safeguards:

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

13.2.1 Machine Safety Responsibilities

Machine safety responsibilities are assigned to employees as follows:

Supervisors

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

Employees

- Do not remove guards unless machine is locked and tagged out.

- Report machine guard problems to supervisor immediately.
- Do not operate equipment unless guards are in place.

Operators should receive the following training:

- Hazards associated with particular machines.
- How the safeguards provide protection and the hazards for which they are intended.
- How and why to use the safeguards.
- How and when safeguards can be removed and by whom.
- What to do if a safeguard is damaged, missing, or unable to provide adequate protection.

Hazards to machine operators that can't be designed around must be shielded to protect the operator from injury or death. Guards, decals and labels which identify the danger must be kept in place whenever the machine is operated. Guards or shields removed for maintenance must be properly replaced before use. Moving parts present the greatest hazard because of the swiftness of their action and unforgiving and relentless motion.

13.2.1 Common Machine Hazards

Common machine hazards occurring around moving parts include:

1) Pinch Points
Where two parts move together and at least one of the parts moves in a circle; also called mesh points, run-on points, and entry points.
Examples include: Belt drives, chain drives, gear drives, and feed rolls.

When shields cannot be provided, operators must avoid contact with hands or clothing in pinch point areas. Never attempt to service or unclog a machine while it is operating or the engine is running.

2) Wrap Points
Any exposed component that rotates.
Examples include: Rotating shafts such as a PTO shaft or shafts that protrude beyond bearings or sprockets. Watch components on rotating shafts, such as couplers, universal joints, keys, keyways, pins, or other fastening devices. Splined, square, and hexagon-shaped shafts are usually more dangerous than round shafts because the edges tend to grab fingers or clothing more easily than a round shaft, but round shafts may not be smooth and can also grab quickly. Once a finger, thread, article of clothing, or hair is caught it begins to wrap; pulling only causes the wrap to become tighter.

3) Shear Points
Where the edges of two moving parts move across one another or where a single sharp part moves with enough speed or force to cut soft material. Remember that crop cutting devices cannot be totally guarded to keep hands and feet out and still perform their intended function. Recognize the potential hazards of

cutting and shear points on implements and equipment that are not designed to cut or shear. Guarding may not be feasible for these hazards.

4) Crush Points

Points that occur between two objects moving toward each other or one object moving toward a stationary object. Never stand between two objects moving toward one another. Use adequate blocking or lock-out devices when working under equipment.

5) Pull-In Points

Points where objects are pulled into equipment, usually for some type of processing. Machines are faster and stronger than people. Never attempt to hand-feed materials into moving feed rollers. Always stop the equipment before attempting to remove an item that has plugged a roller or that has become wrapped around a rotating shaft. Remember that guards cannot be provided for all situations - equipment must be able to function in the capacity for which it is designed. Freewheeling parts, rotating or moving parts that continue to move after the power is shut off are particularly dangerous because time delays are necessary before service can begin.
Allow sufficient time for freewheeling parts to stop moving. Stay alert! Listen and Watch for Motion!

6) Thrown Objects

Any object that can become airborne because of moving parts. Keep shields in place to reduce the potential for thrown objects. Wear protective gear such as goggles to reduce the risk of personal injury if you cannot prevent particles from being thrown. All guards, shields or access doors must be in place when equipment is operating. Electrically powered equipment must have a lock-out control on the switch or an electrical switch, mechanical clutch or other positive shut-off device mounted directly on the equipment. Circuit interruption devices on an electric motor, such as circuit breakers or overload protection, must require manual reset to restart the motor.

13.3 Lighting

A properly lit work area is essential to working safely. Key points to remember about proper lighting:

- Lighting should be adequate for safe illumination of all work areas (100-200 lumens for laboratories).
- Light bulbs that are mounted low and susceptible to contact should be guarded.
- For proper disposal of fluorescent bulbs (universal waste), contact Physical Facilities at 777-2226.
- As an energy conservation measure, please remember to turn off the lights when you leave your lab.

13.4 Compressed Gases

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

- Gas cylinders may contain gases that are flammable, toxic, corrosive, asphyxiates, or oxidizers.

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

13.4.1 Handling and Transporting Compressed Gas Cylinders

Consider the following when using and handling compressed gas cylinders:

- The contents of any compressed gas cylinder must be clearly identified. Such identification should be stenciled or stamped on the cylinder or a label or tag should be attached. Do not rely on the color of the cylinder for identification because color-coding is not standardized and may vary with manufacturer or supplier.
- When transporting cylinders:
  - Always use a hand truck equipped with a chain or belt for securing the cylinder.
  - Make sure the protective cap covers the cylinder valve.
  - Never transport a cylinder while a regulator is attached.
  - Always use caution when transporting cylinders – cylinders are heavy.
  - Avoid riding in elevators with compressed gas cylinders. If this is necessary, consider using a buddy system to have one person send the properly secured cylinders on the elevator, while the other person waits at the floor by the elevator doors where the cylinders will arrive.
  - Avoid highly trafficked areas or eating areas wherever possible
- Do not move compressed gas cylinders by carrying, rolling, sliding, or dragging them across the floor.
- Do not transport oxygen and combustible gases at the same time.
- Do not drop cylinders or permit them to violently strike anything.

13.4.2 Safe Storage of Compressed Gas Cylinders

Procedures for safe storage of compressed gas cylinders include:

- Gas cylinders must be secured to prevent them from falling over. Chains are recommended over clamp-plus-strap assemblies due to the hazards involved in a fire and straps melting or burning. Be sure the chain is high enough on the cylinder to keep it from tipping over.

- Gas cylinders should be tethered individually where possible. If space constraints prohibit individual tethering, care should be taken to tether cylinders with a sturdy chain or strap in a manner that they are all kept snug together.
- Do not store incompatible gases next to each other. Cylinders of oxygen must be stored at least 20 feet away from cylinders of hydrogen or other flammable gas, or the storage areas must be separated by a firewall five feet high with a fire rating of 1/2 hour.
- All cylinders should be stored away from heat and away from areas where they might be subjected to mechanical damage.
- Keep cylinders away from locations where they might form part of an electrical circuit, such as next to electric power panels or electric wiring.
- The protective cap that comes with a cylinder of gas should always be left on the cylinder when it is not in use. The cap keeps the main cylinder valve from being damaged or broken.
- Full and empty cylinders should be stored away from each other and identified with signs.
- Each lab should limit the amount of excess storage cylinders they store both in their own labs and in the loading dock storage areas. Therefore, only order the tanks you are able to safely store and nothing more.

13.4.3 Operation of Compressed Gas Cylinders

The cylinder valve hand wheel opens and closes the cylinder valve. The pressure relief valve is designed to keep a cylinder from exploding in case of fire or extreme temperature. Cylinders of very toxic gases do not have a pressure relief valve, but they are constructed with special safety features. The valve outlet connection is the joint used to attach the regulator. The pressure regulator is attached to the valve outlet connector in order to reduce the gas flow to a working level.

The Compressed Gas Association has intentionally made certain types of regulators incompatible with certain valve outlet connections to avoid accidental mixing of gases that react with each other. Gases should always be used with the appropriate regulator. Do not use adaptors with regulators. The cylinder connection is a metal-to-metal pressure seal. Make sure the curved mating surfaces are clean before attaching a regulator to a cylinder. Do not use Teflon tape on the threaded parts as this may actually cause the metal seal to not form properly. Always leak test the connection.

Basic operating guidelines:

1) Make sure that the cylinder is secured.

2) Attach the proper regulator to the cylinder. If the regulator does not fit, it may not be suitable for the gas you are using.

3) Attach the appropriate hose connections to the flow control valve. Secure any tubing with clamps so it will not whip around when pressure is turned on. Use suitable materials for connections; toxic and corrosive gases require connections made of special materials.

4) Install a trap between the regulator and the reaction mixture to avoid backflow into the cylinder.

5) To prevent a surge of pressure, turn the delivery pressure adjusting screw counterclockwise until it turns freely and then close the flow control valve.

6) Slowly open the cylinder valve hand wheel until the cylinder pressure gauge reads the cylinder pressure.

7) With the flow control valve closed, turn the delivery pressure screw clockwise until the delivery pressure gauge reads the desired pressure.

8) Adjust the gas flow to the system by using the flow control valve or another flow control device between the regulator and the experiment.

9) After an experiment is completed, turn the cylinder valve off first, and then allow gas to bleed from the regulator. When both gauges read zero, remove the regulator and replace the protective cap on the cylinder head.

10) When the cylinder is empty, mark it as "Empty", and store empty cylinders separate from full cylinders.

11) Attach a "Full/In Use/Empty" tag to all of your cylinders. These tags are perforated and can be obtained from the gas cylinder vendor.

Precautions to follow:

- Use a regulator only with gas for which it is intended. The use of adaptors or homemade connectors can cause serious or fatal accidents.

- Toxic gases should be purchased with a flow-limiting orifice.

- When using more than one gas, be sure to install one-way flow valves from each cylinder to prevent mixing. Accidental mixing can cause contamination of a cylinder.

- Do not attempt to put any gas into a commercial gas cylinder.

- Do not allow a cylinder to become completely empty. Leave at least 25 psi of residual gas to avoid contamination of the cylinder by reverse flow.

- Do not tamper with or use force on a cylinder valve.

- Do not allow oil or grease to contact the valve/regulator assembly. Many regulators will be labeled with a “Use no oil” tag.

- Be careful not to stand directly in front of the glass gauges when opening the cylinder as if there are any faults with the regulator the glass gauges may blow out. Many times it is prudent to point the pressure gauges up slightly.

13.4.4 Return of Cylinders

- Disposal of cylinders and lecture bottles is expensive, especially if the contents are unknown. Make sure that all cylinders and lecture bottles are labeled and included in your chemical inventory. Before you place an order for a cylinder or lecture bottle, determine if the manufacturer will take back the cylinder or lecture bottle when it becomes empty. If at all possible, only order from a manufacturer who will accept cylinders or lecture bottles for return.
- You MUST make arrangements for the disposal or return of the empty gas cylinder before purchasing. This is included in most agreements with reputable gas suppliers

13.4.5 Hazards of Specific Gases

1) Inert Gases
    - Examples: Helium, Argon, Nitrogen
  - Can cause asphyxiation by displacing the air necessary for the support of life.
  - Rapid depressurization highly endothermic and may cause freezing

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

3) Oxidizers

    - Examples: Oxygen, Chlorine
- Oxidizers vigorously accelerate combustion! Keep away from all flammable and organic materials. Greasy and oily materials should never be stored around oxygen. Oil or grease should never be applied to fittings or connectors.
- If using a pump with oxygen, make sure to use oxygen compatible pump oil.

4) Flammable Gases
    - Examples: Methane, Propane, Hydrogen, Acetylene
- Flammable gases present serious fire and explosion hazards.
- Do not store near open flames or other sources of ignition.
- Cylinders containing Acetylene should never be stored on their side.
- Flammable gases are easily ignited by heat, sparks, or flames, and may form explosive mixtures with air. Vapors from liquefied gas often are heavier than air and may spread along ground, travel to a source of ignition, and result in a flashback fire.

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

6) Poisonous Gases
- Examples: Arsine, Phosphine, Phosgene, Silane
- Poison gases are extremely toxic and present a serious hazard to laboratory staff.
- Poisonous gases require special ventilation systems and equipment and must only be used by properly trained experts.

There are also special building code regulations that must be followed with regard to quantities kept on hand and storage.

13.5 Battery Charging

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

- A “No smoking” sign should be posted.
- Before working, remove all jewelry from hands and arms and any dangling jewelry to prevent accidental contact with battery connections (this can cause sparks which can ignite vapors).

- Always wear appropriate PPE such as rubber or synthetic aprons, splash goggles (ideally in combination with a face shield), and thick Neoprene, Viton, or Butyl gloves.
- A plumbed emergency eyewash station must be readily available near the station (please note, hand held eyewash bottles are not allowed)
- A class B rated fire extinguisher needs to be readily available. If none is available, contact EH&S at 777-2211.
- Ensure there is adequate ventilation available to prevent the buildup of potentially flammable and explosive gases.
- Keep all ignition sources away from the area.
- Stand clear of batteries while charging.
- Keep vent caps tight and level.
- Only use the appropriate equipment for charging.
- Store unused batteries in secondary containment to prevent spills.
- Have a spill kit available. The waste from a spill may contain lead and neutralized wastes may be toxic. Contact EH&S at 777-2211 for hazardous waste disposal.
- Properly dispose of your used batteries.

13.6 Heat and Heating Devices

Heat hazards within laboratories can occur from a number of sources. There are some simple guidelines that can be followed to prevent heat related injuries:

- Heating devices should be set up on a sturdy fixture away from any ignitable materials (such as flammable solvents, paper products and other combustibles). Do not leave open flames unattended.

- Heating devices should not be installed near drench showers or other water spraying apparatus due to electrical shock concerns and potential splattering of hot water.

- Heating devices should have a backup power cutoff or temperature controller to prevent overheating. If a backup controller is used, an alarm should notify the user that the main controller has failed.

- Provisions should be included in processes to make sure reaction temperatures do not cause violent reactions and a means to cool the dangerous reactions should be available.

- Post signs to warn people of the heat hazard to prevent burns.

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

- Heat generated should be adequately removed from the area.

- If toxic, flammable, or otherwise hazardous chemicals are evolved from the oven, only use ovens with a single pass through design where air is ventilated out of the lab and the exhausted air is not allowed to come into contact with electrical components or heating elements.

- Heating flammables should only be done with a heating mantle or steam bath.

When using **heating baths**, these additional guidelines should be followed:

- Heating baths should be durable and set up with firm support.

- Since combustible liquids are often used in heat baths, the thermostat should be set so the temperature never rises above the flash point of the liquid. Check the SDS for the chemical to determine the flashpoint. Compare that flashpoint with the expected temperature of the reaction to gauge risk of starting a fire.

13.6.1 Heat Stress

Another form of heat hazard occurs when working in a high heat area. Under certain conditions, your body may have trouble regulating its temperature. You can suffer some degree of heat stress. This can occur very suddenly and, if left unrecognized and untreated, can lead to very serious health effects.

Heat stress disorders range from fainting, cramps, or prickly heat to more dangerous effects such as heat exhaustion or heat stroke. Symptoms of mild to moderate heat stress can include: sweating, clammy skin, fatigue, decreased strength, loss of coordination and muscle control, dizziness, nausea, and irritability. Move to a cool place and give plenty of fluids. Place cool compresses on forehead, neck, and under armpits.

Heat stroke is a medical emergency. It can cause permanent damage to the brain and vital organs, or even death. Heat stroke can occur suddenly, with little warning. Symptoms of heat stroke may include: no sweating (in some cases victim may sweat profusely), high temperature (103˚ or more), red, hot, and dry skin, rapid and strong pulse, throbbing headache, dizziness, nausea, convulsions, delirious behavior, unconsciousness, or coma.

In the case of heat stroke, call 911 & get medical assistance immediately! Move the victim to a cool place; cool the person quickly by sponging with cool water and fanning; and offer a conscious person 1/2 glass of water every 15 minutes.

There are a number of factors that affect your body's temperature regulation:

- Radiant heat sources such as the sun or a furnace.
- Increased humidity causes decreased sweat evaporation.

- Decreased air movement causes decreased sweat evaporation. As ambient temperature rises, your body temperature rises and its ability to regulate decreases.

You should be especially careful if:

- You just started a job involving physical work in a hot environment.
- You are ill, overweight, physically unfit, or on medication that can cause dehydration.
- You have had a previous heat stress disorder.

To prevent heat stress, follow these recommendations:

- Acclimatize your body to the heat. Gradually increase the time you spend in the heat. Most people acclimatize to warmer temperatures in 4-7 days. Acclimatization is lost when you have been away from the heat for one week or more. When you return, repeat the acclimatization process.

- Drink at least 4-8 ounces of fluid every 15-20 minutes to maintain proper balance during hot and/or humid environments. THIRST IS NOT A GOOD INDICATOR OF DEHYDRATION. Fluid intake must continue until well after thirst has been quenched.

- During prolonged heat exposure or heavy workload, a carbohydrate electrolyte beverage may be beneficial.

- Alternate work and rest cycles to prevent overexposure to heat. Rest cycles should include relocation to a cooler environment.

- Perform the heaviest workload in the cooler part of the day.

13.7 Cold Traps

- Because many chemicals captured in cold traps are hazardous, care should be taken and appropriate protective equipment should be worn when handling these chemicals. Hazards include flammability, toxicity, and cryogenic temperatures, which can burn the skin.

- If liquid nitrogen is used, the chamber should be evacuated before charging the system with coolant. Since oxygen in air has a higher boiling point than nitrogen, liquid oxygen can be produced and cause an explosion hazard.

- Boiling and splashing generally occur when charging (cooling) a warm container, so stand clear and wear appropriate protective equipment. Items should be added slowly and in small amounts to minimize splash.

- A blue tint to liquid nitrogen indicates contamination with oxygen and represents an explosion hazard. Contaminated liquid nitrogen should be disposed of appropriately.

- If working under vacuum, see the "reduced pressure" section.

- See "cryogenics" for safety advice when working with cryogenic materials.

13.8 Autoclaves

Autoclaves have the following potential hazards:

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

General safety guidelines to follow when using autoclaves:

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

13.9 Centrifuges

General safety guidelines to follow when using centrifuges:

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

13.9.1 Centrifuge Rotor Care

Basic centrifuge rotor care includes:

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

13.10 Cryogenic Safety

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

- Frostbite - Potential hazards in handling liquefied gases and solids result because they are extremely cold and can cause severe cold contact burns by the liquid, and frostbite or cold exposure by the vapor.

- Asphyxiation - The ability of the liquid to rapidly convert to large quantities of gas associated with evaporation of cryogenic liquid spills can result in asphyxiation. For instance, nitrogen expands approximately 700 times in volume going from liquid to gas at ambient temperature. Total displacement of oxygen by another gas, such as carbon dioxide, will result in unconsciousness, followed by death. Exposure to oxygen-deficient atmospheres may produce dizziness, nausea, vomiting, loss of consciousness, and death. Such symptoms may occur in seconds and without warning. Death may result from errors in judgment, confusion, or loss of consciousness that prevents self-rescue.

  Working with cryogenic substances in confined spaces, such as walk-in coolers, can be especially hazardous. Where cryogenic materials are used, a hazard assessment must be created by the PI to determine the potential for an oxygen-deficient condition. Controls such as ventilation and/or gas detection systems may be required to safeguard employees. Asphyxiation and chemical toxicity are hazards encountered when entering an area that has been used to store cryogenic liquids if proper ventilation/purging techniques are not employed.

- Toxicity - Many of the commonly used cryogenic gases are considered to be of low toxicity, but still pose a hazard from asphyxiation. Check the properties of the gases you are using, because some gases are toxic for example, Carbon monoxide, Fluorine, and Nitrous oxide.

- Flammability and Explosion Hazards - Fire or explosion may result from the evaporation and vapor buildup of flammable gases such as hydrogen, carbon monoxide, or methane. Liquid oxygen, while not itself a flammable gas, can combine with combustible materials and greatly accelerate combustion.

- High Pressure Gas Hazards - Potential hazards exist in highly compressed gases because of stored energy. In cryogenic systems, high pressures are obtained by gas compression during refrigeration, by pumping of liquids to high pressures followed by rapid evaporation, and by confinement of cryogenic fluids with subsequent evaporation. If this confined fluid is suddenly released through a rupture or break in a line, significant thrust may be experienced. Over-pressurization of cryogenic equipment can occur due to the phase change from liquid to gas if not vented properly. All cryogenic fluids produce large volumes of gas when they vaporize.

- Materials and Construction Hazards - The selection of materials calls for consideration of the effects of low temperatures on the properties of those materials. Some materials become brittle at low temperatures. Brittle materials fracture easily and can result in material failure. Low temperature equipment can also fail due to thermal stresses caused by differential thermal contraction of the materials. Over-pressurization of cryogenic equipment can occur due to the phase change from liquid to gas if not vented properly. All cryogenic fluids produce large volumes of gas when they vaporize.

13.10.1 Cryogenic Safety Guidelines

1) Responsibilities

Personnel who are responsible for any cryogenic equipment must conduct a safety review prior to the operating the equipment. Supplementary safety reviews must follow any system modification to ensure that no potentially hazardous condition is overlooked or created and that updated operational and safety procedures remain adequate.

2) Personal Protective Equipment

Wear the appropriate PPE when working with cryogenic materials. Face shields and splash goggles must be worn during the transfer and normal handling of cryogenic fluids. Loose fitting, heavy leather or other insulating protective gloves must be worn when handling cryogenic fluids. Shirt sleeves should be rolled down and buttoned over glove cuffs, or an equivalent protection such as a lab coat, should be worn in order to prevent liquid from spraying or spilling inside the gloves. Trousers without cuffs should be worn.

3) Safety Practices

- Cryogenic fluids must be handled and stored only in containers and systems specifically designed for these products and in accordance with applicable standards, procedures, and proven safe practices.

- Transfer operations involving open cryogenic containers such as Dewar's must be conducted slowly to minimize boiling and splashing of the cryogenic fluid. Transfer of cryogenic fluids from open containers must occur below chest level of the person pouring the liquid.

- Only conduct such operations in well-ventilated areas, such as the laboratory, to prevent possible gas or vapor accumulation that may produce an oxygen-deficient atmosphere and lead to asphyxiation. If this is not possible, an oxygen meter must be installed.

- Equipment and systems designed for the storage, transfer, and dispensing of cryogenic fluids must be constructed of material compatible with the products being handled and the temperatures encountered.

- All cryogenic systems including piping must be equipped with pressure relief devices to prevent excessive pressure build-up. Pressure reliefs must be directed to a safe location. It should be noted that two closed valves in a line form a closed system. The vacuum insulation jacket should also be protected by an over pressure device if the service is below 77 degrees Kelvin. In the event a pressure relief device fails, do not attempt to remove the blockage; instead, call the Cryogenic Safety Officer at 777-2211.

- The caps of liquid nitrogen Dewar's are designed to fit snugly to contain the liquid nitrogen, but also allow the periodic venting that will occur to prevent an over pressurization of the vessel. Do not ever attempt to seal the caps of liquid nitrogen Dewar's. Doing so can promote over pressurization that could rupture the container; cause splashes of liquid nitrogen; and, depending on the quantity of liquid nitrogen that may get spilled, cause an oxygen deficient atmosphere within a laboratory due to the sudden release and vaporization of the liquid nitrogen.

- If liquid nitrogen or helium traps are used to remove condensable gas impurities from a vacuum system that may be closed off by valves, the condensed gases will be released when the trap warms up. Adequate means for relieving resultant build-up of pressure must be provided.

4) First Aid

Workers will rarely, if ever, come into contact with cryogenic fluids if proper handling procedures are used. In the unlikely event contact with a cryogenic liquid or gas occurs, a contact burn may occur. The skin or eye tissue will freeze. Recommended emergency treatment is:

- If the cryogenic fluid comes in contact with the skin or eyes, flush the affected area with generous quantities of cold water. Never use dry heat. Splashes on bare skin cause a stinging sensation, but, in general, are not harmful.

- If clothing becomes soaked with liquid, it should be removed as quickly as possible and the affected area should be flooded with water as above. Where clothing has frozen to the underlying skin, cold water should be poured on the area, but no attempt should be made to remove the clothing until it is completely free.

- Contact University Police at 911 from a campus phone or 777-2222 from a cell phone

- Complete an accident report. (CS-13)

13.10.2 Cryogenic Chemical Specific Information

A) Liquid Helium

Liquid helium must be transferred via helium pressurization in properly designed transfer lines. A major safety hazard may occur if liquid helium comes in contact with air. Air solidifies in contact with liquid helium, and precautions must be taken when transferring liquid helium from one vessel to another or when venting. Over-pressurization and rupture of the container may result. All liquid helium containers must be equipped with a pressure-relief device. The latent heat of vaporization of liquid helium is extremely low (20.5 J/gm); therefore, small heat leaks can cause rapid pressure rises.

B) Liquid Nitrogen

Since the boiling point of liquid nitrogen is below that of liquid oxygen, it is possible for oxygen to condense on any surface cooled by liquid nitrogen. If the system is subsequently closed and the liquid nitrogen removed, the evaporation of the condensed oxygen may over pressurize the equipment or cause a chemical explosion if exposed to combustible materials, e.g., the oil in a rotary vacuum pump.

If the mixture is exposed to radiation, ozone is formed, which freezes out as ice and is very unstable. An explosion can result if this ice is disturbed. Air should not be admitted to enclosed equipment that is below the boiling point of oxygen unless specifically required by a written procedure.

Any transfer operations involving open containers such as wide-mouth Dewar's must be conducted slowly to minimize boiling and splashing of liquid nitrogen. The transfer of liquid nitrogen from open containers must occur below chest level of the person pouring the liquid.

C) Liquid Hydrogen

- Anyone proposing the use of liquid hydrogen must first obtain prior approval of EH&S (777-2211).
- Because of its wide flammability range and ease of ignition, special safety measures must be invoked when using liquid hydrogen.
- Liquid hydrogen must be transferred by helium pressurization in properly designed transfer lines in order to avoid contact with air. Properly constructed and certified vacuum insulated transfer lines should be used.
- Only trained personnel familiar with liquid hydrogen properties, equipment, and operating procedures will be permitted to perform transfer operations. Transfer lines in liquid hydrogen service must be purged with helium or gaseous hydrogen, with proper precautions, before using.
- The safety philosophy in the use of liquid hydrogen can be summarized as the following:
    - Isolation of the experiment.
    - Provision of adequate ventilation.
    - Exclusion of ignition sources plus system grounding/bonding to prevent static charge build-up.
    - Containment in helium purged vessels.
    - Efficient monitoring for hydrogen leakage.
    - Limiting the amount of hydrogen cryo-pumped in the vacuum system.

13.11 Extractions and Distillations

Extractions

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

Distillations

- Avoid bumping (sudden boiling) since the force can break apart the apparatus and result in splashes. Bumping can be avoided by even heating, such as using a heat mantle. Also, stirring can prevent bumping. Boiling stones can be used only if the process is at atmospheric pressure.
- Do not add solid items such as boiling stones to liquid that is near boiling since it may result in the liquid boiling over spontaneously.
- Organic compounds should never be allowed to boil dry unless they are known to be free of peroxides, which can result in an explosion hazard.

Reduced pressure distillation

- Do not overheat the liquid. Superheating can result in decomposition and uncontrolled reactions.
- Superheating and bumping often occur at reduced pressures so it is important to ensure even, controlled heating. Inserting a nitrogen bleed tube may help alleviate this issue.
- Evacuate the assembly gradually to minimize bumping.
- Allow the system to cool and then slowly bleed in air. Air can cause an explosion in a hot system (pure nitrogen is preferable to air for cooling).
- See “reduced pressure” for vacuum conditions.

13.12 Glass Under Vacuum

Reduced pressure:

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

Vacuum pumps:

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

13.13 Glass Cleaning

In most cases laboratory glassware can be cleaned effectively by using detergents and water. In some cases, it may be necessary to use strong chemicals for cleaning glassware. Strong acids should not be used unless necessary. In particular, chromic acid should not be used due to its toxicity and disposal concerns. One product that may be substituted for Chromic acid is “Nochromix Reagent”.

When handling glassware, check for cracks and chips before use. Handle glassware with care – avoid impacts, scratches, and intense heating of glassware. Use care when inserting glass tubing into stoppers: use glass tubing that has been fire-polished, lubricate the glass, and protect your hands with heavy gloves.

13.14 General Equipment Set Up

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

13.14.1 Glassware and Plasticware

- Borosilicate glassware (i.e. Pyrex) is recommended for all lab glassware, except for special experiments using UV or other light sources. Soft glass should only be used for things such as reagent bottles, measuring equipment, stirring rods and tubing.
- Any glass equipment being evacuated, such as suction flasks, should be specially designed with heavy walls. Dewar flasks and large vacuum vessels should be taped or guarded in case of flying glass from an implosion. Household thermos bottles have thin walls and are not acceptable substitutes for lab Dewar flasks.
- Glass containers containing hazardous chemicals should be transported in rubber bottle carriers or buckets to protect them from breakage and to contain any spills or leaks. It is recommended to transport plastic containers this way as well since they also can break or leak.

13.14.2 Preparation of Glass Tubing and Stoppers

To cut glass tubing:

- Hold the tube against a firm support and make one firm quick stroke with a sharp triangular file or glass cutter to score the glass long enough to extend approximately one third around the circumference.

- Cover the tubing with cloth and hold the tubing in both hands away from the body. Place thumbs on the tubing opposite the nick 2 to 3 cm and extended toward each other.
- Push out on the tubing with the thumbs as you pull the sections apart, but do not deliberately bend the glass with the hands. If the tubing does not break, re-score the tube in the same place and try again. Be careful to not contact anyone nearby with your motion or with long pieces of tubing.
- All glass tubing, including stir rods, should be fire polished before use. Unpolished tubing can cut skin as well as inhibit insertion into stoppers. After polishing or bending glass, given ample time for it to cool before grasping it.

When drilling a stopper:

- Use only a sharp borer one size smaller than that which will just slip over the tube to be inserted. For rubber stoppers, lubricate with water or glycerol. Holes should be bored by slicing through the stopper, twisting with moderate forward pressure, grasping the stopper only with the fingers, and keeping the hand away from the back of the stopper.
- Keep the index finger of the drilling hand against the barrel of the borer and close to the stopper to stop the borer when it breaks through. Preferably, drill only part way through and then finish by drilling from the opposite side.
- Discard a stopper if a hole is irregular or does not fit the inserted tube snugly, if it is cracked, or if it leaks.
- Corks should have been previously softened by rolling and kneading. Rubber or cork stoppers should fit into a joint so that one-third to one–half of the stopper is inserted.
- When available, glassware with ground joints is preferable. Glass stoppers and joints should be clean, dry and lightly lubricated.

13.14.3 Insertion of Glass Tubes or Rods into Stoppers

The following practices will help prevent accidents:

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

13.14.4 Assembling Apparatus

- Following these recommendations will help make apparatus assembly easier and safer:
- Keep your work space free of clutter.

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

must be stabilized with weights or fasteners. Standing shields are preferably secured near the top. Proper eye and face protection must be worn even when using safety shields or fume hoods.

13.15 Ergonomics

Many lab tasks such as looking through microscopes, working in exhaust hoods, pipetting and continuously looking down require lots of repetitive movements and sustained posturing (usually reaching). Often there is little leg room when sitting at counters or hoods, which causes more reaching. There may be few obvious equipment changes you can make. You can also develop personal strategies that can reduce task-related discomfort. These include:

1. Work as much as you can in a neutral posture - head balanced over shoulders, upper arms vertical, wrists neutral, and spine supported. Use the chair and other adjustments as you can to facilitate this. It is often difficult in lab work to balance the degree of reaching with the need to look down at your task. If reaching is minimal, the demand to look down is usually greater, and vice-versa. Strategies to improve this include:
    a. Raising what you are looking at to higher level; this usually improves the head/neck posture, but often requires more reach.
    b. Alternate positions; e.g. for a time work with hands close, looking down more; then for a time with hands away, holding head/neck more neutral.
    c. Hold hands away, but with forearms supported.

The choices will depend on the specific task and equipment being used.

2. Be aware that reaching demands are usually greater when sitting. Standing permits easy weight shifting side to side or leaning forward, all of which can reduce your shoulder reach. If you have consistent discomfort or strain in shoulders or upper back when doing sitting tasks, and you can’t move items closer, try to do them standing (obviously, items you use will have to be raised).

3. If you want to sit at a lab counter using a high chair, be sure there is sufficient leg room under the counter so you can sit at the counter without twisting or leaning.

4. Take advantage of built-in task interruptions and pauses to frequently stretch and reposition yourself.

5. Listen to your body - if a specific task is causing discomfort, stop briefly every 15-20 minutes and stretch and move the body part that is uncomfortable for a few seconds. Stretch slowly. If feasible, perform a different task for a while.

APPENDIX A: CHEMICAL HYGIENE PLAN

Binghamton University Chemical Hygiene Plan

The Occupational Safety and Health Administration (OSHA) regulation 29 CFR 1910.1450, "Occupational Exposure to Hazardous Chemicals in Laboratories" mandates the development of a Chemical Hygiene Plan which is capable of protecting employees from health hazards associated with hazardous chemicals in the laboratory and capable of keeping exposures below OSHA Permissible Exposure Limits (PEL).

The Binghamton University Chemical Hygiene Plan is developed and coordinated by Environmental Health and Safety (EH&S). This Chemical Hygiene Plan is designed to supplement department and laboratory specific safety manuals and procedures that already address chemical safety in laboratories.

As per the OSHA Laboratory Standard, the following are required elements of the Chemical Hygiene Plan:

1) Standard Operating Procedures

There are over three hundred laboratories at Binghamton University and most of these use hazardous chemicals. Every department should develop a comprehensive safety and health manual. These manuals should address specific safety rules, regulations and standard operating procedures for laboratory workers in the department or college. Most of the laboratories have referred to widely known and accepted laboratory safety practices referenced in *Prudent Practices in the Laboratory,* published by the National Research Council, or *Safety in Academic Chemical Laboratories,* published by the American Chemical Society.

EH&S will assist laboratories in developing general and specific standard operating procedures for chemical use in laboratories. Due to the large variety of research and the number of laboratories involved, it is the responsibility of each laboratory, department or college to ensure that their practices and procedures are adequate to protect their workers who use hazardous chemicals.

It is the responsibility of the Principal Investigator or department head to ensure that written safety procedures are developed for work in their labs and that controls and protective equipment are adequate to prevent overexposure. In many cases, standard operating procedures for laboratory safety have been developed and implemented for years and few changes will be necessary to comply with the OSHA Lab Standard. Existing standard operating procedures may need to be reevaluated to ensure that they address the health and safety requirements for the chemicals currently in use.

2) Control Measures

The exposure to hazardous chemicals in the laboratory shall be controlled through the use of engineering controls, personal protective equipment, good general laboratory practices, and standard operating procedures specific to an individual laboratory or department.

- Engineering controls: There are a variety of engineering controls that can be used in the laboratory to control exposures to hazardous chemicals. Some that are in use in laboratories at Binghamton University include dilution ventilation, local exhaust ventilation (fume hoods), and proper storage facilities.

- Personal protective equipment: Personal protective equipment (PPE) will be available to laboratory workers to reduce exposures to hazardous chemicals in the laboratory. Common PPE such as goggles, gloves, face shields, and aprons are recommended for use with hazardous chemicals. Other PPE such as respirators will be available and recommended if necessary. EH&S can assist in the proper selection of PPE. PPE will be readily available and most equipment is provided at no cost to the employee.

- General laboratory practices: EH&S provides laboratories with information about general laboratory work practices and rules that are recognized as effective control measures to minimize exposure to hazardous chemicals in the laboratory. The information is derived from *Prudent Practices in the Laboratory, Safety in Academic Chemistry Laboratories,* and other references. These general procedures include guidelines on use of chemicals, accidents and spills, personal protection, use of fume hoods and other good laboratory practice information.

- Specific laboratory practices: Individual departments or laboratories must develop additional written safety procedures whenever necessary to protect laboratory workers from specific chemical hazards that are unique to their particular area of research. Particular attention should be given to control measures for operations that involve the use of particularly hazardous substances such as select carcinogens, reproductive toxins, or acutely toxic chemicals. EH&S can assist researchers in developing safety procedures for specific hazards.

- Other: Other control methods that will be used to reduce employee exposures to hazardous chemicals in the laboratory may include exposure monitoring, testing of eyewash and emergency shower facilities, development of emergency procedures, proper container selection, and substitution of less toxic chemicals when possible.

3) Fume Hoods and Other Protective Equipment

Fume hoods are tested annually by EH&S. EH&S will provide a list to Physical Facilities of fume hoods which are not working properly and they will facilitate repairs.

It is the responsibility of the Department Chair to insure all safety equipment is working and checked accordingly.

4) Information and Training

Federal and state laws and Binghamton University policy require all laboratory workers to receive laboratory safety training and be informed of the potential health and safety risks that may be present in their workplace. Documentation must be maintained to demonstrate that such training was provided and received. Laboratory safety training must be obtained through EH&S or documented as having been received from an alternative source. Laboratory personnel who attend EH&S training classes will have documentation entered and maintained for them by EH&S.

It is the responsibility of Principal Investigators and laboratory supervisors to ensure personnel working in laboratories under their supervision have been provided with proper training, have received information about the hazards in the laboratory they may encounter, and have been informed about ways the employees can protect themselves.

EH&S can provide a variety of safety information to laboratories, including the Chemical Hygiene Plan, the Laboratory Safety Manual, SDS's, OSHA Permissible Exposure Limits, and specific topical information.

New Students, Faculty, and Staff that work in a research lab must take training in-person with EHS Staff within a grace period defined by their department. Unless otherwise directed by their department, users will be permitted to take the training session online every year between 8/1 and 8/31 after successful completion of an in-person training session.

5) Prior Approval for High Hazard Work

EH&S can assist in identifying circumstances when there should be prior approval before implementation of a particular laboratory operation. Due to the large variety of research being conducted in laboratories at the

University, it is impossible to develop one prior approval process that can apply to all laboratories. Instead, high hazard types of activities should be identified by the Principal Investigator or person responsible for the work, and any type of approval process should be addressed in the laboratory's or department's standard operating procedures.

EH&S will assist in providing information to researchers about work with select carcinogens, reproductive toxins, and acute toxins. General guidelines and recommendations for the safe handling, use and control of high hazard materials can be provided through SDS's, and reference sources such as *Prudent Practices in the Laboratory*, *Safety in Academic Chemistry Laboratories*

There are some circumstances where prior approval from a campus research related committee is required before beginning an operation or activity. These include:

- Research using live vertebrate animals – contact the Institutional Animal Care and Use Committee.

- Recombinant DNA use – contact the Institutional Biosafety Committee or the Bio Safety Officer at 777-2211.
- Use of Radioactive Materials – contact the Radiation Safety Officer (RSO) at 777-3589.
- Use of Human Subjects - contact the Institutional Review Board (IRB).

6) Medical Consultations and Medical Examinations

Medical consultations and medical examinations will be made available to laboratory workers who work with hazardous chemicals as required. All work related medical examinations and consultations will be performed by or under the direct supervision of a licensed physician and will be provided at no cost to the employee.

The opportunity to receive medical attention, including any follow up examinations, will be provided to employees who work with hazardous chemicals under the following circumstances:

- Whenever an employee develops signs or symptoms associated with a hazardous chemical to which the employee may have been exposed in the laboratory.
- Where airborne exposure monitoring reveals an exposure level routinely above the action level (or in the absence of an action level, the Permissible Exposure Limit) for an OSHA regulated substance for which there are exposure monitoring and medical surveillance requirements. Action level means the airborne concentration of a specific chemical, identified by OSHA, and calculated as an 8-hour time weighted average (TWA).
- Whenever an event such as a spill, leak, explosion or other occurrence takes place and results in the likelihood of a hazardous exposure. Upon such an event, the affected employee shall be provided an opportunity for a medical consultation. The consultation shall be for the purpose of determining the need for a medical examination.

All records of medical consultations, examinations, tests, or written opinions shall be maintained at the BU health center in accordance with 29 CFR 1910.1020 - Access to employee exposure and medical records .

7) Personnel Responsible for the Chemical Hygiene Plan

EH&S will provide technical information and program support to assist laboratories to comply with the OSHA Laboratory Standard. EH&S will maintain the campus Chemical Hygiene Plan (CHP) and the institutional Chemical Hygiene Officer responsibilities will reside within EH&S. It will be the responsibility of the Principal Investigator or individual supervisor, department or college to be in compliance with the components of the CHP.

Each department or laboratory may adopt or modify this CHP or write their own chemical hygiene plan as long as the requirements of the OSHA Laboratory Standard are met. It is assumed if a department or laboratory has not developed their own, then that department or laboratory has adopted the Binghamton University Chemical Hygiene Plan.

8) Provisions for Additional Employee Protection for Work with Particularly Hazardous Substances

The Chemical Hygiene Plan includes provisions for additional employee protection for work with particularly hazardous substances. Research involving the use of particularly hazardous substances, such as select carcinogens, reproductive toxins or acute toxins chemicals may require prior review to ensure adequate controls are in place which will protect the worker. EH&S will assist with the review and make recommendations for additional employee protection.

Additional employee protection may require the use of additional provisions such as:

Establishment of a designated area.

- Use of containment devices such as fume hoods or glove boxes.
- Procedures for safe removal of contaminated waste.
- Decontamination procedures.

The provision for additional controls may require the expertise and recommendations of various groups throughout campus including EH&S. All additional provisions for work with particularly hazardous substances must be incorporated into the lab's standard operation procedures for those materials.

APPENDIX B: DEPARTMENTS' SAFETY MANUALS

1. It is the responsibility of the department to either adopt the university safety manual as written or modify to support the departments policies and procedures. All modifications must be approved by EH&S.

APPENDIX C: ABBREVIATED LAB SAFETY RESPONSIBILITIES

1. It is the responsibility of Principal Investigators and laboratory supervisors to ensure that personnel working in laboratories under their control are familiar with the contents and location of the Chemical Hygiene Plan, including any lab specific standard operating procedures and any department or college level laboratory safety manuals, policies, and procedures. (Section 1.1)

2. It is the responsibility of the Principal Investigator and individual supervisors (and individuals working under their supervision) to be in compliance with the components of the University Chemical Hygiene Plan, the University Health and Safety Policy, and any other department or University specific policies. (Section 1.2)

3. It is the responsibility of laboratory personnel to immediately report malfunctioning protective equipment (such as fume hoods) or mechanical issues to their Building Administrator as soon as malfunctions are discovered. (Section 2.1)

4. Principal Investigators, laboratory supervisors, and departments are free to set policies that establish minimum PPE requirements for personnel working in and entering their laboratories. Be sure to check with your DSR to see if there are any department or college specific requirements for PPE. (Section 2.2.1)

5. It is the responsibility of the Principal Investigator or laboratory supervisor to ensure laboratory staff have received appropriate training on the selection and use of proper PPE; that proper PPE is available and in good condition; and laboratory personnel use proper PPE when working in laboratories under their supervision. (Section 2.2.1.1)

6. EH&S strongly encourages Principal Investigators and laboratory supervisors to make the use of eye protection a mandatory requirement for all laboratory personnel, including visitors, working in or entering laboratories under their control. (Section 2.2.2)

7. EH&S strongly recommends that Principal Investigators and laboratory supervisors prohibit the wearing of shorts and skirts in laboratories using hazardous materials (chemical, biological, and radiological) by laboratory personnel, including visitors, working in or entering laboratories under their supervision. (Section 2.2.4)

8. EH&S strongly encourages Principal Investigators and laboratory supervisors to require the use of closed toed shoes for all laboratory personnel, including visitors, working in or entering laboratories and laboratory support areas under their supervision. (Section 2.2.7)

9. It is the responsibility of the Principal Investigator and laboratory supervisor to ensure written SOPs incorporating health and safety considerations are developed for work involving the use of hazardous chemicals in laboratories under their supervision and that PPE and engineering controls are adequate to prevent overexposure. In addition, Principal Investigators and laboratory supervisors must ensure that personnel working in laboratories under their supervision have been trained on these SOPs. (Section 2.3)

10. It is the responsibility of the Principal Investigator and laboratory supervisor to ensure that personnel working in laboratories under their supervision are informed and follow laboratory specific, departmental, and campus wide policies and procedures related to laboratory safety – such as the guidelines and requirements covered in this Laboratory Safety Manual. (Section 2.4)

11. It is the responsibility of Principal Investigators and laboratory supervisors to ensure laboratories under their supervision are maintained in a clean and orderly manner and personnel working in the lab practice good housekeeping. (Section 2.4.3)

12. It is the responsibility of Principal Investigators and laboratory supervisors to ensure procedures for working alone are developed and followed by personnel working in laboratories under their supervision. (Section 2.4.6)

13. It is the responsibility of Principal Investigators and laboratory supervisors to ensure procedures for unattended operations are developed and followed by personnel working in laboratories under their supervision. (Section 2.4.7)

14. It is the responsibility of the Department Chairperson, Principal Investigators, and laboratory supervisors to restrict access of visitors and children to areas under their supervision when potential health and physical hazards exist in those areas (Section 2.4.8)

15. It is the responsibility of laboratory personnel to activate (flush) emergency showers and eyewash units on a regular basis. (Section 3.5.1)

16. It is the responsibility of the Principal Investigator and laboratory supervisor to ensure all accidents and injuries are reported to University officials through the use of the Binghamton University injury reporting system. (Section 3.4)

17. It is the responsibility of Principal Investigators and laboratory supervisors to ensure personnel working in laboratories under their supervision have been provided with the proper training, have received information about the hazards in the laboratory they may encounter, and have been informed about ways they can protect themselves. (Section 4.0)

18. It is the responsibility of the Principal Investigator and laboratory supervisor to ensure that staff and students under their supervision are provided with adequate training and information specific to the hazards found within their laboratories. (Section 5.2.1)

19. It is the responsibility of Principal Investigators and laboratory supervisors to ensure that staff and students working in laboratories under their supervision have obtained required health and safety training and have access to SDS's (and other sources of information) for all hazardous chemicals used in laboratories under their supervision. (Section 5.2.2)

20. While EH&S can provide assistance in identifying circumstances when there should be prior approval before implementation of a particular laboratory operation, the ultimate responsibility of establishing prior approval procedures lies with the Principal Investigator or laboratory supervisor. (Section 6.3)

21. It is the responsibility of the Principal Investigator and laboratory supervisor to ensure that personnel working in laboratories under their supervision are familiar with and follow hazardous chemical waste container requirements. (Section 7.1)

22. It is the responsibility of the Principal Investigator or laboratory supervisor to ensure any employee working under their supervision who ships or prepares shipments of hazardous materials have received the proper training. (Section 8.0)

23. The responsibility for ensuring that all work with pesticides at Binghamton is conducted properly and legally rests on the individual user. (Section 9.0)

24. When using pesticides in a non-dispersive manner in a laboratory setting, an individual must follow the safety rules outlined in the Binghamton University Laboratory Safety Manual. (Section 9.1.1)

25. It is the responsibility of the Principal Investigator or laboratory supervisor to ensure biological safety cabinets within laboratories under their supervision are certified annually. (Section 10.5.1)

26. It is the responsibility of the Principal Investigator or laboratory supervisor with class 3b or 4 LASERs in laboratories under their supervision to ensure the class 3b or 4 LASERs have been registered with EH&S and employees using these LASERs have received the appropriate training. (Section 12.0)

27. It is the responsibility of the Principal Investigator and laboratory supervisor to ensure that staff and students in laboratories under their supervision are provided with adequate training and information specific to the physical hazards found within their laboratories. (Section 13.0)

APPENDIX D: GLOVE SELECTION FOR SPECIFIC CHEMICALS

Chemical	**Incidental Contact**	**Extended Contact**
Acetic acid	Nitrile	Neoprene, Butyl rubber
Acetic anhydride	Nitrile (8 mil), double glove	Butyl rubber, Neoprene
Acetone	[1] Natural rubber (Latex) (8 mil)	Butyl rubber
Acetonitrile	Nitrile	Butyl rubber, Polyvinyl acetate (PVA)
Acrylamide	Nitrile, or double Nitrile	Butyl rubber
bis-Acrylamide	Nitrile	
Alkali metals	Nitrile	
Ammonium hydroxide	Nitrile	Neoprene, Butyl rubber
Arsenic salts	Nitrile	
Benzotriazole, 1,2,3-	Nitrile	
Bismuth salts	Nitrile	
Butanol	Nitrile	Nitrile, Butyl rubber
Butyric acid	Nitrile	Butyl rubber, Neoprene
Cadmium salts	Nitrile	
Carbon disulfide	Nitrile (8 mil), double glove, or 15 mil or heavier	Viton, Polyvinyl acetate (PVA)
Carbon tetrachloride	Nitrile (8 mil), double glove, or 15 mil or heavier	Viton
Catechol	Nitrile	
Chloroform	Nitrile (8 mil), double glove, or 15 mil or heavier	Viton, Polyvinyl acetate (PVA)
Chlorosulfuron	Nitrile	
Chromium salts	Nitrile	
Cobalt chloride	Nitrile	Nitrile
Cobalt salts	Nitrile	
Copper (Cupric) sulfate	Nitrile	
Cyrogenic liquids	Cryogloves	
3,3'-Diaminobenzidine (DAB)	Nitrile	Nitrile, double glove
Diazomethane in Ether	Nitrile (8 mil), double glove, or 15 mil or heavier	Norfoil
Dichloromethane	Nitrile (8 mil), double glove	Polyvinyl acetate (PVA) or Viton

2,4-Dichlorophenoxy acetic acid	Nitrile	
Diethyl pyrocarbonate	Nitrile	Nitrile, double glove
Dimethyl sulfoxide	[1] Natural rubber (15-18mil)	Butyl rubber

1,4-Dioxane	Nitrile (8 mil), double glove, or 15 mil or heavier	Butyl rubber
Dithiothreitol	Nitrile	
Ethanol	Nitrile	
Ethidium bromide (EtBr)	Nitrile	Nitrile, double glove
Ethyl acetate	Nitrile (8 mil), double glove	Butyl rubber, PVA
Ethyl ether	Nitrile (8 mil), double glove, or 15 mil or heavier	Polyvinyl acetate (PVA)
Formaldehyde	Nitrile	
Formamide	Nitrile	Butyl rubber
Formic acid	Nitrile (8 mil), double glove	Butyl rubber, Neoprene (.28-.33mm)
Gallic acid	Nitrile	
Geneticin	Nitrile	
Glutaraldehyde	Nitrile	
Heavy metal salts	Nitrile	Nitrile, double glove
Heptane	Nitrile (8 mil), double glove, or 15 mil or heavier	Nitrile (35 mils or thicker), Viton, PVA
Hexamethylenediamine (1,6-Diaminohexane)	Nitrile (8 mil)	Neoprene
Hexane	Nitrile (8 mil), double glove, or 15 mil or heavier	Nitrile (35 mils or thicker), Viton, PVA
Hydrochloric acid	Nitrile	Neoprene, Butyl rubber
Hydrofluoric acid (HF)	Nitrile (8 mil), double glove, or 15 mil or heavier	Nitrile or Rubber sleeves
Hypophosphorous acid	Nitrile (4mil), double glove or 8 mil or heavier	
Isoamyl alcohol	Nitrile	

Isoctane	Nitrile	Heavy weight Nitrile
Isopropanol	Nitrile	
Kananmycin	Nitrile	
Lactic acid	Nitrile	Nitrile (double glove), or Neoprene or Butyl rubber
Laser dyes	Nitrile	
Lead acetate	Nitrile	Nitrile, double glove
Lead salts	Nitrile	
Mercuric chloride	Nitrile	Nitrile, double glove
Mercury	Nitrile	
Mercury salts	Nitrile	
Methanol (Methyl alcohol)	Nitrile	
Methylene chloride	Nitrile (8 mil), double glove	Polyvinyl acetate, Viton
Methylphosphonic acid	Nitrile (4 mil), double glove	8 mil or heavier Nitrile
Methyl sulfonic acid, Ethyl ester (EMS) (Ethyl methanesulfonate)	Nitrile	Nitrile, double glove
Monoethanolamine	Nitrile	
Nickel chloride	Nitrile	Nitrile, double glove
Nickel salts	Nitrile	Nitrile, double glove
Nitric acid	Nitrile (8 mil), double glove	Heavy weight (.28.33mm) Butyl rubber or Neoprene
N-Methylethanolamine	Nitrile (8 mil), double glove	Viton, Neoprene, Butyl rubber
Octane	Nitrile	Heavy weight Nitrile or Viton
Organophosphorous compounds	Nitrile (8 mil), double glove, or 15 mil or heavier	
Osmium salts	Nitrile	
Osmium tetroxide	Nitrile	Nitrile, double glove
Paraformaldehyde	Nitrile	

Pentane	Nitrile (8mil), double glove	Heavy weight Neoprene, or Viton
Perchloroethylene (tetrachloroethylene)	Nitrile (8 mil), double glove	Nitrile (22mil or heavier)
Pesticides	heavy weight, unlined Nitrile (8-20 mils), or glove specified by pesticide label.	
Petroleum ether	Nitrile	Heavy weight Nitrile or Viton
Phenol	Nitrile (8 mil), double glove	Neoprene, Butyl rubber
Phenol-Chloroform mixtures	Nitrile (8 mil), double glove, or 15 mil or heavier	Viton
Phenylmethylsulfonyl fluoride (PMSF)	Nitrile	Nitrile, double glove
Phosphonic acid	Nitrile (4 mil), double glove, or 8 mil or heavier single	
Phosphoric acid	Nitrile (4 mil), double glove, or 8 mil or heavier	
Picloram (4-amino-3,5,6-trichloropicolinic acid)	Nitrile	
Polychlorinated Biphenyls (PCB’s)	Nitrile (8 mil) glove over a Neoprene glove	Neoprene (20 mil)
Polyoxyethylenesorbital-n-monolaurate (Tween 20)	Nitrile	
Potassium ferricyanide	Nitrile	
Potassium ferrocyanide	Nitrile	
Potassium permanganate	Nitrile	
Propanol	Nitrile	
Propionic acid	Nitrile	Neoprene or Butyl rubber
Propylene oxide	heavier weight (17 mil or greater) Butyl rubber or Neoprene	Norfoil
Psoralen	Nitrile	Nitrile, double glove
Pump oil	Butyl rubber	

Silane based silanization or derivatization compounds	Nitrile (8 mil), double glove, or 15 mil or heavier single	
Silver nitrate	Nitrile	Nitrile, double glove
Silver salts	Nitrile	
Sodium dodecyl sulfate (SDS)	Nitrile	
Sodium azide	Nitrile, or double glove	
Spermidine	Nitrile	
Sulfuric acid	Nitrile (8 mil)	Neoprene, Butyl rubber (20 mil or greater)
Tetrahydrofuran (THF)	Nitrile (8 mil), double glove, or 15 mil or heavier	Norfoil
3,3’,5,5’-Tetramethylbenzidine (TMB)	Nitrile	Nitrile, double glove
N,N,N’,N’-Tetramethylethylenediamine (TEMED)	Nitrile	Nitrile, double glove
Timetin	Nitrile	
Toluene	Nitrile (8 mil), double glove, or 15 mil or heavier	Viton, Polyvinyl acetate (PVA)
Trichloroethylene	Nitrile (8 mil), double glove	Viton, Polyvinyl acetate (PVA)
Trichloromethyl chloroformate (diphosgene)	Nitrile (8 mil) over Butyl rubber glove	This material must be used in a glove box.
Triton-X100	Nitrile	
Uranium salts	Nitrile	
Valeric acid	Nitrile	Nitrile, double gloves, or Neoprene or Butyl rubber
Xylene	Nitrile	Polyvinyl acetate (PVA), Viton

[1] If you are allergic to natural rubber products; you may double glove with 8 mil Nitrile gloves.

GLOVE SELECTION WEBSITES

DISCLAIMER: While the glove selection web links below are being provided as additional resources, Binghamton University has not investigated the accuracy of the information contained within the webpages.

Comprehensive Guide to Chemical Resistant Best Gloves from Best Manufacturing
http://www.chemrest.com/

Glove Selection Guide from Ansell Safety
https://www.ansellpro.com/download/Ansell_8thEditionChemicalResistanceGuide.pdf

Gloves selection guide from Grainger https://www.grainger.com/

Glove Selection Guide from Stanford University EH&S (also includes other links)
https://ehs.stanford.edu/forms-tools/laboratory-chemical-glove-selection-guidance

Glove Selection Guide from Kimberly Clark
http://www.na.kccustomerportal.com/Documents/Upload/Application/2811/Learning%20Center/Article/K4556_10_01%20Ntrl_Chem_pstr_v3.pdf

APPENDIX E: HOW TO UNDERSTAND SDS's

A Safety Data Sheet (SDS) is the primary source of information about each hazardous chemical found in your workplace. In addition to repeating the hazard information on a product's label, each SDS must include certain specified information, including emergency and clean-up procedures, chemical names, and the manufacturer's phone number.

As your employer, we are required to have an SDS for every hazardous chemical used or stored at all worksites, and to make it available for review upon request.

We are also required to review with you periodically:

1. the physical and health hazards of chemicals present in the workplace
2. identification of those chemicals by appearance and odor
3. procedures for handling the chemicals to protect against hazards
4. that SDS's are available from the EHS office at x7-2211.

SDS Contents
The arrangement of information on the SDS may vary from manufacturer to manufacturer, but all must contain the following:

U.S. DEPARTMENT OF LABOR
Occupational Safety and Health Administration
SAFETY DATA SHEET

Required For compliance with OSHA Act of 1970
Public Law 91-596 (CFR 1910)

Section 1: Identity of the chemical, name and address of the manufacturer, phone numbers in case of emergencies or to obtain more information, and the date the SDS was prepared.

SECTION I	
Product Name	Size
Chemical Name	
Formula	
Manufacturer	
Address	
For Information on Health Hazards Call	
For Other Information Call	
Signature and date	

Section 2: Identity of the hazardous ingredients and properties of the chemical, including both the common name, the trade name of the chemical and, if established, exposure limits — either the PEL (Permissible Exposure Level) or the TLV (Threshold Limit Value). If the levels differ, follow the lowest

SECTION II - HAZARDOUS INGREDIENTS OF MIXTURES		
Principal Hazardous component(s)	%	TVL (Units)

Section 3: The physical and chemical characteristics of the substance, including boiling point, vapor pressure and density, solubility in water, appearance and odor,
evaporation rate and melting point

SECTION III - PHYSICAL DATA			
Boiling Point (°F)		Specific Gravity (H_2O= 1)	
Vapor Pressure (mm Hg)		Percent Volatile By Volume (%)	
Vapor Density (Air= 1)		Evaporation Rate (Butyl Acetate= 1)	

Solubility in Water
Appearance and Odor

Section 4: Fire and explosion hazard data, including the flash point of the substance, flammable limits, extinguishing media and special fire-fighting procedures

SECTION IV - FIRE AND EXPLOSION HAZARD DATA			
Flash Point (^oF)	Flammable Limits in Air (% by Vol.)	Lower	Upper
Extinguisher Media		Autoignition Temperature (^oF)	
Special Fire Fighting Procedures			
Explosion Hazards			

Section 5: The conditions that can cause the substance to react dangerously

SECTION V - HEALTH HAZARD DATA
Threshold Limit Value
Effects of Overexposure
Acute Overexposure
Chronic Overexposure
Emergency and First Aid Procedures
Inhalation
Eyes
Skin
Ingestion

Section 6: The acute and chronic health hazards associated with the chemical, its routes of entry into the body, target organs (whether through the skin, inhalation, or ingestion), carcinogenicity (cancer-causing tendency), signs and symptoms of exposure, medical conditions generally aggravated by exposure, emergency first-aid procedures and whether there is an OSHA regulation on the chemical

SECTION VI - REACTIVITY DATA		
Stability	Unstable	Conditions to avoid
	Stable	
Incompatibility (Materials to Avoid)		

Hazardous Decomposition Products		
Hazardous Polymerization		Conditions to Avoid
May Occur	Will Not Occur	

Section 7: The precautions for safe handling and use of the chemical, such as steps to be taken in case the material is released or spilled, waste-disposal methods and precautions to be taken in storing

SECTION VII - SPILL OR LEAK PROCEDURES
Steps to be Taken in Case Material is Released or Spilled
Waste Disposal Method

Section 8: Control measures needed to protect employees from exposure to the chemical, including personal protective equipment (respirators, gloves, etc.), engineering controls (ventilation, etc.) and work practices

SECTION VIII - SPECIAL PROTECTION INFORMATION		
Respiratory Protection (Specify type)		
Ventilation	Local Exhaust	Special
	Mechanical (general)	Other
Protective Gloves	Eye protection	
Other Protective clothing or Equipment		

Section 9: Physical and chemical properties associated with the substance, including such things as appearance, flammability limits, odor, vapor pressure, pH, melting/freezing points, solubilities, boiling points, flash points and viscosity

SECTION IX - SPECIAL PRECAUTIONS
Precautions to be Taken in Handling and Storing
Other Precautions

Other Sections:

Section 10. Stability and Reactivity describes the reactivity hazards of the chemical and information about the chemical's stability.

Section 11.Toxicological Information identifies toxicological and health-effects information, where available, such as information on the likely routes of exposure, description of the delayed, immediate or chronic effects from short- and long-term exposure, toxicity estimates, description of symptoms, and whether the chemical is listed in the National Toxicology Program (NTP) Report on Carcinogens or has been found to be a potential carcinogen by OSHA or certain other organizations.

Section 12. Ecological Information: a non-mandatory section of the SDS, provides information to evaluate the environmental impact of the chemical if it were released to the environment.

Section 13. Disposal Considerations: a non-mandatory section of the SDS, provides guidance on proper disposal practices for the chemical.

Section 14. Transport Information: a non-mandatory section of the SDS, provides guidance on shipping and transport of the chemical by road, air, rail or sea.

Section 15. Regulatory Information, a non-mandatory section of the SDS, identifies any specific safety, health and environmental regulations for the product that are not indicated elsewhere on the SDS.

Section 16. Other Information, a non-mandatory section of the SDS, indicates when the SDS was prepared or when last revised. It may also indicate where revisions to the previous version were made and may include other useful or relevant information.

APPENDIX F: HAZARDS OF FUNCTIONAL GROUPS

The following information gives a basic overview of the hazards of functional groups. This information is not meant to replace safety data sheets for the specific chemical(s) used in your experiments. While these functional groups are listed alphabetically for convenience, chemicals should be segregated and stored by hazard classes – see the EH&S Segregation Scheme for more information.

ALCOHOLS

The lower aliphatic alcohols are low to moderately toxic and usually have low vapor pressures, therefore inhalation toxicity is low.

- Vapors may be an irritant to the eyes and mucous membranes.
- Ingestion and absorption of the liquids through the skin can be a major health hazard.
- Lower alcohols containing double or triple bonds exhibit a greater degree of toxicity and irritation.

- Fatty alcohols (derived from oils, fats, and waxes) are almost nontoxic.
- Lower alcohols are flammable or combustible liquids.
- Flammability decreases with an increase in the carbon number.
- Solubility of alcohols decrease with increase in carbon chain length.
- Toxicity tends to decrease with an increase in carbon number.

Examples:
Allyl alcohol
1-Butanol
Cyclohexanol
1,2-Ethanediol
Ethanol
Methanol
1-Propanol
2-Propyn 1-ol

ALDEHYDES

Aldehydes are intermediate products in the conversion of primary alcohols to carboxylic acids or vice versa.

- The low molecular weight aldehydes are more toxic than the higher ones.
- Toxicity decreases with increase in the carbon chain length.
- Aromatic aldehydes are less toxic than low molecular weight aliphatic aldehydes.
- Low molecular weight aldehydes are highly flammable, with flammability decreasing with increasing carbon chain length.
- Low aromatic aldehydes are combustible or nonflammable liquids.

Examples:
Acetaldehyde
Acrolein
Benzaldehyde
Formaldehyde
Glutaraldehyde
1-Hexanal
Isobutyraldehyde
Propenal

ALIPHATIC AMINES

The toxicity of most aliphatic amines may fall in the low to moderate category.

- The health hazards from amines arise primarily from their caustic nature.
- All lower aliphatic amines are severe irritants to the skin, eyes, and mucous membranes.
- All of these compounds have a strong to mild odor of ammonia and their vapors produce irritation of the nose and throat.
- Aliphatic amines, especially the lower ones, are highly flammable liquids, many which have flashpoints below 0 degrees Celsius.
- The vapors are heavier than air.
- They react vigorously with concentrated mineral acids.
- The flammability decreases with an increase in the carbon number.
- The reactivity of amines in general, is low.

Examples:
Aminocyclohexane
Ethyleneimine
Methylamine
2-Propylamine

ALIPHATIC and ALICYCLIC HYDROCARBONS

Organic compounds composed solely of carbon and hydrogen.

- Hydrocarbons may be classified into 3 broad categories:
    - Open-chain aliphatic compounds
    - Cyclic or alicyclic compounds of naphthalene type
    - Aromatic ring compounds
- Open chain aliphatic hydrocarbons constitute alkanes, alkenes, alkynes, and their isomers. Alkenes or olefins are unsaturated compounds, characterized by one or more double bonds between the carbon atoms. Alkynes or acetylenic hydrocarbons contain a triple bond in the molecule and are highly unsaturated. An alicyclic hydrocarbon is a cyclic ring compound of 3 or more carbon atoms. Aromatics are ring compounds too, but are characterized by a 6 carbon atom unsaturated benzenoid rings.
- The toxicities of aliphatic and alicyclic hydrocarbons in humans and animals are very low.
- The gaseous compounds are all nontoxic and are simple asphyxiants.
- Lower hydrocarbons are highly flammable substances, an increase in the carbon number causes a decrease in flammability.
- It is the flammable properties that make hydrocarbons hazardous.
- The reactivity of alkanes and cycloalkanes is very low.
- Alkenes and alkynes containing double and triple bonds are reactive.

Examples:
Butane
Cyclohexene
Cyclopentane
Methane
n-Pentane

ALKALI and OTHER REACTIVE METALS

Alkali metals constitute Group IA of the periodic table.

- Alkaline-earth metals constitute Group IIA and are less active than the alkali metals.
- These can be water and/or air reactive.
- Several of these metals are flammable, too, but only in finely divided state.
- Reactions with water produce strong bases.

Examples:
Aluminum
Calcium
Lithium
Magnesium
Potassium
Sodium

ALKALIS

Water-soluble bases, mostly the hydroxides of alkali- and alkaline-earth metals.

- Certain carbonates and bicarbonates also exhibit basic properties but are weak bases.
- These compounds react with acids to form salts and water.
- The health hazard from concentrated solutions of alkalis arises from their severe corrosive actions on tissues.
- These compounds are bitter to taste, corrosive to skin and a severe irritant to the eyes.
- The toxicity of alkalis is governed by the metal ions.
- Hydroxides and carbonates of alkali-and alkaline-earth are noncombustible.
- Strong caustic alkalis react exothermically with many substances, including water and concentrated acids, generating heat that can ignite flammable materials.

Examples: Lithium hydroxide Potassium carbonate Potassium hydroxide
Sodium hydroxide

AROMATIC AMINES

Compounds that contain one or more amino groups attached to an aromatic ring.

- These amines are similar in many respects to aliphatic amines.
- These amines are basic, but the basicity is lower to aliphatic amines.
- The health hazard from aromatic amines may arise in two ways:
  - Moderate to sever poisoning, with symptoms ranging from headache, dizziness, and ataxia to anemia, cyanosis, and reticulocytosis.
  - Carcinogenic, especially cancer of the bladder.
- Many amines are proven or suspected human carcinogens, among aromatic amines, ortho-isomers generally exhibit stronger carcinogenic properties than those of the para- and meta-isomers.
- Unlike aliphatic amines, the aromatic amines do not cause severe skin burn or corneal injury.
- The pure liquids (or solids) may produce mild to moderate irritation on the skin.
- Lower aromatic amines are combustible liquids and form explosive mixtures with air.
- Amines may react violently with strong oxidizing compounds.

Examples: Aniline o-Toluidine
Benzidine

AROMATIC HYDROCARBONS

Aromatics are a class of hydrocarbons having benzene-ring structures.

- Many polyaromatics are carcinogens.
- The acute toxicity of mononuclear aromatics is low.
- Inhalation of vapors at high concentrations in air may cause narcosis with symptoms of hallucination, excitement, euphoria, distorted perception, and headache.
- Benzene is the only mononuclear aromatic with possible human carcinogenicity and other severe chronic effects.

- With a greater degree of substitutions in the benzene ring and/or increase in the carbon chain length of the alkyl substituents, the flammability decreases.

Examples:
Benzene
Benzolalpyrene
Toluene
Xylene Pyrene

AZIDES, FULMINATES, ACETYLIDES, and RELATED COMPOUNDS

These compounds form highly explosive shock- and heat-sensitive salts with many metals.

- Structurally they differ from each other, but have similar detonating characteristics.
- While alkali metal azides are inert to shock, the salts for copper, silver, lead, and mercury are dangerously shock sensitive.
- Fulminates of heavy metals are powerful explosives.
- These compounds are highly sensitive to impact and heat.
- Acetylides of heavy metals are extremely shock sensitive when dry, whereas, the salts of alkali metals are fairly stable.
- Most azides, fulminates, acetylides, nitrides and related compounds are highly unstable and constitute an explosion hazard.
- Salts of Group IB and IIB metals are especially explosive.
- Azides of nonmetals, such as those of halogens or organic azides such as that of cyanogen, are also extremely shock sensitive.
- Some of these compounds may even explode on exposure to light.

Examples:
Cuprous acetylide
Hydrazoic acid
Lead azide
Mercury fulminate
Silver fulminate
Silver nitride
Sodium azide

CARBOXYLIC ACIDS

Weak organic acids, their strength is much weaker than mineral acids.

- Toxicity of monocarboxylic acids is moderate to low and decreases with carbon chain length.
- Some of lower dicarboxylic acids are moderate to high toxicity, becoming less toxic with increasing carbon chain length.
- Low molecular weight carboxylic acids are combustible liquids.
- Aromatic acids are of low toxicity.

Examples:
Acetic acid
Butyric acid
Formic acid
Methacrylic acid
Oxalic acid
Propionic acid
Succinic acid
Valeric acid

EPOXY COMPOUNDS

Epoxides, also called oxiranes and 1,2-epoxides.

- Exposure to epoxides can cause irritation of the skin, eyes, and respiratory tract.
- Low molecular weight epoxides are strong irritants and more toxic than higher ones.
- Inhalation can produce pulmonary edema and affect the lungs, central nervous system and liver.
- Many epoxy compounds have been found to cause cancer in animals.
- Lower epoxides are highly flammable.
- They also polymerize readily in the presence of strong acids and active catalysts, this reaction generates heat and pressure that may rupture closed containers.
- Therefore contact with anhydrous metal halides, strong bases, and readily oxidizable substances should be avoided.

Examples:
Butylene oxide
Epichlorohydrin
Ethylene oxide
Glycidaldehyde
Glycidol
Isopropyl glycidyl ether

ESTERS

- Lower aliphatic esters have a pleasant fruity odor.
- The acute toxicity of esters is generally of low order, they are narcotic at high concentrations.
- Vapors are an irritant to the eyes and mucous membranes.
- Toxicity increases with an increase in the alkyl chain length.
- Lower aliphatic esters are flammable liquids, some have low flash points and may cause flashback to an open container.
- The vapors form explosive mixtures with air.
- The flash point increases with increase in the alkyl chain length.
- The reactivity of esters is low.
- Aromatic esters are similar in effects as aliphatic esters.

Examples:
Ethyl acetate
Ethyl formate
Methyl acrylate
Methyl formate
n-Propyl acetate
(Aromatics) Methyl benzoate
Methyl salicyate

ETHERS

Widely used as solvents.

- They have a high degree of flammability.
- They tend to form unstable peroxides, which can explode spontaneously or upon heating.
- The flash point decreases with increase in carbon chain.

- Lower aliphatic ethers are some of the most flammable organic compounds and can be ignited by static electricity or lightning.
- The vapor densities are heavier than air.
- They form explosive mixtures with air.
- Aromatic ethers are noncombustible liquids or solids and do not exhibit the flammable characteristics common to aliphatic ethers.
- Ethers react with oxygen to form unstable peroxides, this reaction is catalyzed by sunlight, when evaporated to dryness, the concentrations of such peroxides increase, resulting in violent explosions.
- The toxicity of ethers is low to very low, at high concentrations these compounds exhibit anesthetic effects.

Examples:
Butyl vinyl ether
Ethyl ether
Isopropyl ether
Methyl propyl ether
Vinyl ether

GLYCOL ETHERS

Also known by the name Cellosolve.

- The toxic effects are mild, however, moderate to severe poisoning can occur from excessive dosage.
- The routes of exposure are inhalation, ingestion, and absorption through the skin.
- Compounds with high molecular weights and low vapor pressures do not manifest an inhalation hazard.
- Low molecular weight alkyl ethers are flammable or combustible liquids forming explosive mixtures with air.
- The reactivity of glycol ethers is low.
- There is no report of any violent explosive reactions.
- The high molecular weight compounds are noncombustible.

Examples:
Ethylene glycol monobutyl ether
Ethylene glycol monomethyl ether
2-Isopropoxyethanol

HALOETHERS

Haloethers are ethers containing hydrogen atoms.

- Halogen substitutions make ether molecules less flammable or nonflammable.
- The explosion hazards of low aliphatic ethers due to peroxide formation are not manifested by the haloethers. The halogens inhibit the ether oxidation to peroxides.
- Inhalation of Fluoroethers can produce anesthesia similar to that of the lower aliphatic ethers. Lower aliphatic chloro-and bromoethers can be injurious to the lungs.
- Many of these are cancer causing to lungs in animals or humans.

- Aromatic chloroethers are toxic by inhalation, ingestion, and skin absorption only at high doses. These effects can be attributed to the chlorine content and to a lesser extent on the aromaticity of the molecule.

Examples:
Bis(chloromethyl)ether
2-Chloroethyl vinyl ether
Pentachlorodiphenyloxide

HALOGENATED HYDROCARBONS

The flammability of these compounds shows a wide variation.

- Bromo compounds are less flammable than their Chloro- counterparts, the difference in flammability is not great though.
- An increase in the halosubstitutions in the molecule increases the flash point.
- The flammable hydrocarbons are stable compounds with low reactivity.
- These compounds, however, may react violently with alkali metals and their alloys or with finely divided metals.
- Violent reactions may occur with powerful oxidizers, especially upon heating.
- Volatile halocarbons may rupture glass containers due to simple pressure build up or to exothermic polymerization in a closed vessel.
- Halogenated hydrocarbons in general exhibit low acute toxicity.
- Inhalation toxicity is greater for gaseous or volatile liquid compounds.
- The health hazard from exposure to these compounds may be due to their anesthetic actions; damaging effects on liver and kidney; and in case of certain compounds, carcinogenicity.
- The toxic symptoms are drowsiness, lack of coordination, anesthesia, hepatitis, and necrosis of the liver.
- Vapors may cause irritation of the eyes and respiratory tract.
- Death may result from cardiac arrest due to prolonged exposure to high concentrations.
  Ingestion can produce nausea, vomiting, and liver injury. Fluorocarbons are less toxic than the chloro-, bromo-, and iodo- compounds, the toxicity increases with increase in the mass number of the halogen atoms.
- Some of the halogenated hydrocarbons cause cancer in humans.

Examples:
Benzyl chloride
Carbon tetrachloride
Chloroform
1,2-Dichlorobenzene
Ethyl bromide
Fluorobenzene
Methylene chloride

HYDRIDES

The single most hazardous property of hydrides is their high reactivity toward water.

- The reaction with water is violent and can be explosive with liberation of hydrogen.
- Many hydrides are flammable solids that may ignite spontaneously on exposure to moist air.
- Many ionic hydrides are strongly basic; their reactions with acids are violent and exothermic, which can cause ignition.
- Hydrides are also powerful reducing agents, they react violently with strong oxidizing substances, causing explosions.
- Covalent volatile hydrides such as arsine, silane, or germane are highly toxic.
- Ionic alkali metal hydrides are corrosive to skin, as they form caustic alkalis readily with moisture.

Examples:

- Decarborane
- Sodium borohydride
- Lithium aluminum hydride Sodium hydride
- Potassium hydride

INDUSTRIAL SOLVENTS

The toxic effects of most of the solvents are of low order, chronic exposures or large doses can produce moderate to severe poisoning.

- Most organic solvents are flammable or combustible liquids, the vapors of which can form explosive mixtures with air.
- Many of the common solvents can cause flashback of the vapors, and some form peroxide on prolonged storage, especially those compounds containing an ether functional group, some also can form shock-sensitive solvated complexes with metal perchlorates.

Examples:

Acetamide	Chloroform	Acetone	Methyl acetate
Benzene	Carbon tetrachloride	Pyridine	Tetrahydrofuran

INORGANIC CYANIDES

Inorganic cyanides are the metal salts of Hydrocyanic acid.

- Cyanides of alkali metals are extremely toxic.
- In addition to being extremely toxic by ingestion or skin absorption, most metal cyanides present a serious hazard of forming extremely toxic Hydrogen cyanide when they come into contact with acids.

Examples:	Barium cyanide	Hydrogen cyanate
	Cyanogen chloride	Potassium cyanide
	Cyanamide cyanogen	Sodium cyanide

KETONES

Similar to aldehydes.

- In general, the toxicity is much lower than that of other functional groups, such as cyanides or amines.
- Unlike aldehydes and alcohols, some of the simplest ketones are less toxic than the higher ones.
- Beyond 7 carbons, the higher ones are almost nontoxic.
- Substitution of other functional groups can alter toxicity significantly.
- The simplest ketones are highly flammable.
- The flammability decreases with increase in the carbon number.

Examples: Acetophenone Mesityl oxide
Acetone Methyl Ethyl Ketone
Ketene

MINERAL ACIDS

Acid strengths vary widely.

- Sour in taste.
- React with a base to form salt and water.
- Produce hydrogen when reacting with most common metals.
- Produce carbon dioxide when reacting with most carbonates.
  All mineral acids are corrosive. Noncombustible substances.
- Some are highly reactive to certain substances, causing fire and/or explosions.

Examples: Hydrochloric acid Phosphoric acid Hydrofluoric acid
Nitric acid
Hydroiodic acid Sulfuric acid

ORGANIC CYANIDES (NITRILES)

These are organic derivatives of Hydrocyanic acid or the cyano substituted organic compounds.

- Nitriles are highly reactive, the CN group reacts with a large number of reactants to form a wide variety of products, such as amides, amines, carboxylic acids, aldehydes, ketones, esters, thioamides, and other compounds.
- Nitriles are highly toxic compounds, some of them are as toxic as alkali metal cyanides.
- Lower aliphatic nitriles are flammable and form explosive mixtures with air. The explosive range narrows down with an increase in the carbon chain length.

Examples: Acrylonitrile Butyronitrile Acetonitrile Cyanohydrin

ORGANIC ISOCYANATES

Organic groups attached to the isocyanate group.

- These compounds are highly reactive due to the high unsaturation in the isocyanate functional group.
- Isocyanates in general are highly reactive toward compounds containing active hydrogen atoms.
- Most isocyanates are hazardous to health.
- They are lachrymators and irritants to the skin and mucous membranes.
- Skin contact can cause itching, eczema, and mild tanning.
- Inhalation if isocyanate vapors can produce asthma-like allergic reaction, with symptoms from difficulty in breathing to acute attacks and sudden loss of consciousness.
- Toxicities of isocyanates vary widely, in addition, health hazards differ significantly on the route of exposure but occur primarily via inhalation exposure.
- Most isocyanates have high flash points, therefore the fire hazard is low.
- However, closed containers can rupture due to the pressure built up from carbon dioxide, which is formed from reaction with moisture.

Examples:
n-Butyl isocyanate
Hexamethylene diisocyanate
Methyl isocyanate
Phenyl isocyanate

ORGANIC PEROXIDES

Compounds containing the peroxide group bound to organic groups.

- In general the toxicity is low to moderate.
- Peroxides are a hazardous class of compounds, some of which are extremely dangerous to handle.
- The dangerous ones are highly reactive, powerful oxidizers, highly flammable and often form decomposition products, which are more flammable.
- Many organic peroxides can explode violently due to one or a combination of the follow factors:
    - Mechanical shock, such as impact, jarring, or friction ○ Heat
    - Chemical contact
- Short chain alkyl and acyl peroxides, hydroperoxides, peroxyesters, and peroxydicarbonates with low carbon numbers are of much greater hazard than the long chain peroxy compounds.
- The active oxygen content of peroxides is measured as the amount of active oxygen (from peroxide functional group) per 100 gm of the substance. The greater the percentage of active oxygen in formulation, the higher is its reactivity. An active oxygen content exceeding 9% is too dangerous for handling and shipping.

Examples:
Benzoyl peroxide
Cumene hydroperoxide
Diacetyl peroxide
Diisopropyl peroxydicarbonate
Hydroperoxyenthanol

OXIDIZERS

Include certain classes of inorganic compounds that are strong oxidizing agents, evolving oxygen on decomposition.

These substances are rich in oxygen and decompose violently on heating.

- The explosion hazard arises when these substances come into contact with easily oxidizable compounds such as organics, metals, or metal hydrides.
- When the solid substances are finely divided and combined, the risk of explosion is enhanced.
- The unstable intermediate products, so formed, are sensitive to heat, shock, and percussion.
- The health hazard from the substances arises due to their strong corrosive action on the skin and eyes.
- The toxicity depends on the metal ions in these molecules.

Examples:
Bromates
Chlorites
Dichromates
Hypochlorites
Iodates
Inorganic peroxides
Nitrates
Perchlorates
Periodates
Permanganates

PEROXY ACIDS

There are 2 types: Peroxycarboxylic acids and Peroxysulfonic acids.

- Peroxycarboxylic acids are weaker acids than the corresponding carboxylic acids.
- Lower peroxy acids are volatile liquids, soluble in water.
- Higher acids with greater than 7 carbons are solids and insoluble in water.
- These compounds are highly unstable and can decompose violently on heating.
- May react dangerously with organic matter and readily oxidizable compounds.
- Among organic peroxides, peroxy acids are the most powerful oxidizing compounds.
- The lower acids are also shock sensitive, but less than some organic peroxides.
- Health hazard primarily due to their irritant actions.

Examples:
Peroxyacetic acid
Peroxybenzoic acid
Peroxyformic acid

PHENOLS

Phenols are a class of organic compounds containing hydroxyl groups attached to aromatic rings.

- The hydroxyl group exhibits properties that are different from an alcoholic hydroxyl group.
- Phenols are weakly acidic, forming metal salts on reactions with caustic alkalies.
- In comparison, acid strengths of alcohols are negligibly small or several orders of magnitude lower than those of phenols.
- In comparison with many other classes of organic compounds, phenols show relatively greater toxicity.

Examples:	Cresol	Phenols
	2-Naphthol	Resorcinol
	Pentachlorophenol	

PHTHALATE ESTERS

These are esters of Phthalic acid.

- They are noncombustible liquids.
- Some are EPA-listed priority pollutants.
- The acute toxicity is very low.
- High doses may produce somnolence, weight loss, dyspnea, and cyanosis.
- The pure liquids are mild irritants to the skin.
- These are relatively harmless and are among the least toxic organic industrial products.

Examples: Dibutyl phthalate
Diethylhexyl Phthalate (DEHP)

APPENDIX G: PEROXIDE FORMING CHEMICALS

SAFE STORAGE PERIODS FOR PEROXIDE FORMERS	
Unopened chemicals from manufacturer	18 months or (expiration date)
Opened containers:	
Chemicals in Table A	3 months
Chemicals in Tables B and D	12 months
Uninhibited chemicals in Table C	24 hours
Inhibited chemicals in Table C (Do not store under an inert atmosphere)	12 months

A. Chemicals that form explosive levels of peroxides without concentration		
Butadiene[a]	Isopropyl ether	Sodium amide (sodamide)
Chloroprene[a]	Potassium metal	Tetrafluoroethylene[a]
Divinylacetylene	Potassium amide	Vinylidene chloride
B. Chemicals that form explosive levels of peroxides on concentration		
Acetal	Diethyl ether	4-Methyl-2-pentanol

Acetaldehyde	Diethylene glycol dimeth ether (diglyme)	y2-Pentanol
Benzyl alcohol	Dioxanes	4-Penten-1-ol
2-Butanol	Ethylene glycol dimethyl ether (glyme)	1-Phenylethanol
Cumene	4-Heptanol	2-Phenylethanol
2-Cyclohexen-1-ol	2-Hexanol	2-Propanol
Cyclohexene	Methylacetylene	Tetrahydrofuran
Decahydronaphthalene	3-Methyl-1-butanol	Tetrahydronaphthalene
Diacetylene	Methylcyclopentane	Vinyl ethers
Dicyclopentadiene	Methyl isobutyl ketone	Other secondary alcohols
C. Chemicals that may autopolymerize as a result of peroxide accumulation		
Acrylic acid[b]	Methyl methacrylate[b]	Vinyl chloride
Acrylonitrile[b]	Styrene	Vinylpyridine
Butadiene[c]	Tetrafluoroethylene[c]	Vinyladiene chloride
Chloroprene[c]	Vinyl acetate	
Chlorotrifluoroethylene	Vinylacetylene	
D. Chemicals that may form peroxides but cannot clearly be placed in sections A-C		
Acrolein	p-Chlorophenetole	4,5-Hexadien-2-yn-1-ol
Allyl ether[d]	Cyclooctene[d]	*n*-Hexyl ether
Allyl ethyl ether	Cyclopropyl methyl ether	*o,p*-Iodophenetole
Allyl phenyl ether	Diallyl ether[d]	Isoamyl benzyl ether[d]
p-(*n*-Amyloxy)benzoyl chloride	*p*-Di-n-butoxybenzene	Isoamyl ether[d]
n-Amyl ether	1,2-Dibenzyloxyethane[d]	Isobutyl vinyl ether
Benzyl *n*-butyl ether[d]	*p*-Dibenzyloxybenzene[d]	Isophorone[d]
Benzyl ether[d]	1,2-Dichloroethyl ethyl ether	*B*-Isopropoxypropionitrile[d]
Benzyl ethyl ether[d]	2,4-Dichlorophenetole	Isopropyl 2,4,5-trichloro-phenoxy- acetate
Benzyl methyl ether	Diethoxymethane[d]	Limonene
Benzyl 1-napthyl ether[d]	2,2-Diethoxypropane	1,5-*p*-Methadiene
1,2-Bis(2-chloroethoxy) Ethane	Diethyl ethoxymethylene Malonate	Methyl *p*-(*n*-amyloxy)-benzoate
Bis(2 ethoxyethyl)ether	Diethyl fumarate[d]	4-Methyl-2-pentanone
Bis(2-(methoxyethoxy)- ethyl) ether	Diethyl acetal[d]	*n*-Methylphenetole
Bis(2-chloroethyl)ether	Diethyketene[f]	2-Methyltetrahydrofuran
Bis(2-ethoxyethyl)adipate	*m,o,p*-diethoxybenzene	3-Methoxy-1-butyl acetate
Bis(2-ethoxyethyl)phthalat	1,2-Diethoxyethane	2-Methoxyethanol

Bis(2-methoxyethyl)-Carbonate	Dimethoxymethane[d]	3-Methoxyethyl acetate
Bis(2-methoxyethyl) ether	1,1-Dimethoxyethane[d]	2-Methoxyethyl vinyl ethe
Bis(2-methoxyethyl) Phthalate	Dimethylketene[f]	Methonxy-1,3,5,7-cyclo-octatetraene
Bis(2-methoxymethyl) Adipate	3,3-Dimethoxypropene	B-Methoxypropionitrile
Bis(2-n-butoxyethyl) Phthalate	2,4-Dinitrophenetole	m-Nitrophenetole
Bis(2-phenoxyethyl) ether	1,3-Dioxepane[d]	1-Octene
Bis(4-chlorobutyl) ether	Di(1-propynyl)ether[f]	Oxybis(2-ethyl acetate)
Bis(chloromethyl) ether[e]	Di(2-propynyl)ether	Oxybis(2-ethyl benzoate)
2-Bromomethyl ethyl ethe	Di-*n*-propoxymethane[d]	*B,B*-oxydipropionitrile
B-Bromophenetole	1,2-Epoxy-3-isopropoxypropane[d]	1-Pentene
o-Bromophenetole	1,2-Epoxy-3-phenoxypropane	Phenoxyacetyl chloride
p-Bromophenetole	*p*-Ethoxyacethophenone	*a*-Phenoxypropionyl chlorid
3-Bromopropyl phenyl eth	2-Ethoxyethyl acetate	Phenyl *o*-propyl ether
1,3-Butadiyne	(2-Ethoxyethyl)-o-benzoy benzoate	*p*-Phenylphenetone
Buten-3-yne	1-(2-Ethoxyethoxy)ethyl acetate	*n*-Propyl ether
tert-Butyl ethyl ether	1-Ethoxynaphthalene	*n*-Propyl isopropyl ether
tert-Butyl methyl ether	o,p-Ethoxyphenyl isocyanate	Sodium 8,11,14-eicosatetraenoate
n-Butyl phenyl ether	1-Ethoxy-2-propyne	Sodium ethoxyacetylide[f]
n-Butyl vinyl ether	3-Ethoxyopropionitrile	Tetrahydropyran
Chloroacetaldehyde diethylacetal[d]	2-Ethylacrylaldehyde oxi	mTriethylene glycol diacetat
2-Chlorobutadiene	2-Ethylbutanol	Triethylene glycol dipropionate
1-(2-Chloroethoxy)-2-phenoxyethane	Ethyl *B*-ethoxypropionate	1,3,3-Trimethoxypropene[d]
Chloroethylene	2-Ethylhexanal	1,1,2,3-Tetrachloro-1,3-butadiene
Chloromethyl methyl ethe	Ethyl vinyl ether	4-Vinyl cyclohexene
B-Chlorophenetole	Furan	Vinylene carbonate
o-Chlorophenetole	2,5-Hexadiyn-1-ol	Vinylidene chloride[d]

NOTES:

[a] When stored as a liquid monomer.

[b] Although these chemicals form peroxides, no explosions involving these monomers have been reported.

[c] When stored in liquid form, these chemicals form explosive levels of peroxid without concentration. They may also be stored as a gas in gas cylinders. When stored as a gas, these chemicals may autopolymerize as a result of peroxide accumulation.

[d] These chemicals easily form peroxides and should probably be considered under Part B.

[e] OSHA - regulated carcinogen.

[f] Extremely reactive and unstable compound.

References:

Prudent Practices in the Laboratory, National Research Council, 1995.

"Review of Safety Guidelines for Peroxidizable Organic Chemicals," *Chemical Health and Safety*, September/October 1996.

APPENDIX H: INCOMPATIBLE CHEMICALS

Substances in the left-hand column should be stored and handled so they cannot contact corresponding substances in the right-hand column. The following list contains some of the chemicals commonly found in laboratories, but should not be considered exhaustive. Information for the specific chemical you are using can usually be found in the "REACTIVITY" or "INCOMPATIBILITIES" section of the Safety Data Sheet.

Alkaline and alkaline earth metals, such as Sodium, Potassium, Cesium, Lithium, Magnesium, Calcium	Carbon dioxide, Carbon tetrachloride and other chlorinated hydrocarbons, any free acid or halogen. Do not use water, foam or dry chemical on fires involving these metals.
Acetic acid	Chromic acid, Nitric acid, hydroxyl compounds, Ethylene glycol, Perchloric acid, peroxides, permanganates.
Acetic anhydride	Chromic acid, Nitric acid, hydroxylcontaining compounds, Ethylene glycol, Perchloric acid, peroxides and permanganates.
Acetone	Concentrated Nitric and Sulfuric acid mixtures.
Acetylene	
Alkali & alkaline earth metals (such Water, Carbon tetrachloride or other as powdered Aluminum or chlorinated hydrocarbons, Carbon dioxide, Magnesium, Calcium, Lithium, and halogens. Sodium, Potassium)	Copper, Silver, Mercury and halogens, Fluorine, Chlorine, Bromine.
Aluminum alkyls	Halogenated hydrocarbons, water.
Ammonia (anhydrous)	Silver, Mercury, Chlorine, Calcium hypochlorite, Iodine, Bromine, Hydrogen fluoride, Chlorine dioxide, Hydrofluoric acid (anhydrous).
Ammonium nitrate	Acids, metal powders, flammable liquids, chlorates, nitrites, Sulfur, finely divided organics or combustibles.

Aniline	Nitric acid, Hydrogen peroxide.
Arsenical materials	Any reducing agent.
Azides	Acids.
Benzoyl peroxide	Chloroform, organic materials.
Bromine	Ammonia, Acetylene, Butadiene, Butane and other petroleum gases, Sodium carbide, Turpentine, Benzene and finely divided metals, Methane, Propane, Hydrogen.
Calcium carbide	Water (see also Acetylene).
Calcium hypochlorite	Methyl carbitol, Phenol, Glycerol, Nitromethane, Iron oxide, Ammonia, activated carbon.
Calcium oxide	Water.
Carbon, activated	Calcium hypochlorite, all oxidizing agents.
Carbon tetrachloride	Sodium.
Chlorates	Ammonium salts, acids, metal powders, Sulfur, finely divided organics or combustibles.
Chlorine	Ammonia, Acetylene, Butadiene, Butane, Propane, and other petroleum gases, Hydrogen, Sodium carbide, Turpentine, Benzene and finely divided metals, Methane.
Chlorine dioxide	Ammonia, Methane, Phosphine and Hydrogen sulfide.
Chlorosulfonic acid	Organic materials, water, powdered metals.
Chromic acid & Chromium trioxide	Acetic acid, Naphthalene, Camphor, Glycerin, Turpentine, alcohol and other flammable liquids, paper or cellulose.
Copper	Acetylene, Hydrogen peroxide, Ethylene oxide.
Cumene hydroperoxide	Acids, organic or mineral.
Cyanides	Acids.
Ethylene oxide	Acids, bases, Copper, Magnesium perchlorate.
Flammable liquids	Ammonium nitrate, Chromic acid, Hydrogen peroxide, Nitric acid, Sodium peroxide, halogens.
Fluorine	Almost all oxidizable substances.
Hydrocarbons (such as Bromine, Butane)	Fluorine, Chlorine, Chromic acid, Sodium peroxide.
Hydrocyanic acid	Nitric acid, alkalis.
Hydrofluoric acid (anhydrous)	Ammonia (aqueous or anhydrous).
Hydrogen peroxide	Copper, Chromium, Iron, most metals or their salts, any flammable liquid, combustible materials, Aniline, Nitromethane, alcohols, Acetone, organic materials, Aniline.
Hydrides	Water, air, Carbon dioxide, chlorinated hydrocarbons.

Hydrofluoric acid, anhydrous (Hydrogen fluoride)	Ammonia (anhydrous or aqueous), organic peroxides.
Hydrogen sulfide	Fuming Nitric acid, oxidizing gases.
Hydrocarbons (Benzene, Butane,	Fluorine, Chlorine, Bromine, Chromic acid,
Propane, Gasoline, Turpentine, etc.)	Sodium peroxide, fuming Nitric acid.
Hydroxylamine	Barium oxide, Lead dioxide, Phosphorus pentachloride and trichloride, Zinc, Potassium dichromate.
Hypochlorites	Acids, activated Carbon.
Iodine	Acetylene, Ammonia (anhydrous or aqueous), Hydrogen.
Maleic anhydride	Sodium hydroxide, Pyridine and other tertiary amines.
Mercury	Acetylene, Fulminic acid, Ammonia, Oxalic acid.
Nitrates	Acids, metal powders, flammable liquids, chlorates, sulfur, finely divided organics or combustibles, Sulfuric acid.
Nitric acid (concentrated)	Acetic acid, Aniline, Chromic acid, Hydrocyanic acid, Hydrogen sulfide, flammable liquids, flammable gases, nitratable substances, organic peroxides, chlorates, Copper, brass, any heavy metals.
Nitroparaffins	Inorganic bases, amines.
Oxygen	Oil, grease, Hydrogen, flammable liquids, solids, or gases.
Oxalic acid	Silver, mercury, organic peroxides.
Perchlorates	Acids.
Perchloric acid	Acetic anhydride, Bismuth and its alloys, alcohol, paper, wood, grease, oil, organic amines or antioxidants.
Peroxides, organic	Acids (organic or mineral); avoid friction, store cold.
Phosphorus (white)	Air, Oxygen, alkalis, reducing agents.
Phosphorus pentoxide	Propargyl alcohol.
Potassium	Carbon tetrachloride, Carbon dioxide, water.
Potassium chlorate	Acids, Sulfuric acid (see also chlorates).
Potassium perchlorate	Sulfuric & other acids (see also Perchloric acid, & chlorates).
Potassium permanganate	Glycerin, Ethylene glycol, Benzaldehyde, any free acid, Sulfuric acid.

Selenides	Reducing agents.
Silver	Acetylene, Oxalic acid, Tartaric acid, Fulminic acid, ammonium compounds.
Sodium	Carbon tetrachloride, Carbon dioxide, water. See alkaline metals (above).
Sodium amide	Air, water.
Sodium nitrate	Ammonium nitrate and other ammonium salts.
Sodium oxide	Water, any free acid.
Sodium peroxide	Any oxidizable substance, such as Ethanol, Methanol, glacial Acetic acid, Acetic anhydride, Benzaldehyde, Carbon disulfide, Glycerine, Ethylene glycol, Ethyl acetate, Methyl acetate and Furfural.
Sulfides	Acids.
Sulfuric acid	Chlorates, perchlorates, permanganates, organic peroxides. Potassium chlorate, Potassium perchlorate, Potassium permanganate (similar compounds of light metals, such as Sodium, Lithium).
Tellurides	Reducing agents.
UDMH (1,1-Dimethylhydrazine)	Oxidizing agents such as Hydrogen peroxide and fuming Nitric acid.
Zirconium	Prohibit water, Carbon tetrachloride, foam and dry chemical on zirconium fires.

APPENDIX I: EH&S SEGREGATION SCHEME

EH&S CHEMICAL SEGREGATION PROCEDURE

KEY

Hazard Class # – All Hazard Classes must be segregated from other **Hazard Classes**

- Class – must segregate from other Classes within **Hazard Class**
- *Group – recommend to segregate from other groups within* Class

- **Hazard Class 1 - Explosives (potentially explosive)**
- **Hazard Class 2 - Compressed Gases / Lecture Bottles**

- **Hazard Class 2.1 - Flammable gases**
- **Hazard Class 2.2 - Non-Flammable gases**
- **Hazard Class 2.3 - Poisonous gases**
    - Oxidizing gases (separate from everything)
    - Corrosive – acids
    - Corrosive – bases
    - Cryogenics
    - Pyrophorics

- **Hazard Class 3 - Flammable liquids**
    - Combustible liquids (that do not have another hazard)

- **Hazard Class 4 - Flammable solids**
- **Hazard Class 4.1 - Flammable solids**
- **Hazard Class 4.2 - Spontaneously combustible**
- **Hazard Class 4.3 - Dangerous When Wet**

- **Hazard Class 5.1 - Oxidizers**
    - *Liquids*
    - *Solids*
- **Hazard Class 5.2 - Organic peroxides**

- **Hazard Class 6.1 – Poisons**
    - *Liquids*
    - *Solids*
    - *Carcinogens*
    - *Reproductive hazards (Teratogens, Mutagens)*
    - *Irritants*
    - *Organic acids, solid*
    - Poison Inhalation Hazards (PIH)
    - Cyanides
    - Controlled substances
- **Hazard Class 6.2 - Biohazards – Infectious agents**
    - *CDC Select agents*

- **Hazard Class 7 - Radioactive**

- **Hazard Class 8 - Corrosives**
    - Inorganic acids
    - Oxidizing acids (Nitric acid and Perchloric acid)

    - Hydrofluoric acid
    - Organic acids, liquid (can store in flammable cabinet)
    - Bases
- **Hazard Class 9- N Nonhazardous chemicals**

APPENDIX J: SAMPLE PRIOR APPROVAL FORM

Prior Approval for Highly Hazardous Operations

PI or supervisor:______________________________ Location:___________________________

Name of chemical(s) or operation: ____

Each person on this list should have permission from the lab supervisor or Principal Investigator to use the chemicals or conduct the operation above in this lab and have completed the following:

- Are aware of the hazards the chemical(s) or operation(s) pose?
- Has read the Standard Operating Procedures for this process?
- Knows the first aid procedure in case of an exposure?
- Knows what to do in the event of a spill or other emergency?
- Has received any specific training needed above the standard lab safety training (i.e.: radiation, hazardous waste)

Name	Initials	Date

APPENDIX K: COMPREHENSION LETTER

Chemical Hygiene Plan Comprehension Record

I have read and understand all the information preceding this letter

Print Name ______________________________

Signature ______________________________

Email ______________________________

Date ______________________________

B Number ______________________________

APPENDIX L: SOP TEMPLATE

Environmental Health & Safety Binghamton University	Standard Operating Procedure for: ____________________ Department Of ____________________ Principal Investigator ____________________	SOP #	
		Revision #	
		Implementation Date	
		Author	
Page 180 of___		Last Reviewed/Updated	

Type of SOP: ☐ Process ☐ Hazardous Chemical

1. Purpose

2. Potential Hazards

3. Responsibilities

4. Procedure

5. Engineering Controls

6. PPE

7. Waste Disposal

APPENDIX M: REFERENCE MATERIALS

1) Reference materials identified in the OSHA Lab Standard

Patnaik, Pradyot*, A Comprehensive Guide to the Hazardous Properties of Chemical Substances*, Van Nostrand Reinhold, 1992.

A Handbook of Radioactive Measurements Procedures, National Council on Radiation Protection and Measurements, 1978.

A Practical Guide to the Determination of Human Exposure to Radiofrequency Fields, National Council on Radiation Protection and Measurements, 1993.

Adams, Lowder, *The Natural Radiation Environment*, William Marsh Rice, 1964.

Adelberg, Edward A., *Biosafety in the Laboratory*, National Academy of Sciences, 1989.

Agriculture Biotechnology at the Crossroads, Volume 2 & 3, Committee On Aldehydes Formaldehyde and Other Aldehydes, National Agricultural Biotechnology Council, National Academy Press, 1996.

Alberty, Robert A., *Prudent Practices for Disposal of Chemicals from Laboratories*, National Academic Press, Washington D.C., 1983.

Albisser, R. H., *Guide for Safety in the Chemical Laboratory*, Van Nostrand Reinhold Company, New York, 1972.

Al-Soraya, Ahmed, *Proceedings of International Symposium on Applications and Technology of Ionizing Radiations, Volumes 1-3*, King Saud University, 1983.

Altman, Philip L., editor, *Biology Data Book*, Federation of American Societies for Experimental Biology, U.S.A., 1964.

American Chemical Society Task Force, *Laboratory Waste Management A Guidebook*, American Chemical Society, 1994.

American Red Cross CPR Workbook, American Red Cross, 1988.

American Red Cross Multimedia Standard First Aid, American Red Cross. U.S.A., 1981.

Armour, M A, *Hazardous Laboratory Chemicals*, CRC Press, 1991.

Armour, Margret Ann, *Hazardous Chemicals Information and Disposal Guide*, University of Alberta, 1984.

Armour, Margret Ann, *Potentially Carcinogenic Chemicals*, University of Alberta, 1986.

Ashford, Nicholas, *Chemical Exposures: Low Levels and High Stakes, 2nd Edition*, Van Nostrand Reinhold, 1998.

Attix, Frank H., *Radiation Dosimetry, Volumes 1- 3*, Academic Press, 1968.

Attix, Frank H., *Topics in Radiation Dosimetry*, Academic Press, 1972.

Ayres, J. A., *Decontamination of Nuclear Reactors and Equipment*, Ronald Press Co., 1970.

Badger, Donald W., *Work Practice Guide for Manual Lifting*, American Industrial Hygiene Association, 1983.

Bagniewski, Joan, *Cardiopulmonary Resuscitation CPR*, American Red Cross U.S.A., 1986.

Balows, Albert, *Manual of Clinical Microbiology*, American Society for Microbiology, Washington D.C., 1991.

Barlow, Susan M., *Reproductive Hazards Of Industrial Chemicals*, Academic Press London, 1982.

Basic Radiation Protection Criteria, National Council on Radiation Protection and Measurements, 1971.

Bates, Lloyd M., *Some Physical Factors Affecting Radiographic Image Quality: Their Theoretical Basis And Measurement*, U.S. Department Of Health, 1969.

Becker, Ernist I., *First Aid Manual for Chemical Accidents*, Dowden, Hutchinson & Ross Inc.

Benedetti, Robert P., *Flammable and Combustible Liquids Code Handbook*, National Fire Protection Association, 1988.

Benenson, Abram S., editor, Control of Communicable Diseases Manual, American Public Health Association, Washington D.C., 1995.

Bierbaum, Philip J., *Proceedings of the Scientific Workshop on The Health Effects of Electric and Magnetic Fields on Workers*, U.S. Department of Health & Human Services, 1991.

Biohazards Reference Manual, Biohazards Committee, American Industrial Hygiene Association, Ohio, 1985.

Biological Effects and Exposure Criteria for Radiofrequency Electromagnetic Fields, National Council on Radiation Protection and Measurements, 1986.

Biological Effects of Ultrasound Mechanism and Clinical Implications, National Council on Radiation Protection and Measurements, 1983.

Biosafety in the Laboratory: Prudent Practices for the Handling and Disposal of Infectious Materials, National Research Council, National Academy Press, 1989.

Block, Seymour S., *Disinfection, Sterilization, and Preservation, 4th Edition*, Lea & Febiger, 1991.

Bretherick, L., *Bretherick's Handbook of Reactive Chemical Hazards, 5th Edition, Volumes 1-2*, 1995.

Bretherick, L., *Hazards in the Chemical Laboratories*, Royal Society of Chemistry London, 1981.

Brodsky, Allen B., *CRC Handbook of Radiation Measurement and Protection*, CRC Press, 1978.

Budavari, Susan, Editor, *The Merck Index, 12th Edition (On CD-ROM version 12:3)*, CRC Press, 2000.

Budavari, Susan, Editor, *The Merck Index, 13th Edition*, Merck & Co Inc, U.S.A., 2001.

Burke, Robert, *Hazardous Materials Chemistry for Emergency Responders, 2nd Edition*, Lewis Publishers, 2003.

Carbon-14 In the Environment, National Council on Radiation Protection and Measurements, 1985.

Carson, George A., *The American Conference of Governmental Industrial Hygienists, Volumes 6 and 10*, The American Conference Of Governmental Industrial Hygienists, 1985.

Case Studies in Environmental Health and Safety, Association of Physical Plant Administrators of Universities and Colleges, 1990.

Certified Equipment List, National Institute for Occupational Safety and Health, U. S. Department Of Health And Human Services, 1989.

Chaffin, Don B., *Ergonomic Interventions to Prevent Musculoskeletal Injuries in Industry*, Lewis Publishers Inc., 1987.

Charnley, H. W. Jr., *Arsenic and its Compounds*, National Safety Council. *Chemical Hazards to Human Reproduction*, Council On Environmental Quality, Government Printing Office, Washington D.C., 1981.

Claton, George D., *Patty's Industrial Hygiene And Toxicology, 4th Edition 2A, B, C, D, E, F*, John Wiley & Sons Inc, Canada, 1993.

Claton, George D., *Patty's Industrial Hygiene And Toxicology, Volume 2A, 2B, 2C and 3*, John Wiley & Sons Inc, Canada, 1981.

Coast Guard Hazardous Chemical Data, U.S. Coast Guard, U.S. Government Printing Office, 1978.

Collins George R., editor, *Manual for Laboratory Animal Technicians*, American Association for Laboratory Animal Science, IL.

Collins, C. H., *Laboratory - Acquired Infections*, Butterworths & Co Ltd. London, 1983.

Comparative Carcinogenicity of Ionizing Radiation and Chemicals, National Council on Radiation Protection and Measurements, 1989.

Control of Biohazards in the Research Laboratory Course Manual, Office of Environmental Health & Safety, Department of Environmental Health Sciences, Baltimore MD.

Control of Radon in Houses, National Council on Radiation Protection and Measurements, 1989.

Costle, Douglas, *The Effects on Populations of Exposure to Low Levels of Ionizing Radiation*, National Academy Press, 1980.

Cox, Doye B, editor, *Hazardous Materials Management, Institute of Hazardous Materials Management*, U.S.A., 1995.

Criteria for a Recommended Standard Welding, Braising and Thermal Cutting, National Institute for Occupational Safety and Health, U.S. Department Of Health And Human Services, 1988.

Czerski, P., *Biologic Effects and Health Hazards of Microwave Radiation*, U.S. Department of Health Education and Welfare, 1973.

Dangerous Goods Regulations, 44th Edition, International Air Transport Association, 2003.

Dental X-Ray Protection, National Council on Radiation Protection and Measurements, 1970.

DiBerardinis, Louis, *Guidelines for Laboratory Design*, John Wiley & Sons New York, 1987.

Documentation of the Threshold Limit Values and Biological Exposure Indices, 5th Edition, American Conference of Governmental Industrial Hygienists, 1986.

Dosimetry of X-Ray and Gamma-Ray Beams for Radiation Therapy in the Energy Range 10 KeV to 50 MeV, National Council on Radiation Protection and Measurements, 1981.

Dreisbach, Robert H., *Handbook of Poisoning*, Lange Medical Publications California, 1983.

Drury, Peter, *Guidelines for Laboratory Safety*, Canadian Society of Laboratory Technologists, Canada, 1996.

Duggan, Jerome, *Laboratory Investigators in Nuclear Science*, Nucleus Inc., 1988.

Dunworth, J.V., *Treatment and Disposal of Radioactive Wastes*, Pergamon Press, 1961.

Ebert, Michael, *Radiation Effects In Physics, Chemistry and Biology*, North Holland Publishing Co., 1963.

Effects of Exposure to Toxic Gases - First Aid & Medical Treatment, 3rd Edition, Matheson Gas Products, Inc., 1988.

Environmental Radiation Measurements, National Council on Radiation Protection and Measurements, 1976.

Estabrook, Ronald, *Identifying and Estimating the Genetic Impact of Chemical Mutagens*, National Academy Press Washington D.C., 1983.

Evaluation of Occupational and Environmental Exposures to Radon and Radon Daughters in the U.S., National Council on Radiation Protection and Measurements, 1984.

Evaluation of the Carcinogenic Risk of Chemicals to Humans, Monographs, International Agency for Research on Cancer, Lyon, France, 1984.

Exner, Jurgen H., *Detoxification of Hazardous Waste*, Ann Arbor Science U.S.A., 1982.

Exposure of the Population in the U.S. and Canada from Natural Background Radiation, National Council on Radiation Protection and Measurements, 1987.

Exposure Of The U.S. Population From Occupational Radiation, National Council on Radiation Protection and Measurements, 1989.

Exposures from the Uranium Series with Emphasis on Radon and its Daughters, National Council on Radiation Protection and Measurements, 1984.

Faires, R.A., *Radioisotope Laboratory Techniques*, R.A. Faires, 1960.

Fawcett, Howard H., *Hazardous and Toxic Materials*, John Wiley & Sons Inc. Canada, 1984.

Few, Richard E., *Radiological Assessment*, Prentice Hall Inc., 1993.

Fire Protection Guide to Hazardous Materials, 12th Edition, National Fire Protection Association, 1997.

Fleming, Diane O., *Biological Safety: Principles and Practices, 3rd Edition*, American Society for Microbiology Press, 2000.

Fleming, Diane O., editor, *Laboratory Safety Principles and Practices, 2nd Edition*, American Society for Microbiology, Washington, D.C., 1995.

Fluer, Larry, *Chemical Handler's Guide*, Larry Fluer,Inc., 1984.

Formaldehyde and Other Aldehydes, National Research Council, National Academy Press, 1981.

Freeman, Leonard M., *Physician's Desk Reference for Radiology and Nuclear Medicine*, Litton Industries, 1979.

Friedlander, G., *Nuclear and Radiochemistry*, John Wiley & Sons Ltd., 1962.

Friel, John, editor, *Dorland's Pocket Medical Dictionary*, W. B. Saunders Company, U.S.A., 1977.

Furr, Keith A., *CRC Handbook of Laboratory Safety*, CRC Press U.S, 1995.

Fuscaldo, Anthony A., *Laboratory Safety*, Academic Press, New York, 1980.

Gardner, William, *Gardner's Chemical Synonyms and Trade Names, 10th Edition*, Gower Publishing Limited, 1994.

General Concepts for the Dosimetry Internally Deposited Radionuclides, National Council on Radiation Protection and Measurements, 1985.

Genetic Effects from Internally Deposit Radionuclides, National Council on Radiation Protection and Measurements, 1987.

Genium Publishing, *Genium's Handbook of Safety, Health, and Environmental Data for Common Hazardous Substances Volumes 1 - 3*, McGraw-Hill Companies, 1999.

Gibson, David E., *Printmaking, Occupational Hygiene Branch*, 1987.

Godish, Thad, *Indoor Air Pollution Control*, Lewis Publishers, 1990.

Goh, Kean S, *The Transportation of Pesticides as Hazardous Materials by Highway*, New York State College, 1986.

Goh, Kean S., *Farm Guide To The Right To Know Law*, Cornell University Cooperative Extension, 1987.

Goldberg, Alfred, *H-6 Design Guide to the Uniform Codes for High Tech Facilities*, Alfred Goldberg And Larry Fluer, 1986.

Gosselin, R., *Clinical Toxicology of Commercial Product, 5th Edition*, 1976.

Gottschall, Carl W., *Chemical Safely Manual for Small Businesses*, American Chemical Society, Washington D.C., 1992.

Gray, Joel E., *Quality Control in Diagnostic Imaging*, Mayo Foundation, 1983.

Green, Michel E., *Safety in Working With Chemicals*, Macmillan Publishing Co. Inc., New York, 1978.

Guide to Occupational Exposure Values, American Conference of Governmental Industrial Hygienists, 1999.

Guide to Safe Handling of Compressed Gases, Matheson Gas Products, Inc., 1983.

Guidelines for the Selection of Chemical Protective Clothing, Volume 1 and 2, American Conference of Governmental Industrial Hygienists, 1983.

Handling Chemical Carcinogens in the Laboratory Problems of Safety, International Agency for Research on Cancer, Lyon U.S.A., 1979.

Hawley, Gessner, *Hawley's Condensed Chemical Dictionary, 14th Edition*, John Wiley & Sons Inc., 2001.

Hayes Davis J., *Superfund 2 A New Mandate, Also The Clean Water Act And The Safe Drinking Water Act*, Bureau Of National Affairs Inc., 1987.

Health and Ergonomic Considerations of Visual Display Units, Ergonomics Committee, American Industrial Hygiene Association, 1983.

Health Physics at Research Reactor, Health Physics, Conference, 1996.

Heisler, Robin, *Office of Pesticides and Technical Reports*, Environmental Protection Agency, 1982.

Hollaender, Alexander, *Radiation Biology, Volume 1 (part1,2), 2, 3*, McGraw-Hill Book Co., 1954.

Identifying and Estimating the Genetic Impact of Chemical Mutagens, National Research Council, National Academy Press, 1983.

Implementation of the Principle of As Lowas Reasonably Achievable for Medical and Dental Personnel, National Council on Radiation Protection and Measurements, 1990.

Indoor Pollutants, Committee On Indoor Pollutants, National Academic Press, 1981.

Indoor Pollutants, National Research Council, National Academy Press, 1981.

Industrial Ventilation: A Manual of Recommended Practice, 20th Edition, American Conference of Governmental Industrial Hygienists, 1988.

Influence of Dose and its Distribution in Time on Dose-Response Relationships for Low-Let Radiations, National Council on Radiation Protection and Measurements, 1980.

Instrumentation and Monitoring Methods for Radiation Protection, National Council on Radiation Protection and Measurements, 1978.

International Commission on Radiological Protection Limit for Intakes of Radionuclides, Volumes 1–8, International Commission on Radiological Protection, Pergamon Press, 1980.

Introduction of Thyroid Cancer by Ionizing Radiation, National Council on Radiation Protection and Measurements, 1985.

Ionizing Radiation Exposure of the Population Of the U.S., National Council on Radiation Protection and Measurements, 1987.

Jacob, Shapiro, *Radiation Protection - A Guide for Scientists, Regulators, and Physicians*, 4th edition.

Johns, Harold Elford, *The Physics Of Radiology*, Charles C. Thomas, 1974

Kingsbury, David, *Emerging Issues in Biomedical Research Safety*, U.S. Department of Health and Human Services, U.S.A., 1987.

Klaassen, Curtis D., *Casarett and Doull's Toxicology*, Macmillan Publishing Co. U.S., 1986.

Klement, Alfred W., *CRC Handbook of Environmental Radiation*, CRC Press, 1982.

Krypton-85 in the Atmosphere, Biological Significance and Control Technology, National Council on Radiation Protection and Measurements, 1975.

Laboratory Decontamination and Carcinogens in Laboratory Wastes: Some NNitrosamides, International Agency for Research on Cancer, Lyon U.S.A., 1982.

Laboratory Decontamination and Destruction of Aflatoxins B1, B2, G1, G2 In Laboratory Wastes, International Agency for Research on Cancer, Lyon U.S.A., 1980.

Laboratory Decontamination and Destruction of Antineoplastic Agents, International Agency for Research on Cancer, Lyon, U.S.A., 1985.

Laboratory Decontamination and Destruction of Carcinogens In Laboratory Wastes: Some Haloethers, International Agency for Research on Cancer, Lyon, U.S.A., 1984.

Laboratory Decontamination and Destruction of Carcinogens in Laboratory Wastes: Some N–Nitrosamines, International Agency for Research on Cancer, Lyon U.S.A., 1982.

Laboratory Decontamination and Destruction Of Carcinogens In Laboratory Wastes: Some Hydrazines, International Agency for Research on Cancer, Lyon, U.S.A., 1983.

Laboratory Decontamination and Destruction of Carcinogens In Laboratory Wastes: Some Antineoplastic Agents, International Agency for Research on Cancer, Lyon, U.S.A., 1985.

Laboratory Safety Monograph, Office of Research Safety, U.S. Department of Health, Education and Welfare, U.S.A, 1979.

Langham, Wright H., *Radiobiological Factors In Manned Space Flight*, National Academy Of Sciences, 1967.

Laser Safety Resource Literature, Laser Institute of America, Cincinnati, 1975.

Lefevre, Marc J., *First Aid Manual for Chemical Accidents: for Use with Nonpharmaceutical Chemicals*, 1980.

Lessard, Edward T., *Interpretation of Bioassay Measurements*, U.S. Nuclear Regulatory Commission, 1990.

Lide, David R., Editor-in-Chief, *CRC Handbook of Chemistry and Physics (On CD-ROM version 2005 for Windows)*, CRC Press, 2005.

Limit for Exposure to "Hot Particles" on the Skin, National Council on Radiation Protection and Measurements, 1989.

Lowry, George G., *Handbook of Hazard Communication and OSHA Requirements*, Lewis Publishing Inc., 1986.

Lunn, G., *Destruction of Hazardous Chemicals in the Laboratory*, 1994.

Mackison, Frank W., *Occupational Health Guidelines for Chemical Hazards*, U.S. Department Of Health And Human Services, 1981.

Makower, Joel, *Office Hazards*, Tilden Press, 1981.

Maletskos, Constantine J., *Radiation Protection at Nuclear Reactors*, Health Physics Society, 1995.

Mammography A User's Guide, National Council on Radiation Protection and Measurements, 1986.

Mammography, National Council on Radiation Protection and Measurements, 1980.

Management of Chemical Wastes Policy and Manual, Chemical Safety Advisory Committee, Yale University,1987.

Management of Persons Accidentally Contaminated with Radionuclides, National Council on Radiation Protection and Measurements, 1980.

Manufacture and Formulation of Pesticides, National Institute for Occupational Safety and Health, U.S. Department Of Health, Education And Welfare, 1978.
McCann, Michael, *Artist Beware*, Watson Guptill Publications, 1979.

Measurement of Radon and Radon Daughters in Air, National Council on Radiation Protection and Measurements, 1988.

Medical X-Ray and Gamma -Ray Protection for Energies up to 10 MeV, National Council on Radiation Protection and Measurements, 1973.

Mettler, Fred A., Jr., *Medical Management of Radiation Accidents*, CRC Press, 1990.

Meyer, Eugene, *Chemistry of Hazardous Materials*, Prentice Hall Career and Technology, 1990.

Miller, Brinton M., editor, *Laboratory Safety Principles and Practices*, American Society for Microbiology, Washington, D.C., 1986.

Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Humans, Volume 34, International Agency for Research on Cancer, 1984.

Mossman, Kenneth L, *The Biological Basis of Radiation Protection Practice*, Williams & Wilkens, 1992.

Murray, Patrick R., *Manual of Clinical Microbiology, 6th Edition*, ASM Press, 1995.

Mutgeert, B. J., *Handling Chemicals Safely*, Dutch Association of Safety Experts, 1980.

Natural Background Radiation In The U.S., National Council on Radiation Protection and Measurements, 1975.

Neal, Robert A., *Prudent Practices for Handling Hazardous Chemicals in Laboratories*, National Academy Press, Washington D.C, 1981.

Neptunium: Radiation Protection Guidelines, National Council on Radiation Protection and Measurements, 1988.

Neutron Contamination from Medical Electron Accelerators, National Council on Radiation Protection and Measurements, 1984.

NIOSH Pocket Guide to Chemical Hazards, U.S Department of Health and Human Services, U.S.A., 1985.

Noyes, Robert, *Handbook of Leak, Spill, and Accidental Techniques*, Noyes Publications NJ, 1992.

Noyes, Robert, *Northeastern Regional Pesticide Information Manual*, Chemical Pesticides Program, Mass., 1986.

Occupational Cancer - Prevention and Control, International Labor Office - Geneva, 1979.

Occupational Cancer Prevention and Control, Occupational Safety and Health Series, International Labor Office, Geneva Switzerland, 1979.

Occupational Health Guideline For Endrin, U.S. Department Of Health And Human Services, U.S. Department Of Labor, 1978.

Occupational Health Guideline For Osmium Tetroxide, U.S. Department Of Health And Human Services, U.S. Department Of Labor, 1978.

Occupational Safety & Health Cases, Volume 11-15, The Bureau Of National Affairs Inc., 1993.

Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities, National Institute for Occupational Safety and Health, U.S.A., 1985.

Oldham, K.G., *Radiochemical Review, Volumes 1 & 2*, Amersham Searle. *Operation Radiation Safety Training*, National Council on Radiation Protection and Measurements, 1983.

Overman, Ralph T., *Radioisotope Techniques*, Magraw Hill Book Co., 1960.

Pakes, Steven P., *Guide for the Care and Use of Laboratory Animals*, , U.S Department of Health and Human Services, 1987.

Parkin, William P., *The Complete Guide to Environmental Liability and Enforcement in New York*, STP, 1992.

Patnaik, Pradyot, *A Comprehensive Guide to the Hazardous Properties of Chemical Substances*, Van Nostrand Reinhold, 1992.

Pelt, Van, *Laser Fundamentals and Experiments*, U.S. Department of Health, Education And Welfare, 1970.

Phillips, Jack J., *Handbook of Training Evaluation and Measurement Methods*, Gulf Publishing Co, 1983.

Physical, Chemical, and Biological Properties of Radiocerium Relevant to Radiation Protection Guidelines, National Council on Radiation Protection and Measurements, 1978.

Pipitone, David A, *Safe Storage of Laboratory Chemicals*, John Wiley & Sons Inc., Canada, 1984.

Pitt, Martin J., *Handbook of Laboratory Waste Disposal*, M.J Pitt Great Britain, 1985.

Plimpton, Sarah W., *Prudent Practices In The Laboratory*, National Academy Press, 1995.

Plog, B., *Fundamentals of Industrial Hygiene, 4th Edition*, National Safety Council, 1996.

Precautions for the Proper Usage of Polyurethanes, Polyisocyanurates and Related Materials, The Upjohn Company, 1981.

Protection Against Radiation From Brachytherapy Sources, National Council on Radiation Protection and Measurements, 1972.

Protection in Nuclear Medicine and Ultrasound Diagnostic Procedures in Children, National Council on Radiation Protection and Measurements, 1983.

Protection of the Thyroid Gland in the Event of Releases of Radioiodine, National Council on Radiation Protection and Measurements, 1977.

Prudent Practices for Disposal of Chemicals from Laboratories, National Research Council, National Academy Press, 1983.

Prudent Practices in the Laboratory: Handling and Disposal of Chemicals, National Research Council, National Academy Press, 1995.

Public Radiation Exposure from Nuclear Power Generation in the U.S., National Council on Radiation Protection and Measurements, 1987.

Quality Assurance for Diagnostic Imaging Equipment, National Council on Radiation Protection and Measurements, 1988.

Radiation Alarms and Access Control Systems, National Council on Radiation Protection and Measurements, 1986.

Radiation Exposure from Consumer Products and Miscellaneous Sources, National Council on Radiation Protection and Measurements, 1977.

Radiation Exposure of the U.S. Population from Consumer Products and Miscellaneous Sources, National Council on Radiation Protection and Measurements, 1987.

Radiation Protection and Measurement for Low Voltage Neutron Generators, National Council on Radiation Protection and Measurements, 1983.

Radiation Protection for Medical and Allied Health Personal, National Council on Radiation Protection and Measurements, 1989.

Radiation Protection in Educational Institutions, National Council on Radiation Protection and Measurements, 1996.

Radiation Protection in Pediatric Radiology, National Council on Radiation Protection and Measurements, 1981.

Radiation Protection Recommendations of the International Commission on Radiological Protection, Publication 6, 7, 9, 10, Pergamon Press, 1959.

Radiation Protection, International Commission on Radiological Protection, Pergamon Press, 1977.

Radiation Safety Manual, John Hopkins Medical Institutions, 1981.

Radiation Safety Training Criteria for Industrial Radiography, National Council on Radiation Protection and Measurements, 1978.

Radioactive Tracers in Microbial Immunology, International Atomic Energy Agency, Vienna, 1972.

Radiofrequency Electromagnetic Fields, National Council on Radiation Protection and Measurements, 1981.

Radiological Assessment: Predicting the Transport, Bioaccumulation and Uptake by Man of Radionuclides Released to the Environment, National Council on Radiation Protection and Measurements, 1984.

Radiological Health Handbook, Bureau of Radiological Health, U.S. Department Of Health, Education and Welfare, 1970.

Recommendations on Limits for Exposure to Ionizing Radiation, National Council on Radiation Protection and Measurements, 1987.

Reinhardt, P. A., *Pollution Prevention and Waste Minimization in Laboratories*, 1996.

Richardson, John H., *Biosafety in Microbiological and Biomedical Laboratories*, U.S. Government Printing Office, Washington, 1988.

Richmond, Jonathan Y. editor, *Biosafety in Microbiological and Biomedical Laboratories*, U.S. Government Printing Office Washington D.C., 1993.

Rossol, Monona, *Stage Fright: Health and Safety in the Theater. A Practical Guide*, Center for Occupational Hazards, 1986.

Rossol, Monona, *The Artist's Complete Health and Safety Guide, 2nd Edition*, Allworth Press, 1994.

Safe Handling of Compressed Gases in the Laboratory and Plant, Matheson Gas Products, Inc., 1997.

Safety in Academic Chemistry Laboratories, American Chemical Society U.S.A., 1995.

Sax, Irving N., *Cancer Causing Chemicals*, Van Nostrand Rienhold Co., 1981.

Sax, Irving N., *Dangerous Properties of Industrial Materials, 6th Edition*, Van Nostrand Reinhold Company Inc. U.S.A., 1984.

Sax, Irving N., *Hazardous Chemicals In the Workplace*, Van Nostrand Rienhold Co. New York, 1986.

Schilt, Alfred A., *Perchloric Acid and Perchlorates*, Fredrick Smith Chemical Company Ohio, 1979.

Schwope, A.D., *Guidelines for the Selection of Chemical Protective Clothing*, American Conference Of Governmental Industrial Hygienists Inc., 1983.

Seeger, Nancy, *Alternatives for the Artist: A Ceramist's Guide to the Safe Use of Materials*, The School of the Art Institute of Chicago, 1984.

Seeger, Nancy, *Alternatives for the Artist: A Painter's Guide to the Safe Use of Materials*, The School of the Art Institute of Chicago, 1984.

Seeger, Nancy, *Alternatives for the Artist: A Photographer's Guide to the Safe Use of Materials*, The School of the Art Institute of Chicago, 2000.

Seeger, Nancy, *Alternatives for the Artist: A Printmaker's Guide to the Safe Use of Materials*, The School of the Art Institute of Chicago, 1984.

Seeger, Nancy, *Alternatives for the Artist: An Introductory Guide to the Safe Use of Materials*, The Art Institute Of Chicago., 1982.

Setter, Lloyd R., *Regulations, Standards and Guides for Microwave, Ultraviolet Radiation, and Radiation from Lasers and Television Receivers-An Annotated Bibliography*, U.S. Department Of Health, Education, And Welfare, 1969.

Seventh Annual Report on Carcinogens, Environmental Health Sciences, U.S. Department of Health and Human Services, Washington D.C., 1994.

Shaw, Susan, *Overexposure Health Hazards in Photography, Friends Of Photography*, 1983.

Shepard M.D., Thomas H., *Catalog of Teratogenic Agents, 5th Edition*, John Hopkins University Press, 1986.

Shultis, Kenneth, *Radiation Shielding*, Prentice Hall PTR, 1996.

SI Units in Radiation Protection and Measurements, National Council on Radiation Protection and Measurements, 1985.

Sliney, David H. editor, *Threshold Limit Values*, American Conference of Governmental Industrial Hygienists, Cincinnati, 1993.

Smith, William V., *Laser Applications*, Artech House Inc., 1970.

Snavely, David R., *Regulations, Standards and Guides Pertaining to Medical and Dental Radiation Protection An Annotated Bibliography*, U.S. Department Of Health, Education, and Welfare, 1969.

Spandorfer, Merle, *Making Art Safely*, Van Nostrand Reinhold, 1993.

Steere, Norman V., *Handbook of Laboratory Safety*, Chemical Rubber Co., Cleveland, Ohio, 1967.

Stellman, Jeanne, *Office Work can be Dangerous to Your Health*, Jenne Stellman, 1983.

Stewart, Donald C., *Handling Radioactivity*, John Wiley & Sons, 1981.

Tardiff, Robert G., *Principles and Procedures for Evaluating the Toxicity of Household Substances*, National Academy of Sciences, Washington D.C, 1977.

Tatken, Rodger L., *Registry of Toxic Effects of Chemical Substances, Volume 1, 2 and 3*, U.S. Department of Health And Human Services, Cincinnati, 1983.

Taylor, David G., *Manual Of Analytical Methods*, U.S. Department Of Health And Human Services, 1980.

The Experimental Basis for Absorbed-Dose Calculations in Medical Uses of Radionuclides, National Council on Radiation Protection and Measurements, 1985.

The Medical NBC Battlebook, US Army Center for Health Promotion and Preventive Medicine, 2002.

The Relative Biological Effectiveness of Radiations of Different Quality, National Council on Radiation Protection and Measurements, 1990.

The Safe Handling of Chemical Carcinogens, Division of Safety, National Institutes of Health, U.S.A.

Till, John E., *Radiological Assessment*, Nuclear Regulatory Commission, 1983.

TLV's and BEI's: Threshold Limit Values for Chemical Substances and Physical Agents. Biological Exposure Indices, American Conference of Governmental Industrial Hygienists, 1999.

Tracy, Tony M., *Clinical Toxicology of Commercial Products*, Williams Wilkins U.S.A., 1984.

Tritium and Other Radionuclide Labeled Organic Compounds Incorporated in Genetic Material, National Council on Radiation Protection and Measurements, 1979.

Tritium in the Environment, National Council on Radiation Protection and Measurements, 1979.

Tritium Measurement Techniques, National Council on Radiation Protection and Measurements, 1976.

Tuohey, Seamus M., *Manager's Guide to Safety and the Retail Environment*, Cornell University, 1993.

Tver, David F., *Industrial Medicine*, Chapman & Hall, New York, London, 1988.

Upton, Arthur C., *Health Effects of Exposure to Low Levels of Ionizing Radiation*, National Academy Press, 1990.

US Senate: Radiation Standards, Scientific Basis Inconclusive, and EPA & NRC Disagreement Continues, Government Accountability Office, GAO Report to the Honorable Pete Domenici, June, Government Accountability Office, 2000.

Use of Bioassay Procedures for Assessment of International Radionuclide Deposition, National Council on Radiation Protection and Measurements, 1987.

Veterinary and Human Toxicology, Veterinary and Human Toxicology U.S, 1981.

Video Display Terminals, Bell Laboratories, Bell Telephones, 1983.

Vrschueren, K., *Handbook of Environmental Data on Organic Chemicals, 2nd Edition*, Van Nostrand Reinhold Company, 1983.

Wagner, Sheldon L., *Clinical Toxicology of Agricultural Chemicals*, Noyes Data Corporation, NJ, 1983.

Walters Douglas B., *Safe Handling of Chemical Carcinogens, Mutagens, Teratogens and Highly Toxic Substances, Volume 1 & 2,* Ann Arbor Science, U.S.A, 1980.

Weast, Robert C., *Handbook of Chemistry and Physics*, Chemical and Rubber Co. *Welding Health and Safety Resource Manual*, American Industrial Hygiene Association, Akron, 1984.

Weng, Yen, *Handbook of Radioactive Nuclides*, Chemical Rubber Co., 1969.

Whittenberger, James L., *Toxicity Testing*, National Academy Press, Washington D.C., 1984.

Wohlhueter, Robert, *Working Safely with Hazardous Chemicals*, U.S. Department of Health And Human Services U.S., 1991.

Wood, Clair G., *Safety in School Science Labs*, James A. Kaufman & Associates.

Working with Chemicals and You - Health Instructors Manual, National Safety Council, National Safety Council, 1982.

Wyckoff, H.O., *International Commission on Radiation Units and Measurements, Volume 28, 35, 36*, Library Of Congress Cataloging In Publication Data, 1985.

Yaws, Carl L., *Matheson Gas Data Book, 7th Edition*, McGraw-Hill, 2001.

APPENDIX N: DOCUMENT CHANGE LOG

2024 Edition Updates:

- Added Appendix N: change log
- Replaced Appendix K with Comprehension Letter, removed laser registration form
- Updated University Policy to 1011 from 807
- Added Visitor requirements to “training” section
- Added 1.2.8 Sabbatical and Leaves