LABORATORY SAFETY MANUAL

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Office of Environmental, Health, Safety and Risk Management
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CALL PUBLIC SAFETY OR 911 IN ANY EMERGENCY THAT REQUIRES IMMEDIATE POLICE, FIRE, OR MEDICAL RESPONSE TO PRESERVE A LIFE.

If 911 is called, be sure to alert Public Safety so they can coordinate the response.

PURPOSE OF THIS MANUAL

The Office of Environmental, Health, Safety and Risk Management, in partnership with the Environmental, Health and Safety Officer Council and the Office of the Vice-Chancellor for Research, has developed this Laboratory Safety Manual to minimize the risks associated with lab activity and ensure that CUNY remains in compliance with the Occupational Safety and Health Administration (OSHA) regulation 29 CFR 1910.1450, "Occupational Exposure to Hazardous Chemicals in Laboratories," or what is commonly referred to as the "Laboratory Standard."[1] The Laboratory Standard requires the development of a Chemical Hygiene Plan (CHP) for each laboratory workplace that protects employees from health hazards associated with hazardous chemicals in the laboratory and maintains exposures below OSHA Permissible Exposure Limits. In addition to addressing those regulations that are mandatory, this manual also offers some *best management practices* supported by leading standards setting organizations and research institutions.

Throughout this document, regulatory requirements will be clearly identified using words such as "must," "required," and "shall." **Colleges, departments, other units, and individual laboratories are free to adopt any non-mandatory guidelines found within this document as applicable for their units or laboratories.**

To take advantage of the Internet, this document is formatted to be a "front door" to other resources, including useful web links. Where appropriate, web links will be embedded within the document and identified as a hyperlinked word that can be clicked on to view the webpage. Please note that by clicking on these external resources you will be leaving the Laboratory Safety Manual and will have to click on the "Back" button on your browser to return to the Manual. For those internal hyperlinks, including the Table of Contents, you can navigate through the document by clicking on the "Back" and "Forward" hyperlink arrow buttons.

This Laboratory Safety Manual is not intended to replace or supersede any specific operational rules or procedures that have been adopted by the University to comply with environmental, health, and safety regulations or policies. It is a dynamic document and will be reviewed periodically and updated based on the comments and suggestions of readers, laboratory users, and the broader CUNY scientific community.

[1] Although this manual is a compilation of ideas from various sources, CUNY EHSRM gratefully acknowledges the generosity of Cornell University's Office of Environmental Health and Safety for allowing CUNY to base this manual on the extensive work that Cornell has done to prepare its own Laboratory Safety Manual.

CREDITS

The Office of Environmental, Health, Safety and Risk Management acknowledges the work of the Laboratory Safety Committee in developing this Laboratory Safety Manual. The members of the Laboratory Safety Committee are:

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LIST OF ACRONYMS AND ABBREVIATIONS

ABSA	American Biological Safety Association
ACGIH	American Conference of Governmental Industrial Hygienists
AIHA	American Industrial Hygiene Association
ANSI	American National Standards Institute
ASHRAE	American Society of Heating, Refrigerating, and Air Conditioning Engineers
BSC	Biological Safety Cabinet
BSL	Biosafety Laboratory
CDC	Center for Disease Control and Prevention
CFR	Code of Federal Regulations
CHO	Chemical Hygiene Officer
CHP	Chemical Hygiene Plan
CPR	Cardiopulmonary Resuscitation
DEC	Department of Environmental Conservation
DEP	Department of Environmental Protection
DOHMH	Department of Health and Mental Hygiene
DOT	Department of Transportation
EHS	Environmental, Health and Safety
EHSO	Environmental, Health and Safety Officer
EHSRM	Environmental, Health, Safety and Risk Management
EPA	Environmental Protection Agency
FDA	Food and Drug Administration
FDNY	The Fire Department of the City of New York
GFCI	Ground Fault Circuit Interrupters
HEPA	High Efficiency Particulate Air
IACUC	Institutional Animal Care and Use Committee
IBC	Institutional Biosafety Committee
IRB	Institutional Review Board
LASER	Light Amplification by Stimulated Emission of Radiation
MSDS	Material Safety Data Sheet
NFPA	National Fire Protection Association
NIH	National Institutes of Health
NIOSH	National Institute of Occupation Safety and Health
NMR	Nuclear Magnetic Resonance
NRC	National Research Council
NYS	New York State
ORC	Office of Research Conduct

OSHA	Occupational Safety and Health Administration
P.I.	Principal Investigator
PEL	Permissible Exposure Limits
PESH	Public Employee Safety and Health
PPE	Personal Protective Equipment
RCNY	Rules of the City of New York
RF	Research Foundation
RMW	Regulated Medical Waste
RSO	Radiation Safety Officer
SOP	Standard Operating Procedure
TLV	Threshold Limit Value
UL	Underwriters Laboratories

1.0 INTRODUCTION

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 because of chemicals while they are working in a laboratory. This regulation applies to all employers engaged in the laboratory use of hazardous chemicals as defined by OSHA.

> "Laboratory" means a facility where the "laboratory use of hazardous chemicals" occurs. 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.
>
> "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 CUNY 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 that 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. The main goals of the OSHA Laboratory Standard and the requirement to develop a CHP 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 that the CHP 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." **The components of the CHP are outlined in Appendix A of this manual.**

The New York State Plan for Public Employee Safety and Health (PESH), by authority under Section 27(a) of the New York Labor Law, is responsible for promoting the health and safety of state and local government employees. The PESH Program has adopted all federal OSHA standards and regulations in regards to laboratory safety with the exception of the Recordkeeping Rule, 29 CFR 1904.[2] The New York Department of Labor has been designated as the agency responsible for administering the plan throughout New York State. The Commissioner of Labor has full authority to enforce and administer all laws and rules adopted by the PESH Program.

1.1 Chemical Hygiene Plan (CHP) Accessibility

The OSHA Laboratory Standard, enforced by the New York State Commissioner of Labor under the Public Employee Safety and Health (PESH) Plan, requires the CHP to be readily available to employees, employee representatives and, upon request, to the NYS Commissioner 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 federal, state, or local regulatory inspectors upon request. While it is recommended that a hard copy be kept in the laboratory, electronic access is acceptable and encouraged.

******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.***

[2] New York promulgated and adopted an alternative approach to recordkeeping requirements under 12 NYCRR section 801 and administrative instructions 901.

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 (P.I.), 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. P.I.s, Faculty, and Lab Supervisors have numerous resources at their disposal for helping to ensure a safe and healthy laboratory that is compliant with federal, state, and local regulations.

It is the responsibility of the Principal Investigator and individual supervisors (and individuals working under their supervision) to be in compliance with all federal, state, and local regulatory requirements as well as any other department or university-specific policies.

1.2.1 CUNY Environmental, Health, Safety and Risk Management (EHSRM)

The City University of New York's Office of Environmental, Health, Safety and Risk Management is committed to fostering a safe and healthy environment for the CUNY community and to reducing the University's risks. The first step in pursuit of this mission is to ensure that CUNY is in compliance with applicable regulations and University policies and procedures. EHSRM works with the Environmental, Health and Safety Officer Council to mitigate hazards by coordinating and organizing safety compliance through training and oversight programs at each campus and throughout the University.

1.2.2 Environmental, Health and Safety (EHS)

For each campus, the Environmental, Health, and Safety Officer (EHSO) will provide technical information and program support to assist in compliance with the Laboratory Standard and all other regulatory requirements. This includes providing training programs designed to meet these regulatory requirements and providing health and safety information to laboratory personnel. EHS will maintain the campus Chemical Hygiene Plan and the institutional Chemical Hygiene Officer responsibilities.

1.2.3 Chemical Hygiene Officer (CHO)

The role of the Chemical Hygiene Officer (CHO) 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. All campuses with laboratories must designate a CHO, in accordance with the Laboratory Standard. The Associate CHO, if so designated, will act in the absence of the CHO. The names of the current CHO and the Associate CHO can be found in Appendix B.
The major duties of the Chemical Hygiene Officer include:

- 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.

- Ensure that guidelines are in place and communicated for particularly hazardous substances regarding proper labeling, handling, use, 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 P.I.s and department personnel for the use, disposal, and decontamination of hazardous chemicals and the proper selection and use of personal protective and spill-response equipment.

- Coordinate the acquisition, testing, and maintenance of fume hoods and emergency safety showers and eyewashes in all laboratories where hazardous chemicals are used.

- 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 action where appropriate.

- Stay informed of plans for renovations or new laboratory construction projects and serve as a resource in providing code citations and internal standards to assist with the design and construction process.

- Keep the 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.

1.2.4 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 the guidelines and requirements of the Laboratory Safety Manual. The laboratory safety responsibilities of Deans, Directors, and Department Chairpersons, which can be delegated to other authorized personnel within the department, are:

- Communicate the requirements of the Laboratory Safety Manual 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 that laboratory personnel develop and adhere to proper health and safety protocols.

- Direct individuals under their supervision, including but not limited to—P.I.s, 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 equipment for units/departments are met (e.g., engineering controls, training, protective equipment) and ensure that corrective measures for noncompliance items identified in safety audits are corrected promptly.

- Encourage the formation of a college and/or department safety committee(s).

- Keep Facilities Management, the Chemical Hygiene Officer and/or the EHS Officer informed of plans for renovations or new laboratory construction projects.

- Ensure that 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 so that proper laboratory decommissioning occurs. For more information, see the Lab Move Guide in the Appendix E.

- Establish college and departmental priorities, objectives, and targets for laboratory safety and health performance. Obtain assistance and guidance from CUNY EHSRM when necessary.

- Ensure college and departmental laboratory participation in EHS Research Area Inspections as a means to regularly check performance against regulatory requirements and identify opportunities for improvement.

1.2.5 Principal Investigators (P.I.s), Faculty, and Laboratory Supervisors

P.I.s, faculty, and laboratory supervisors are responsible for laboratory safety in their research or teaching laboratories. The Fire Department for the City of New York (FDNY) requires that all chemical laboratory units be supervised by an FDNY "Certificate of Fitness" holder whenever laboratory operations are being conducted. The specific Certificate of Fitness required is a C-14, "Certificate of Fitness for the Supervision of Chemical Laboratories." **It is strongly recommend that all laboratory supervisors and principal investigators who qualify for the certificate obtain it.** Qualification requirements, study materials, and other test information can be found on FDNY's website. The laboratory safety duties of P.I.s, faculty, and laboratory supervisors (which can also be delegated to other qualified personnel within the laboratory) are:

- Implement and communicate all college and university safety practices and programs, including the guidelines and procedures found within the Laboratory Safety Manual, in laboratories under his/her supervision or control.

- Establish laboratory priorities, objectives, and targets for laboratory safety, health, and environmental performance.

- Communicate roles and responsibilities of 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 that laboratory personnel have been trained in these operating procedures and use proper control measures.

- Attend required health and safety training.

- Require all staff members and students under their direction to obtain and maintain required health and safety training.

- Participate in EHS Research Area Inspections with their laboratory employees, or designate someone in the laboratory to conduct these inspections.

- Ensure that all items identified during EHS research area inspections are corrected in a timely manner.

- 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 EHS when significant changes in chemical use may require a re-evaluation of the laboratory ventilation.

- Ensure that 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 their Director or Department Chairperson, and that a written Injury/Illness Report is filed with EHS for each injured person.

- Ensure that 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 P.I. and laboratory supervisor responsibilities. A compiled version of these responsibilities can be found in the Appendix C.

- Keep the Department Chairperson and the Chemical Hygiene Officer informed of plans for renovations or new laboratory construction projects.

1.2.6 Laboratory Employees

Laboratory employees are those personnel who conduct their work in a 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.

The safety duties of laboratory employees are:

- Comply with all university 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 your supervisor or instructor of any safety hazards in the workplace, classroom, or laboratory, and report any unsafe working conditions, faulty fume hoods, or other emergency safety equipment to the laboratory supervisor.

- Ensure that an MSDS is present for all new chemicals you purchase (The MSDS should have been either sent with the original shipment or be available online). Review the MSDSs for chemicals you are working with and check with your laboratory supervisor or P.I. if you ever 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 and EHS Research Area Inspections.

- Follow the standard operating procedures for her/his laboratory and incorporate the requirements outlined in this Laboratory Safety Manual into everyday practice.

1.2.7 Facilities Management[3]

Facilities Management serves 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 the Facilities Management include:

- Comply with all 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 Department Chairperson, the Chemical Hygiene Officer, and/or EHS Officer informed of plans for renovations or new laboratory construction projects and the laboratory needs of new faculty and staff.

[3] This department title varies across campuses. “Building and Grounds” is a common alternative.

- Ensure that ticket 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 the EHS Office related to building-wide laboratory safety issues are addressed.

- Be aware of building issues that could impact the health and safety of laboratory personnel and contact your EHS Office whenever building-wide health and safety issues occur in laboratories.

- Be familiar with what to do in the event of an emergency situation.

- Assist emergency responders during emergencies by serving as a resource for control of building control systems (ventilation, turning off water main, etc.).

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2.0 ENGINEERING CONTROLS

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

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

The proper functioning and maintenance of fume hoods and other protective equipment used in the laboratory is the responsibility of a variety of service groups. Facilities Management, the EHSO, and other groups service equipment such as fire extinguishers, emergency eyewash and showers, and mechanical ventilation. Periodic inspections and maintenance by these groups ensures the proper functioning and adequate performance of these important pieces of protective equipment. ***However, it is the responsibility of laboratory personnel to IMMEDIATELY report malfunctioning protective equipment, such as fume hoods or other mechanical problems, to Facilities Management as soon as any malfunctions are discovered.*** For more information, see Ticket Requests.

2.1 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, aerosols, or dusts. Bench top 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. Laboratory personnel may want to conduct a dry ice capture test with their fume hoods when using new materials for the first time or whenever substantial changes have been made to an experimental setup in a hood, such as the addition of more apparatus.

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

- Before using a fume hood, ensure that the fume hood is working by checking the tell tale (green crepe paper hanging from hood sash) and air monitoring device if the hood is equipped with one. ***If the EHSO or Facilities Management has posted the hood as being out of service, DO NOT use the fume hood for any reason.***

- Always work with the fume hood sash as low as possible. 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 the fume hood sash closed all of the way whenever the fume hood is not being used to help conserve energy.

- For those laboratories equipped with occupancy sensors or where the ventilation rates are controlled by the light switches, when you first enter the lab, wait a few minutes before beginning to work with chemicals in order for the ventilation system to ramp up to occupied settings and higher ventilation rates.

- Minimize all materials stored in hoods. 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 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, 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 the laboratory personnel's breathing zone.

- Using fume hoods to evaporate 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 have 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 all 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.

- Always report any malfunctioning fume hood to Facilities Management immediately by requesting a ticket to have the unit repaired. If the fume hood is not working properly, let other people in the lab know by hanging up a "Do Not Use" sign on the hood.

2.1.1 Perchloric Acid Use

Be aware that use of heated perchloric acid requires a special perchloric acid fume hood with a wash down function. DO NOT use heated perchloric acid in a regular fume hood. If heated perchloric acid is used in a regular fume hood (without a wash down function), shock sensitive metallic perchlorate crystals can form inside the duct work, and could result in causing an explosion during maintenance work on the ventilation system. If you suspect your fume hood has perchlorate contamination or would like more information on perchloric acid fume hoods, contact your EHS Office.

2.1.2 Fume Hood Inspection and Testing Program

Your EHS Office coordinates annual testing and inspection of fume hoods on campus. 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, and average face velocity measurements.

Follow-up inspections for proper use and face velocity (airflow) measurements will be performed on an annual basis and 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. Hoods will also be labeled with arrow stickers. The arrows represent the sash position at which the hood was tested for optimum working height. All inspection information will be recorded and kept on file**. 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, contact your EHSO immediately to schedule an inspection.**

Fume hood testing and inspection consists of the following:

- Testing must be done annually in accordance with NFPA 45, A.8.4.7. Hoods should be measured from a sash height of 12" to 18" sash and found to have a minimum face velocity of 80 feet per minute (fpm) and a maximum of 120 fpm. A maximum face velocity of 150 fpm in existing hoods is allowed where required (OSHA). An inspection sticker must be affixed to all fume hoods indicating proper face velocity.

- According to NFPA 45, fume hoods may require additional testing under the American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE) standard 110-1995. Additional testing is performed when a hood has an average face velocity below 80 fpm or above 150 fpm

- A report will be sent to Facilities Management documenting the testing and indicating any needed repairs.

- If your fume hood was too full to test, you will be contacted by the EHS office for further information before your fume hood can be tested.

Hoods will be classified as acceptable or unacceptable based on the average face velocity measurement. If a hood is found to be unacceptable, a warning sign indicating that the hood did not pass inspection, does not provide optimum protection, and must not be used will be attached in a conspicuous location.

<u>Under no circumstances</u> should laboratory personnel continue to use a fume hood that has not passed the EHS 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. The EHS Office will coordinate fume hood repairs with Facilities Management and campus service shops to ensure a timely and accurate repair process.

2.1.3 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 in consultation with Facilities Services, the EHS Office, and the appropriate campus service shops. All new installations of fume hoods must comply with FDNY regulations and be approved by the EHS Office.

The EHSO can provide information regarding the selection, purchase, and inspection requirements for laminar flow clean benches, biosafety cabinets, and portable fume hoods. For more information, see the Laboratory Design and Construction section in this manual or contact your EHSO.

2.1.4 Removal of Existing Fume Hoods

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

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

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

2.3 Glove Boxes

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

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

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

Regular maintenance and inspection is essential to ensure that a glove box is adequately protecting the user, the environment and/or the product/process. Routine maintenance procedures and the frequency of inspection (or certification) should follow the manufacturers and regulatory recommendations. It is recommended that biological safety cabinets on campus be inspected annually by the manufacturer or an industrial hygienist. Glove boxes used for work with hazardous chemicals or processes currently do not have a required frequency of inspection, but annual certification by the manufacturer or an industrial hygienist is strongly encouraged. If the manufacturer does not offer an inspection program, contact your EHSO for information on qualified industrial hygienists in the area.

The integrity of the glove box is key to successful containment. The gloves of a glove box are particularly vulnerable. Gloves should be regularly inspected for cuts, tears, cracking and pin hole leaks. If defects are found, the gloves should be replaced. Note that there are many different types of glove box gloves that vary in thickness, material, size, etc. Choose the correct one for the glove box and application.

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

2.4 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 (e.g. hot water coming from a drinking water fountain).

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

1) A tube attached to a faucet without a vacuum breaker; and
2) Drainage tubing hanging down into the sink.

These tubes can be immersed in wash water when the sink is stopped up and backflow into the faucet, contaminating the building's water supply.

The most common example of backflow 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 your laboratory faucets have a vacuum breaker or backflow protection, contact your EHSO or Facilities Management. 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 from back flowing up the faucet.

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3.0 PERSONAL PROTECTIVE EQUIPMENT

Personal Protective Equipment (PPE) should be considered as a major line of defense in protecting laboratory personnel against chemical hazards. 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 has 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.

3.1 Laboratory Responsibilities for Personal Protective Equipment

Laboratory personnel need to conduct hazard assessments of specific operations occurring in their laboratories to determine what PPE is necessary to carry out the operations safely. 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 used by laboratory personnel.

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

P.I.s, laboratory supervisors, departments, and colleges are free to set policies that establish minimum PPE requirements for personnel working in and entering their laboratories. Check with your EHSO to see if there is any department or college-specific requirements for PPE.

3.2 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 the 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 don, doff, adjust, and wear PPE.
- The proper cleaning, care, maintenance, useful life, limitations, and disposal of the 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. Training records must be kept of the names of the persons trained, the type of training provided, and the dates when training occurred. Your EHSO will maintain records of employees who attend 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. Your EHS Office can provide information, training, and assistance with conducting hazard assessments and the selection and use of proper PPE.

It is the responsibility of the P.I. 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 that laboratory personnel use proper PPE when working in laboratories under their supervision.

3.3 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, broken glass, molten metal, acids or caustic liquids, chemical liquids, chemical gases or vapors, or potentially injurious light radiation.

P.I.s and laboratory supervisors are strongly encouraged to make use of 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 eyewear while in laboratories where chemicals are being handled or stored, 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.

3.3.1 Eye Protection Selection

All protective eye and face devices must comply with ANSI Z87.1-2003, "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 eyewear that serve different functions.

Prescription Safety Eyewear
OSHA regulations require that employees who wear 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 Z87.1-1989. **Contact lenses by themselves are not considered to be protective eyewear.**

Safety Glasses
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

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 facepiece. In the event of a splash, chemicals could enter into the small holes, and result in a chemical exposure to the face. Ensure that the goggles you choose are rated for use with chemicals.

Welder's/Chippers' Goggles

Welder's goggles provide protection from sparking, scaling, or splashing metals and harmful light rays. Lenses are impact resistant and are available in graduated lens shades. Goggles used for chipping and grinding provide protection from flying particles. A dual protective eyecup houses impact resistant clear lenses with individual cover plates.

Face Shields

Face shields provide additional protection to 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 wire screen. They should be used in operations when the entire face needs protection and should be worn to protect the eyes and face from flying particles, metal sparks, and chemical/biological splashes. Face shields with a mesh wire screen are not appropriate for use with chemicals. ***Face shields are not intended to be used alone and are not a substitute for appropriate eyewear. It is recommended that face shields always be worn in conjunction with a primary form of eye protection such as safety glasses or goggles.***

Welding Shields

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.

It is recommended that equipment fitted with appropriate filter lenses always 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 your EHSO. See the LASER Hazards section for more information.

3.4 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).

***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 (e.g., thickness, permeation rate, and time) are known. The EHSO 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.

3.4.1 Selecting the Proper Gloves

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

If the manufacturer's glove chart does not list the specific chemical you will be using, call the manufacturer directly and speak with a technical representative to determine which glove is best suited for your particular 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.

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.

- Because of potential chemical contamination, which may not always be visible, gloves should always be removed before leaving the laboratory. Do not wear gloves while performing common tasks such as answering the phone, grabbing a door handle, or using an elevator.

3.4.2 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 (e.g., change of color, change of texture, tears). 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 the chemical manufacturer's glove selection charts first before choosing which type of glove to use.

To remove disposable gloves properly, 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 glove in the palm of your hand and dispose of them properly. Be sure to wash your hands thoroughly with soap and water after the gloves have been removed.

3.4.3 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
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
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
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
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
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 your glove manufacturer's recommendations or glove selection charts, or contact your EHSO 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 alcohols, caustics, organic acids, and some ketones.
- 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.
- 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 minutes or even seconds when used with common lab and shop chemicals. Latex gloves also can cause an allergic reaction in a percentage of the population because of several 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 wearing 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% concentrations for most hazardous chemicals or less than 0.1% for known or suspected human carcinogens.

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, use non-latex gloves. A general purpose substitute for disposable latex gloves are disposable Nitrile gloves.

See the Appendix I 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.

3.5 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, and provide additional body protection from some physical hazards.

It is strongly recommended that P.I.s and laboratory supervisors discourage 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.

The following characteristics should be taken into account when choosing protective clothing:

- The specific hazard(s) and the degree of protection required, including the potential exposure to chemicals, radiation, biological materials, and physical hazards such as heat.

- The type of material the clothing is made of and its resistance to the specific hazard(s) that will be encountered.

- The comfort of the protective clothing, which impacts the acceptance and ease of use by laboratory personnel.

- Whether the clothing is disposable or reusable - which impacts cost, maintenance, and cleaning requirements.

- How quickly the clothing can be removed during an emergency. It is recommended that lab coats use snaps or other easy to remove fasteners instead of buttons.

Laboratory personnel who are planning experiments that may require special protective clothing or have questions regarding the best protective clothing to choose for their experiment(s) should contact their EHSO for recommendations.

3.6 Respirators

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 in most laboratory environments. 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 CUNY is governed by the OSHA standards and enforced by PESH. ***A laboratory worker at CUNY may not purchase a respirator and bring it to their lab for personal use without prior approval from their EHSO. Please refer to your college's respiratory protection program or consult with your EHSO.***

The following are situations where respiratory protection would be appropriate for laboratory workers (after consultation with the EHSO):

- 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 your EHS Office to schedule a hazard assessment prior to using a disposable respirator.

- The voluntary use of N-95 respirators in the laboratory is permitted. OSHA requires the following reading: (Mandatory) Information for Employees Using Respirators When not Required Under Standard – 29 CFR 1910.134 Appendix D.

- The use of large volumes of certain hazardous chemicals, such as formaldehyde in a room where dilution ventilation or capture devices will not be able to offer adequate protection.

- Changing out cylinders of hazardous gases. (Additional training is required).

- Cleaning up hazardous chemical spills. (Additional training is required.)

- To reduce exposure to some chemicals to which certain individuals may be or may become sensitive.

- When mixing chemicals that may result in more hazardous vapors from the combination of 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, and thoroughly clean up and decontaminate working surfaces.

There are some situations in which the use of a respirator would be 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.

3.7 Hearing Protection

Hearing protective devices includes earplugs, earmuffs, or similar devices designed to protect your hearing. If occupational noise exposures, as defined by the Occupational Safety and Health Administration (OSHA) General Industry Standard "Occupational Exposure to Noise" Part 1910.95, exceed permissible levels and cannot be reduced through engineering or other controls, then hearing protective devices must be worn.

Contact your EHSO if you have questions about whether you are receiving an occupational noise exposure or would like to request workplace monitoring.

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

3.8 Foot Protection

Laboratory personnel (and other personnel) should wear foot protection at all times in laboratories, laboratory support areas, and other areas with chemical, biological and physical hazards are present. This is because of the potential exposure to toxic chemicals and the potential associated with physical hazards such as dropping pieces of equipment or broken glass being present. In general, shoes should be comfortable, and leather shoes are preferable to cloth shoes because of the better chemical resistance of leather compared to cloth. 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. **P.I.s and laboratory supervisors are strongly encouraged 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.

4.0 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 that laboratory workers are protected against exposure to physical hazards and hazardous chemicals as outlined in the Laboratory Standard.

It is the responsibility of the P.I. and laboratory supervisor to ensure that personnel working in laboratories under their supervision follow laboratory specific, departmental, and campus-wide policies and procedures covered in this Laboratory Safety Manual.

***While this Laboratory Safety Manual provides the minimum requirements and recommendations to meet the intent of the Laboratory Standard, colleges, departments, P.I.s, and laboratory supervisors have the authority to implement more stringent policies within laboratories under their supervision and are encouraged to do so.

4.1 Standard Operating Procedures

The Laboratory Standard requires that Chemical Hygiene Plans include specific elements and measures to ensure employee protection in the laboratory. One such element is the establishment of 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 be supplemental information included as part of research notebooks, experiment documentation, or research proposals. The requirement for SOPs is to ensure that a process is in place to document and addresses relevant health and safety issues as part of every experiment.

At a minimum, SOPs should address:

- The chemicals involved and their hazards.
- Special hazards and circumstances.
- The use of engineering controls (such as fume hoods).
- Required PPE.
- Spill response measures.
- Waste disposal procedures.
- Decontamination procedures.

- A 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 high voltage equipment

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

- "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 MSDS located in the MSDS binder. Read the MSDS before using this chemical."
- "When using chemical X, wear safety goggles, nitrile gloves, and a lab coat."

Your EHS Office can assist laboratories with developing SOPs. Because of the variety of research and the large number of laboratories throughout the CUNY system, it is the responsibility of each laboratory, department, and college to ensure that SOPs are developed and that the practices and procedures are adequate to protect lab workers who use hazardous chemicals.

It is the responsibility of the P.I. and laboratory supervisor to ensure that 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 exposure. In addition, P.I.s and laboratory supervisors must ensure that personnel working in laboratories under their supervision have been trained to use these SOPs.

4.2 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, but provide a 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 because of 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 may also reduce the overall liability for the P.I., the laboratory supervisor, and the college. Procedural controls are fundamental to instilling safe work behavior and helping to create a culture of safety within the laboratory environment.

4.3 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, and trash cans.
- Keeping all containers of chemicals closed when not in use.
- Cleaning up all chemicals spills immediately, regardless of whether the chemical is hazardous or not. When cleaning up a chemical spill, look for any splashes that may have resulted 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 and devices clean and free of clutter. This includes items such as eyewash/emergency showers, electric power panels, fire extinguishers, and spill cleanup supplies.
- Keeping a minimum of three feet of clearance (as required by FDNY codes) between benches and equipment. Exits must be clear of obstacles and tripping hazards such as bottles, boxes, equipment, and electric cords. Combustible materials may not be stored in exits (including corridors and stairways), exit enclosures, boiler rooms, mechanical rooms, or electrical equipment rooms.
- When storing items overhead, keep heavier and bulkier items closer to the floor. FDNY prohibits any type of storage within 18 inches (457 mm) of sprinkler head deflectors in areas of buildings protected by a sprinkler system and within 24 inches (610 mm) of the ceiling in non-sprinklered areas (see Fire Code §315.2).
- Always use a stepladder when reaching for overhead items; do not stand on chairs or countertops. If you do not have a stepladder available, contact Facilities Management.

In summary, good housekeeping has obvious health and safety benefits and can lead to increased productivity. During an inspection by a federal, state, or local 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 P.I.s and laboratory supervisors to ensure that laboratories under their supervision are maintained in a clean and orderly manner and that personnel working in the lab practice good housekeeping.

4.4 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 can prevent chemical exposure.

Recommended personal hygiene guidelines include:

- Do not eat, drink, chew gum, or apply cosmetics in a lab or other area where chemicals are used.
- Do not store food or drink in refrigerators that are used to store chemicals.
- Never start a siphon or pipette by mouth. Doing so 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.
- Shorts and sandals should not be worn in a lab when anyone is using corrosives or other chemicals that present a skin contact hazard, or where there is the potential for physical hazards such as dropping pieces of equipment or broken glass.
- Wear a lab coat whenever working with hazardous materials.
- Remove laboratory coats, gloves, and other PPE immediately when chemical contamination occurs. Failure to do so could result in chemical exposure.
- After removing contaminated PPE, be sure to wash any affected skin areas 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 not 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 touching items such as the phone, doorknobs, or elevator buttons.

- Always wash lab coats separately from personal clothing. Be sure to identify contaminated lab coats to commercial laundry facilities to help protect their workers. Place the contaminated lab coat in a separate plastic bag and clearly identify the bag with a note or label indicating the lab coat is contaminated.

- Smoking is prohibited in indoor areas on all CUNY campuses.

4.5 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 thus 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. Cosmetics have the ability of absorbing chemical vapors, dusts, and mists from the air and when applied to the skin and 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 where 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, freezers, microwave ovens, and food processors should be properly labeled. For example, 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 evident 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.

4.6 Working Alone

In Appendix A of OSHA standard 29 CFR 1910.1450, the National Research Council (NRC) recommends the following in terms of working alone in the laboratory:

> "Avoid working alone in a building; do not work alone in a laboratory if the procedures being conducted are hazardous."

Although the Council's recommendations are not mandated by OSHA, laboratory supervisors and P.I.s are strongly encouraged to follow them. Whenever possible, laboratory personnel should avoid working alone when conducting research, especially when experiments involve hazardous substances and procedures. In addition, the FDNY requires that any ongoing laboratory operation be under the personal supervision of a C-14 Certificate of Fitness holder (Certificate of Fitness for the Supervision of Chemical Laboratories). Therefore, anyone working alone must have a C-14 Certificate of Fitness. Laboratories should establish specific guidelines and SOPs 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 P.I. or laboratory supervisor**.

If a laboratory worker determines that 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 (e.g., every 15 – 30 minutes) to ensure that no accidents have occurred. This could be accomplished by physically walking to the engaged laboratory, by phone, or by CCTV. If the person working alone is engaged in highly hazardous work, the person checking on the lab worker should not enter the room unless they are properly trained and equipped.

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 the campus Office of Public Safety 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 make an effort to complete the experiment in a safe manner and notify the campus Office of Public Safety upon completion of the experiment. **Under no circumstances should a campus public safety officer be used in place of a "lab buddy."**

PLEASE NOTE: For rooms that are locked because of security needs, prior arrangements are required to facilitate buddy access. Be aware that emergency responders and/or campus public safety may not always have immediate access to locked doors, which could result in a delay in response in the event of an emergency. If the door to the lab does not have a window, or if the window is covered, there is a chance that if something happened to a person working alone

in a locked lab, they may not be discovered until someone else from the lab goes into the room.

Examples of activities where working alone would be understandable include:

- Office work such as writing papers, calculations, computer work, and reading.
- Housekeeping activities such as general cleaning, reorganization of supplies or equipment, 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 that are part of a standard operating procedure that 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 those with 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 class 4 LASERS.
- Transfer of large quantities of flammable materials, acids, bases, or other hazardous materials.
- Changing out compressed gas cylinders containing hazardous materials.

It is the responsibility of P.I.s and laboratory supervisors to ensure that procedures for working alone are developed and followed by personnel working in laboratories under their supervision. The P.I. shall be aware at all times of all work being performed in the laboratory and shall ensure that at least one holder of a Certificate of Fitness for the Supervision of Chemical Laboratories (C-14)be present while the laboratory is in operation.

4.7 Phones in Labs

All labs are strongly recommended to have a means of communication in the event of an emergency. This can include a "landline" phone, cell phone (if service is available), or two-way radio. If a phone is not available within the lab, it is advisable to post a sign and/or map indicating where the nearest phone is located.

4.8 Unattended Operations

Whenever it is necessary to have unattended operations occurring in a lab, it is important to ensure that 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. The guidelines were taken from Appendix A of OSHA standard 29 CFR1910.1450 and/or *Prudent Practices in the Laboratory.*

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, or explosion.)
- The name of the person conducting the experiment and a contact number as well as a secondary name and contact number (most likely the P.I.).

When setting up an experiment that will be left unattended, try to anticipate 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 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 or over-temperature shut off.
- Use emergency power outlets for those pieces of equipment that could be negatively affected in the event that utilities are interrupted.
- Equipment should always be inspected to ensure that it is in proper working order prior to leaving an experiment unattended.

It is the responsibility of P.I.s and laboratory supervisors to ensure that procedures for unattended operations are developed and followed by personnel working in laboratories under their supervision. The P.I. should be aware at all times of all work being performed in her respective laboratory.

4.9 Access to Laboratories

Because of potential hazards, access to CUNY laboratories, workshops, and other work areas housing hazardous materials or machinery is restricted to CUNY faculty, staff, students, or other persons on university-related business.

4.9.1 Visitors

As noted above, only visitors participating in a university-sanctioned activity (e.g., tour, open house, or university-related business) are permitted in hazardous work areas. In these instances, all non-laboratory trained visitors must be under careful and continuous supervision. Check with your EHSO to see if your college has specific procedures or policies in place for visitors.

4.9.2 Visiting Scientists and Other Similar Users

There are potential risks associated with allowing access to labs and equipment by visiting scientists including theft or questions of ownership of intellectual property, bodily injury, and property damage. Colleges and units 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 visitor's responsibility to have or obtain the appropriate training.

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

4.9.3 Pets in Labs

In general, P.I.s and laboratory supervisors are strongly encouraged to restrict access of pets in the laboratory. Please refer to your college's specific policy regarding building and lab access for pets.

4.10 Chemical Purchasing

Before ordering new chemicals, search your existing inventories and use those chemicals currently in stock. An accurate and up-to-date chemical inventory can help to minimize purchase of chemicals already on hand and can facilitate acquisition of Material Safety Data Sheets (MSDS). CUNY has an institutional subscription to the Chemtracker chemical inventory system that can help facilitate maintaining a chemical inventory. If you are interested in learning more about the Chemtracker system, contact your EHS office.

If it is necessary to purchase new chemicals, laboratory personnel should order only the minimum required to carry out the experiment. Avoid ordering larger quantities simply because the chemical "might be needed in the future." Try to take advantage of chemical vendor's "Just-In-Time" delivery rather than stockpiling chemicals in your lab. Before ordering chemicals, be sure to check CUNY purchasing guidelines.

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 or 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, floors, and buildings at a time. For more information, contact your EHS Office.

4.11 Ordering New Equipment

Whenever new equipment is planned for purchase and installation in laboratories, especially equipment that must be connected to the building utility services such as electric, water, or gas, laboratory personnel must first consult with Facilities Management and their EHS Office to ensure that the building can support the new piece of equipment. Lab personnel should not assume they can purchase equipment first and then expect the building to accommodate them. By preplanning and communicating well in advance with appropriate campus groups (such as Facilities Management and your EHSO), potential issues may be identified ahead of time, which in turn may help make the transition smoother.

Additionally, as with installation of fume hoods, certain pieces of equipment require special installation because of their potential impact on the rest of the building ventilation system and utilities, and cannot be connected by laboratory personnel, building managers, or private contractors without first consulting with Facilities Engineering and the EHSO. Laboratory personnel are strongly encouraged to be proactive and to consult with the appropriate departments before purchasing new pieces of large equipment.

Laboratory personnel are encouraged 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” ratings and alternatives. For more information, see Energy Conservation in Laboratories.

4.12 Work Orders and Ticket Requests

In the event of a maintenance issue or if equipment repairs are needed, laboratory personnel should first consult with the manufacturer and their service contract. Because of NYC building codes, laboratory personnel must not try to repair utility services (such as electrical, plumbing, or gas issues) by themselves. These repairs must be handled by qualified personnel only.

Whenever maintenance workers will be working on your fume hood system or in your laboratory, please remove all chemicals, laboratory apparatus, and equipment from the area requiring maintenance work. Ensure that 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.

4.13 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 for another university, or when facility renovations take place. When changes in lab occupancy are planned, 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.

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:

- Notify your department chairperson and lab supervisor well in advance of the planned move.
- Ensure that all chemical containers are properly labeled.
- Properly dispose of any hazardous and chemical waste left in the laboratory.
- Ensure that all chemical spills and contamination has been cleaned up.
- Review the Lab Move Guide.

4.14 Laboratory Design and Construction

To provide the best service during the construction/renovation process for laboratories, it is important to take health and safety considerations into account during the design process, well BEFORE construction begins. If you are planning lab construction or renovation, please contact the Chemical Hygiene Officer and EHSO with the following information:

- Contact name, phone number, email
- Department, building and room(s) the project will occur in
- Expected start date for project
- Equipment to be installed, such as fume hoods, biosafety cabinet, other capture devices, eyewash and emergency shower, toxic gas cabinet and monitoring devices.
- NOTE: A list of chemicals, including approximate usage (weekly/monthly) and storage quantities will be needed during the process to ensure proper ventilation rates and engineering controls.
- If you are planning to vacate your laboratory, please see the Lab Move Guide before you begin your move.

All NYC Building and Fire Codes (e.g. Section 2706 of the FDNY Fire Code entitled "Non-production Chemical Laboratories") must be followed for new construction and renovation. Consult with CUNY Facilities, Planning, Construction and Management (FPCM) for additional details.

4.15 Ventilation Rates

Ventilation rates for laboratories are determined based on the occupancy and the type of research being conducted. Whenever the function of a room changes, it is very important to notify your EHS Office of the change. The EHSO will then verify if the ventilation rate for a given room is appropriate for the type of research being conducted.

4.15.1 Room Air Pressure in Labs

Laboratory personnel should occasionally check to ensure that there is negative air pressure in their labs with respect to the hallway. This means the fume hood is operating properly by removing more air from the room than that is being supplied to the lab. When positive air pressure occurs, more air is being supplied to the room than that is being removed by the fume hood. This can result in air from the laboratory (including chemical vapors and dusts) being blown out into the hallway outside of the lab and can negatively affect the performance of the fume hood. This can also result in chemical odors permeating the hallways and surrounding rooms.

The following steps can be taken to ensure that there is a negative air pressure in the laboratory:

- Ensure that the entrance door to the laboratory is closed. You may want to hang a sign on the outside of the door indicating that people should knock before entering to avoid someone opening the door while you are performing this test.

- Carry a bowl of water over to the entrance door and place it on the floor right next to the door.

- Add dry ice to the bowl of water as specified in the dry ice test procedure from the ANSI/American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE) standard 110-1995

- Slowly move the bowl along the floor and the edge of the door while observing the path of the dry ice vapors. Carefully pick up the bowl and move it along the edges of the door while continuing to observe vapors.

- If the dry ice vapors flow into the laboratory, then the room is under proper negative air pressure. If the dry ice vapors flow underneath the door and between the door and doorframe and into the hallway, then the lab is improperly under positive air pressure.

- If you discover your lab to be under positive air pressure, please contact Facilities Management or your EHSO for assistance.

4.16 Energy Conservation in Laboratories

Laboratories are well 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 tap 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 very substantial energy savings in recently constructed lab buildings. However, many of these energy saving improvements are only fully effective if the people working in the 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:

- Turn off equipment when not in use, disconnecting power as close to the source as possible (e.g., turn off at power strip or unplug from wall outlet). Use timers and automatic shutoffs if practical to do so.
- Fume hoods are a major energy consumer.
  - Keep the sash closed whenever possible, especially with Variable Air Volume (VAV) hoods.
  - Regularly inspect fume hoods. Adjust hood fans to reduce the throughput volume to the lowest velocity of air flow required.
  - Use appropriately designed storage cabinets rather than fume hoods to store chemicals and equipment.
- Open refrigerators and especially deep freezers used to store specimens sparingly and for as short of time as possible.
- Regularly defrost appliances and keep a clear perimeter of at least one foot to facilitate air flow and efficiency.
- Buy energy efficient equipment. Look for the Energy Star logo or other statements that an electrical device is designed to be energy efficient.
- When purchasing natural gas powered or consuming devices, buy equipment that uses an electronic ignition instead of a pilot light. Pilot lights waste more than 20% of the gas used in the United States.
- Keep rooms an acceptable temperature by adjusting thermostats accordingly. Rooms that are too hot or too cool may have faulty thermostats or other controls that are malfunctioning or have drifted from set points, resulting in wasted energy as well as uncomfortable conditions. If you experience these problems, contact Facilities Management for assistance.
- Use shades and blinds as provided to help keep your space cool on sunny days. The shade can reduce the amount of cooling required in a south or west facing room by more than 30%.
- Computers and associated equipment such as monitors consume substantial amounts of electricity. Researchers should turn them off overnight and place them in standby or "sleep" mode for shorter periods of inactivity such as when they attend a meeting or seminar.
- Turn off lights when lab is unoccupied. Use small area lamps whenever possible.

WHEN ATTEMPTING TO CONSERVE ENERGY IN THE LABORATORY, NEVER JEOPARDIZE THE HEALTH AND SAFETY OF YOURSELF OR YOUR COLLEAGUES.

You can find additional information on selecting energy efficient products on the U.S. Environmental Protection Agency's (EPA) Pollution Prevention website for Green products and 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.

4.17 Research Area Inspections

Laboratories and other research areas are regulated by OSHA laboratory safety standards and general industry regulations; EPA, DEC, and DEP hazardous waste regulations; DOHMH regulations; NFPA and FDNY life and fire safety standards; and NYC building codes. Additionally, accreditation and granting agencies such as the CDC, NIH, and USDA are increasing scrutiny over researchers and their compliance with federal and state laws. To assist researchers to be in compliance with these regulations and standard, your EHS Office will conduct required inspections of all campus research areas.

The purpose of the inspections is to assist responsible faculty and staff members in identifying and correcting potential regulatory compliance issues or other issues that could affect granting activities, and identify potential health and safety hazards that could pose an unreasonable risk to laboratory personnel, students, and the campus community. The EHSO will schedule inspections by working with college-level contacts, Facilities Management, and staff throughout the college's departments and buildings. Research areas are strongly encouraged to conduct their own self inspections prior to the EHSO inspection to address any potential issues and to provide a training opportunity for research staff.

4.17.1 Self Inspections

An important part of any research safety program is implementation of self inspections. Self inspections provide a number of useful benefits and 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 federal and state regulations.
- Identifying and addressing any potential issues before an inspection by a federal and state regulatory agency.
- Providing an opportunity for lab specific training by identifying potential issues within the lab and then training lab personnel to look for these issues.
- Serving as a regular health and safety check of laboratory facilities.
- Serving as a vehicle for addressing faculty, staff, and student concerns.

The following frequency for self inspections is recommended:

- On a daily basis lab personnel should maintain good housekeeping inspections within their lab.
- Informal weekly lab walkthroughs or “Friday afternoon cleanups.”
- Ideally, self inspections should occur at least once per month. These could include participation of research staff and/or safety committee members, and use of an inspection checklist (see Appendix G)
- At least once per semester research personnel should perform a formal self inspection

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 liability by identifying potential issues and provide lab personnel the opportunity to look for and correct potential issues.

4.17.2 Inspections by Regulatory Agencies

Inspections by federal and state regulatory agencies can occur at any time and can result in citations and significant fines for the University. The best way to be prepared for these inspections is to understand what regulations apply to your area and what you need to do to comply with those regulations. You can obtain this information from resources such as this Laboratory Safety Manual, by conducting your own self inspections, and by contacting your EHSO.

If a federal and state inspector arrives at your work area unescorted, politely ask them to wait and contact your EHSO immediately.

4.18 Laboratory Security

Laboratories must provide security against theft of highly hazardous materials, valuable equipment, and ensure compliance with federal, state, and local regulations. The EHSO will work with each unit (college, department, and research group) to review and develop procedures to ensure that the security of all hazardous materials.

Many laboratories already implement various means of security, including requirements to lock up controlled substances, syringes and needles, and radioactive materials. Be sure to review and assess the hazardous materials in your laboratory and consider security issues in protecting those materials.

*****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.**

4.18.1 Security Guidelines

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

- Recognize that laboratory security is related to, but different from laboratory safety. Security is preventing intrusion into the laboratory and the theft of equipment or materials from the lab.

- Develop a site-specific security policy. Make an assessment of your laboratory area for hazardous materials and particular security issues. Then develop and implement lab security procedures for your lab group and train lab group members on security procedures and on their assigned responsibilities.

- Control access to areas where hazardous chemicals are used and stored. 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 P.I.

    - 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.

- Know who is in the laboratory area at any given time. Consider using a logbook for staff to sign in and out each day or use carded access devices. Also consider having all lab staff wear identification tags. Approach anyone whom you don't recognize wandering in laboratory areas and hallways and ask if you can help direct them. Don't hesitate to call Public Safety if you have any concerns.

- Secure your highly hazardous materials. Consider using a log to sign hazardous materials in and out of secure storage and be sure to take a 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 nothing is missing. Laboratories must maintain a chemical inventory through ChemTracker or some other means. Report any missing inventory to the Office of Public Safety 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 track the use and disposal of hazardous materials in accordance with EPA's Recovery and Resource Conservation Act (RCRA).

- Develop an emergency plan and protocols for reporting incidents. Control of access to laboratory areas can make an emergency response more challenging. This must be considered when emergency plans are developed. Laboratory directors, in cooperation with facility safety and security officials, should have SOPs 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 your protocols and emergency plans and update as necessary.

- Be aware of hazardous chemicals that pose a security risk. 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
    - Unusual activities

Many of the laboratory supply catalogs carry information and products such as various locks, lock boxes, and other security devices for chemical storage in laboratories. For more information, you can contact your EHS Office or Public Safety for assistance concerning security devices.

5.0 EMERGENCY PREPAREDNESS

Emergencies can occur at any time and without warning. Careful planning with an emphasis on safety can help members of the CUNY community handle crises and emergencies with appropriate responses and can save lives – including your own. Every member of the CUNY community shares responsibility for emergency preparedness. **In the case of an emergency, please follow your College's Emergency Procedure Manual** and contact your EHSO and Public Safety. Remember: If you are working in your laboratory, during off-hours, please make sure that you notify Public Safety. Public Safety Officers are on duty 24 hours a day, 365 days a year.

5.1 CUNY Emergency Response and Recovery Plan

The effectiveness of the CUNY Emergency Response and Recovery Plan is dependent on the development of a comprehensive central plan and individual college/unit plans as outlined in the University Emergency Response and Recovery Plan. The University expects each college to develop an overall college emergency procedure manual as well as individual emergency procedure manuals for each building. The manuals must include a chain of command establishing the authority and responsibilities of campus officials and staff members, and requires that colleges, divisions, and individual departments designate emergency coordinators with the authority to make modifications in emergency procedures and to commit resources for emergency preparedness and recovery, as necessary.

5.2 Emergency Procedures

Emergencies can include both fire and non-fire emergencies. Fires are an "expected" emergency in all lab situations and almost all lab staff are trained on emergency steps in the event of a fire. "Non-fire" emergencies can include:

- Loss of electricity, heat, 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 (from the lab down the hall or an explosion one-half mile away).
- Terrorist actions or civil unrest.

5.2.1 Emergency Evacuation Procedures

Building occupants are required by law to evacuate the building when the fire alarm sounds (Pursuant to RNYC §27-4267 and FDNY Regulations). Evacuation directions, fire alarm locations and escape routes are required to be posted throughout the building at the base of stairways, elevator landings, and inside public doors. Also listed should be the specific location(s) of the building's designated evacuation meeting points.

Buildings designated with Class E occupancy code must have a fire safety plan on file with the FDNY. Additional information concerning Class E building fire code requirements can be found in the CUNY College Emergency Procedures Manual.

When evacuating a building or work area, please follow these procedures:

- Remain calm.
- Safely stop work.
- Gather personal belongings only if it is safe to do so. [Reminder: take prescription medications, as it may be hours before occupants are allowed back into the building.]
- Assist persons with disabilities.
- If safe, close the office door and window, but do not lock them
- Use the nearest safe stairs and proceed quickly to the exit. **Do not use the elevator.**
- Proceed to the designated evacuation meeting point.
- Wait for instructions from emergency responders.
- **Do not re-enter the building or work area until instructed to do so by the emergency responders.**

5.2.2 Laboratory Emergency Shutdown Procedures

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 contents of the plan and in response to a non-fire emergency. Below is a set of simple steps for the shutdown of labs in non-fire emergency situations. These and other steps, specific to characteristic requirements of the facility should be included in the emergency response plan. This list is by no means complete, but it gives laboratory personnel simple steps to facilitate a safe lab shutdown.

- Close fume hood sashes.

- Be certain that the caps are on all bottles of chemicals.

- Turn off all non-essential electrical devices. Leave refrigerators and freezers on and make sure that the doors are closed. Check the disconnects of large LASERs, radio frequency generators, NMRs, etc. It may be necessary to check to ensure that essential equipment is plugged in to the power outlets supplied by the emergency generator (usually orange or red).

- Turn off all gas cylinders at the tank valves.
  PLEASE NOTE: If a low flow of inert gas is being used to "blanket" a reactive compound or mixture, 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/moistureless reactions, and all reactions in progress. Be prepared to terminate all reactions that are in progress, based on the known scope of the emergency.

- If experimental animals are in use, special precautions may have to be taken to secure those areas such as emergency power, alternative ventilation, and other essential support.

- All non-essential staff/students must leave the building. Depending on the nature of the emergency, some staff may have 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.

5.2.3 Medical Emergency Procedures

CALL PUBLIC SAFETY OR 911 IN ANY EMERGENCY THAT REQUIRES IMMEDIATE POLICE, FIRE, OR MEDICAL RESPONSE TO PRESERVE A LIFE. If 911 is called, be sure to alert Public Safety so they can coordinate the response.

- 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. Do not, however, move the victim unnecessarily, and do not delay in obtaining trained medical assistance if it is safe to do so.

- Notify First Responders of the location, nature, and extent of the injury by calling Public Safety or 911 or by using a Blue Light security system or Emergency Telephone. Always call from a safe location.
- Provide first aid until help arrives if you have appropriate training and equipment and if it is safe to do so.
- Send someone outside to escort emergency responders to the appropriate location, if possible.

5.2.4 First Aid Kits

Although there are work areas throughout CUNY that could be considered hazardous, there are no legal requirements to support first aid kits in work spaces within the campus buildings, according to OSHA (29 CFR 1910.151) and the ANSI Standard (Z308.1-1998). **Your EHSO should be consulted before placing first aid kits in your work area.**

If your EHSO gives you approval to have a first aid kit in your work space, then there are some additional requirements to address. The kit must contain items appropriate to mediate an injury that could happen in your work area. There must also be a trained, responsible person in your work space, and their contact information must be posted on the kit. The kit should be maintained and refilled after use. An Injury/Illness report should be completed when a first aid kit is used because of an injury/illness in a CUNY laboratory.

The ANSI Standard lists the following minimum fill requirements for a first aid kit:

- 1 - absorbent compress, 4 x 8 in. minimum
- 5 yards adhesive tape
- 10 - Antiseptic applications, 0.14 fl. oz. each
- 1 - triangular bandage, 40 x 40 x 56 in. minimum
- 16 - adhesive bandages, 1 x 3 inch minimum
- 2 - pairs of medical exam gloves
- 4 - sterile pads, 3 x 3 in. minimum
- 6 - burn treatment applications, 1/32 oz. each

Your EHSO can provide information on where to obtain the appropriate training if you choose to keep a first aid kit in your work space.

5.2.5 Fire or Explosion Emergency Procedures

All fires must be reported to the Office of Public Safety, including those that have been extinguished. Do not hesitate to activate the fire alarm if you discover smoke or fire. In the case of a fire or explosion, follow the procedures below.

- 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 a fire alarm by pulling on an alarm box.
- Notify first responders of the location and size of the fire by calling Public Safety or 911 or by using a Blue Light emergency box or Emergency Telephone. Always call from a safe location.
- Evacuate the building using the Emergency Evacuation Procedure. Do not use elevators to evacuate unless directed to do so by emergency responders.
- Notify emergency responders of the location, nature, and size of the fire once you are outside.

If you have been trained and it is safe to do so, you may attempt to extinguish the fire with a portable fire extinguisher. Attempt to extinguish only small fires (a fire no bigger than the width of a waste basket and no higher than one's knees) and make sure you have a clear escape path. Consult the Building Emergency Procedure Plan for additional information.

If clothing is on fire:

- **Stop, drop** to the ground or floor, and **roll** to smother flames.
- Smother flames using a fire blanket.
- Drench with water from a safety shower or other source.
- Seek medical attention for all burns and injuries.

5.2.6 Fire Extinguishers

- All fire extinguishers must be inspected annually.

- Laboratory personnel should perform regular visual checks (***at least on a monthly basis***) to ensure that fire extinguishers present in their labs are fully charged. For those fire extinguishers with a dial, labs must ensure that the indicator arrow on the dial is within the green zone. If the indicator arrow is on either side of the green zone, which indicates a problem, contact your EHSO to have the fire extinguisher replaced.

Any fire extinguisher that has been used at all, even if it was not fully discharged, must be reported to the EHSO so that a replacement fire extinguisher can be provided in its place. You can obtain training in using a fire extinguisher from your EHSO.

5.2.7 Power Outage Procedures

In the case of a power outage, follow the procedures below.

- Assess the extent of the outage in the unit's area.
- Report the outage to Public Safety.
- 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 unit's 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.
- If needed, open windows (in mild weather) for additional light and ventilation unless it is problematic to do so, such as in a BSL2 lab.

5.3 Chemical Spill Procedures

When a chemical spill occurs, it is necessary to take prompt and appropriate action. The type of response will depend on the quantity of the chemical spilled and the severity of the hazards associated with the chemical. The first action 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 the EHSO. **Only individuals that are trained and equipped with the proper spill cleanup materials and PPE should attempt to clean up incidental spills.**

5.3.1 Incidental Spills

PLEASE NOTE: The following advice is intended for spills that occur within a campus building. A release to the outside environment may require the college to file a report with the responsible government agency. The EHS office can make this determination.

The following criteria must be met for a spill to be considered incidental:

<u>Physical</u>:

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

Equipment:

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

5.3.1.1 Incidental 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). The first priority is to always protect yourself and others.

2) Put on the proper personal protective equipment (PPE) such as goggles, gloves, respiratory protection, etc. before beginning cleanup.

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 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 be absorbed. 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 residue in a leak-proof container.

9) For acid and base spills, transfer the absorbed materials to a sink and complete the neutralization prior to drain disposal.

10) For absorbed hazardous chemicals, label the container and dispose of through the hazardous waste management program.

11) If possible, mark the area of the spill on the floor with chalk.

12) Wash the contaminated surface with soapy water. If the spilled chemical is highly toxic, collect the rinsate for proper disposal.

13) Report the spill to your supervisor, Public Safety, and the EHS office immediately.

14) Restock any spill cleanup supplies that you may have used from any spill kits.

5.3.2 Spill Absorbent Materials

PLEASE NOTE: The following materials are recommended spill absorbent materials; however, they are not appropriate for every possible chemical spill. When in doubt, contact your EHSO for advice.

<u>For acid spills (except Hydrofluoric acid)</u>:

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

<u>For Hydrofluoric acid (HF) spills</u>:

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

<u>For liquid base spills</u>:

- Use Citric Acid or similar weak acid to lower the pH sufficiently for drain disposal.

<u>For oil spills</u>:

- Use ground up corn cobs, vermiculite, or absorbent clay (kitty litter).
- <u>For most aqueous solutions</u>:
- Use ground corn cobs

<u>For most organic liquid spills</u>:

- Use ground corn cobs.

<u>For oxidizing liquids</u>:

- Use absorbent clay, vermiculite, or some other nonreactive absorbent material. Do not use paper towels. [Note: Most nitrate solutions will not oxidize sufficiently for this requirement.]

For mercury spills:

- Do not dispose of mercury or mercury contaminated spill debris in the regular trash or down the drain. **Never pour laboratory chemicals down the drain.**
- There are no absorbent materials available for mercury. Physical removal processes are best for removing and collecting mercury.
- If you need help collecting Mercury from a spill, contact your EHS Office. [Note: While powdered sulfur will help reduce mercury vapors, the sulfur greatly complicates the spill cleanup.]

5.3.3 Spill Kits

While commercial spill kits are available from a number of safety supply vendors, laboratory personnel can assemble their own spill kits to clean up chemicals specific to their laboratory. Whether commercially purchased or made in-house, all laboratories must obtain a spill kit for their use. Colleges and departments should give serious consideration to distributing basic spill kits to all laboratories within their units.

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 ground-up corn cobs – for most aqueous and organic liquid spills.
- 1-5 lbs of absorbent clay (kitty litter) - for oils or oxidizing liquids.
- 1-5 lbs of Sodium bicarbonate - for liquid acid and base spills.
- 1-5 lbs of Calcium carbonate or Calcium bicarbonate - for HF spills.

Equipment in the spill kit could include:

- Wisk broom and dust pan (available at home improvement stores)
- Sponge
- pH paper
- 1 gallon and 5 gallon bags - for collection of spill cleanup material
- Small and large self-sealing bags – for collection of spill cleanup material or to enclose leaking bottles/containers.
- Safety goggles
- Thick and thin nitrile gloves
- Hazardous waste labels

The spill kit should be clearly labeled as “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.

<u>Laboratory personnel must also be properly trained on:</u>

- How to determine if they can or should clean up the spill, or if they should call the EHS office, Public Safety, or outside assistance.
- 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.

For more information regarding assembling a spill kit or training in spill cleanup, contact your EHS Office.

5.3.4 Major Spills

A major spill is any chemical spill for which the researcher determines the need for outside assistance to clean up the spill safely. In the case of a major spill, contact your EHS Office and Public Safety.

5.3.4.1 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 or 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 people or yourself.
- Evacuate any nearby rooms that may be affected. If the hazard will affect the entire building, evacuate the entire building by pulling the fire alarm.
- Notify your EHS Office and Public Safety. Always call from a safe location.

Be prepared to provide first responders with the following information:

- Where the spill occurred (building and room number).
- If there are 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 and when you will meet with emergency responders, either in person or by the phone.

Once outside, notify emergency responders of the location, nature and size of the spill. Isolate contaminated persons and protect yourself and others from chemical exposure.

5.4 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 Z358.1-2004 - Emergency Eyewash and Shower Equipment provides additional guidance by 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. 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 your EHSO.

PLEASE NOTE: Because of the flow requirements outlined in the ANSI standard, hand held bottles do not qualify as approved eyewashes.

5.4.1 Testing and Inspection of Emergency Eyewash and Showers

The ANSI Standard provides guidance that plumbed emergency eyewash and safety showers should be activated **weekly** to verify proper operation and inspected annually. Regular activation (weekly flushing) ensures that 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 recommended to allow the water to run for at least 3 minutes. Laboratories are strongly encouraged to post an “Eyewash Testing Sheet” near the eyewash to keep track and document that weekly activation and annual inspections are occurring. Check with your EHSO for the location of the emergency shower test kit and for any additional instructions.

It is the responsibility of laboratory personnel to activate (flush) units on a weekly basis*. *Annual inspection and testing should be conducted in accordance with FDNY Fire Code §2706 and Fire Code §105.3.8.

Laboratories are responsible for ensuring that access to eyewashes and emergency showers are 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 could result in dust or other particles being forced into the eyes when the eyewash is used.

Always report any malfunctioning eyewashes and emergency showers to Facilities Management immediately to request that the unit be repaired. If either the emergency shower or eyewash is not working properly, let other people in the lab know by hanging up a "**Do Not Use**" sign on the unit.

Your EHSO will perform inspections of eyewashes and emergency showers to test for compliance with ANSI Z358.1-2004 including:

- Test the water flow for proper quantity, spray pattern, and water quality;
- Ensure that the unit is the proper height from the floor;
- Ensure that the unit is not obstructed;
- Ensure that the unit has a tempering valve (If the unit does not have a tempering valve, this will be identified as a recommended repair in the inspection report);
- Ensure that valves are working properly;
- Ensure that signs are posted; and
- Ensure that the unit is free of corrosion.

5.4.2 Installation of New Emergency Eyewash and Showers

Please contact the EHSO whenever a new emergency shower or eyewash has been installed in your lab so the unit can be added to the EHS inventory and included as part of the annual eyewash and emergency shower inspection program. For more information, see the Laboratory Design and Construction section in this manual or contact your EHS Office.

5.4.3 Using Emergency Eyewash and Showers

Always preplan your experiments and determine what you will do in case of an emergency. Always identify the locations of the nearest emergency shower and eyewash before working with hazardous chemicals.

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

Eyewashes

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.
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 to get 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! For accidents involving Hydrofluoric acid, follow the special Hydrofluoric acid precautions.
6) If you are alone, call Public Safety or 911 after you have finished flushing your eyes for at least 15 minutes.
7) Seek medical attention.
8) Complete an Injury/Illness Report.

If someone else in the lab needs 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 Public Safety. After calling, 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 precautions.
5) If you are alone, call Public Safety or 911 after you have finished flushing for at least 15 minutes.
6) Seek medical attention.
7) Complete an Injury/Illness Report.

If someone else in the lab needs 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 and then call Public Safety. After calling, 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.

PLEASE 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 the 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 consult with your EHS Office to see if the rinsate must be collected as hazardous waste.

5.5 Injury/Illness Reporting

All accidents and injuries, no matter how minor, must be reported to campus officials through the college's incident reporting system. The supervisor of an injured employee, the department head, or a designated individual within the department must complete all sections of this form within **24 hours** after the injury is first reported and submit to Public Safety.

5.6 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. In such an event, the employee shall be provided an opportunity for a medical consultation. The

consultation shall be for the purpose of determining the need for further medical examination.

More information on action levels and Permissible Exposure Limits can be found on the OSHA Health and Safety topics page – Permissible Exposure Limits.

5.6.1 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 Material Safety Data Sheet (MSDS) for the chemical(s);
- A description of the conditions under which the exposure occurred including quantitative exposure data, if available; and
- A description of the signs and symptoms of exposure that the employee is experiencing, if any.

5.6.2 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;
- 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; and
- 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 the college health center in accordance with 12 NYCRR section 801 and administrative instructions 901.[4] Exposure monitoring records of contaminate levels in laboratories will be maintained at the EHS Office of each campus. For more information, contact your EHSO.

[4] New York State promulgated and adopted an alternative approach to recordkeeping requirements from that in the OSHA Lab Standard

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6.0 EMPLOYEE INFORMATION AND TRAINING

Federal, state, and local laws require that all laboratory workers receive laboratory safety training and be informed of the potential health and safety risks that may be present in their workplace. In order to assist laboratory personnel comply with this requirement, laboratory safety training must be obtained either through your EHS Office or through an EHSO approved alternative source. Laboratory personnel who attend training classes will have documentation entered and maintained by the EHSO. Laboratory personnel who have not attended EHS-sponsored safety training must submit documentation of training received from the alternative sources for verification by the EHSO.

The OSHA Laboratory Standard requires employers provide employees with information and training to ensure that they are apprised of the hazards of chemicals present in their work area. The Laboratory Standard goes on to state 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 Laboratory Standard, information that must be provided to employees includes:

- The contents of the Laboratory Standard and its appendices (Appendix A and Appendix B).
- The location and availability of the employer's Chemical Hygiene Plan.
- The permissible exposure limits for OSHA regulated substances or recommended exposure limits for other hazardous chemicals where there is no applicable OSHA standard.
- 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, MSDSs received from the chemical supplier.

The Laboratory Standard goes on to state 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.

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

While the OSHA Laboratory Standard is specific to working with hazardous chemicals, laboratory employees must also be provided with the proper training and information related to the other health and physical hazards that can be found in their work environment, including the hazards described within this Laboratory Safety Manual.

It is the responsibility of P.I.s and laboratory supervisors to ensure that 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.

6.1 Training Options

P.I.s and laboratory supervisors have a number of options available to them to ensure that laboratory employees under their supervision have received proper training. These options are described in detail on the following page. They include:

- Training programs provided by your EHS Office;
- Training programs provided by outside vendors;
- In-house training programs (provided by the P.I. or laboratory supervisor);
- Training manuals and booklets; and
- Training videos.

These are requirements of any training program:

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

PLEASE NOTE: One training class is usually not comprehensive enough to cover all of the hazards found within a laboratory. P.I.s and laboratory supervisors may find that it is necessary to use a combination of the options available to ensure that their employees are properly trained.

Description of training options

EHS Sponsored Training Programs.
Your EHS Office offers a number of training programs on a regular basis and offers a number of programs "Upon Request." For any "Upon Request" training class, EHS can come to your building or laboratory and provide the training program for your laboratory group. All EHS-provided training program materials and attendance sheets are kept on file at your EHS Office.

Outside Vendor Training Programs.
P.I.s 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 when 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/or training by P.I.s and laboratory supervisors. Training sessions can be stand-alone classes, on-the-job training, or short training sessions incorporated as part of a laboratory group meeting. The key is to make sure that the training is documented and a sign-in sheet is collected.

Training Manuals and Booklets.
P.I.s 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 and understood the material.

Training Videos.
P.I.s and laboratory supervisors can make use of videos to supplement training of their employees. As with any training, it is important to document that 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 title and running time of the video, in addition to signatures of those people who watched the video.

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7.0 SAFE CHEMICAL USE

Safe chemical use includes minimizing exposure to chemicals, proper training, understanding chemical hazards, proper labeling, proper storage and segregation, proper transport and proper disposal.

7.1 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 your 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 out their experiments in advance. These plans should include the specific measures that will be taken to minimize exposure to all chemicals, 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 must 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.

- Request exposure monitoring to ensure that 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 regardless of 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 air.

- 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 EHS 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. For example, 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 to check your setup prior to each run.

7.2 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." Physical hazards are covered in other sections within this manual.

7.2.1 Chemical Hazard Information

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

It is the responsibility of the P.I. 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, other sources of information on chemical and physical hazards include:

- This Laboratory Safety Manual
- Known reference materials
- Training videos
- Other department's safety manuals
- Material Safety Data Sheets (MSDSs)
- Websites
- EHS Training Programs
- Container labels

- Laboratory Standard Operating Procedures
- Laboratory signage and postings
- Publications such as the American Chemical Society's Safety in Academic Chemistry Laboratories

7.3 Material Safety Data Sheets (MSDSs)

Material Safety Data Sheets (MSDSs) are an important part of any laboratory safety program in communicating information to chemical users. MSDSs 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 MSDS was prepared.

Any chemical shipment received should be accompanied by an MSDS (unless one has been shipped with a previous order). If you do not receive an MSDS with your shipment, check the chemical manufacturers website first (or call the manufacturer directly) or contact your EHSO to request assistance in obtaining the MSDS.

If you have questions on how to read an MSDS, or questions about the terminology or data used in MSDSs, contact your EHSO for more information. Additional information, including how to read an MSDS, can be found in the MSDS FAQ and a glossary of terms used on MSDSs 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 P.I.s 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 MSDSs (and other sources of information) for all hazardous chemicals used in laboratories under their supervision.

MSDSs must be accessible at all times. Access to MSDSs can mean access to paper copies or electronic access via the internet. P.I.s and laboratory supervisors are strongly encouraged to keep paper copies of MSDSs in the laboratory; however, having MSDS websites bookmarked is acceptable as long as all employees in the workplace know where to find the MSDSs and are trained on the use of computers to access MSDSs. If a laboratory chooses to use electronic access, it is recommended that the MSDS website link be posted on the computer or in another conspicuous location.

Please Note: Any accidents involving a chemical will require that an MSDS be provided to emergency response personnel and to the attending physician so proper treatment can be administered. The "rule of thumb" is that a person working in a laboratory should be able to produce an MSDS for any hazardous chemical found in the lab within five minutes.

7.3.1 MSDSs and Newly Synthesized Chemicals

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

The P.I. may need to prepare a MSDS for newly synthesized chemicals. Please consult with your EHSO if you need assistance.

7.4 Routes of Chemical Entry

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

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

7.4.1 Inhalation

Inhalation of chemicals occurs by absorption of chemicals via the respiratory tract. 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 Injury/Illness Report.

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

7.4.2 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. Chemical exposure can also occur by way of indirect ingestion. This can occur when food or drink is brought into a chemical laboratory. The food or drink can then absorb chemical contaminants (vapors or dusts) in the air and result in 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 fails to wear gloves or practice good personal hygiene, such as frequent hand washing, and then leaves the laboratory to eat, drink, or smoke. In these cases, a chemical exposure can result, although the effects of chronic exposure may not manifest themselves 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 by alerting Public Safety and/or calling the Poison Control Center at 1(800) 222-1222.** After receiving medical attention, complete an Injury/Illness Report.

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

7.4.3 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. Symptoms from chemical exposure may occur immediately from direct injection into the bloodstream.

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

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

If you do receive a cut or injection from a chemically contaminated item, take the following steps:

1. Gently try to remove the object;
2. Immediately rinse under water to flush the wound and remove any chemical contamination;
3. Administer first aid;
4. Seek medical attention if necessary; and
5. Complete an Injury/Illness Report.

7.4.4 Eye and Skin Absorption

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

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

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

Symptoms of skin exposure to chemicals include dry, whitened skin, redness, swelling, rashes, blisters, itching, chemical burns, cuts, and defatting. It should be recognized 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 by someone else in the lab.

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

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

PLEASE NOTE: Some chemicals require use of a special antidote and special emergency procedures. Be sure to read MSDSs for any chemical you work with to determine if a special antidote is needed when chemical exposure occurs.

7.5 Chemical Exposure Limits

The Laboratory Standard requires that laboratory employee exposure of OSHA Regulated Substances do not exceed the Permissible Exposure Limits as specified in 29 CFR Part 1010, subpart Z. The Permissible Exposure Limits (PEL) are based on the average concentration of a chemical to which workers can be exposed to over an 8-hour workday, 5 days per week, for a lifetime without observing ill effects. In some cases, chemicals can also have a Ceiling (C) limit, which is the maximum concentration that cannot be exceeded. OSHA has established PELs for over 500 chemicals. Permissible Exposure Limits are legally enforceable.

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

A main point of difference between PELs and TLVs is that TLVs are advisory guidelines only and are not legally enforceable. Both PELs and TLVs can be found in MSDSs. Another good resource for information is the National Institute for Occupational Health and Safety (NIOSH). If laboratory personnel follow the guidelines described within this Laboratory Safety Manual—use fume hoods and other engineering controls, use proper PPE, practice good housekeeping and personal hygiene, keep food and drink out of laboratories, and follow good lab practices—the potential for exceeding exposure limits is significantly reduced.

7.6 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. Your EHSO 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 are exposed to a chemical in excess of OSHA exposure limits, have symptoms commonly associated with exposure to hazardous materials, or work with any of the chemicals listed below, contact your EHSO.

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

- Formaldehyde;
- Vinyl chloride;
- Methylene chloride;
- Benzene; and
- Ethylene oxide.

Other substances that have exposure monitoring requirements include:

- Lead;
- Cadmium; and
- Silica.

7.7 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 to the chemical.

7.7.1 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 are often reversible. An example of acute toxicity is the over-consumption of alcohol and "hangovers."

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

7.7.2 Evaluating Toxicity Data

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

As a general rule of thumb, the lower the LD50 or LC50 number, the more toxic the chemical. Note there are other factors (e.g., concentration of the chemical and frequency of exposure) 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 provide an indication of the toxicity of a chemical, particularly relative to another chemical. For example, when making a decision on what chemical to use in an experiment based on safety for the lab worker, a chemical with a high LD50 or LC50 would be safer to work with, assuming the chemical did not possess multiple hazards and everything else being equal.

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

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

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

7.8 Chemical Labeling

All chemical containers must be labeled properly in order to satisfy OSHA and EPA federal regulations. Proper labeling of chemicals is one way of informing people who work in or enter laboratories of potential hazards that exist, preventing the generation of unknowns, allowing for the correct disposal of wastes, and facilitating emergency responses such as cleaning up spills and obtaining the proper medical treatment.

Most new chemical containers have the proper labeling information on the chemical label. The Laboratory Standard requires that labels on all incoming containers be maintained and not defaced. As part of laboratory good housekeeping and self-inspections, if any chemical labels appear to be falling off, then laboratory personnel should tape the label back on the container or relabel entirely. All personnel working in the laboratory must be fully trained on how to label chemicals.

7.8.1 Labeling Non-Original Containers for Content

Whenever possible, the full chemical name must be written on a label. If this is not possible, then abbreviations are acceptable. A full list of chemical abbreviations must be posted in the laboratory in a readily visible location. However, if you use any abbreviations, you must hang up a “key” to the abbreviations in a visible location (preferably close to the chemicals and/or by the door). The “key” must contain the abbreviation and the name of the chemical. In addition, the P.I. must have a copy of the “key” in his/her office.

7.8.2 Labeling Non-Original Containers for Hazards

Non-original containers (secondary use containers) such as wash bottles, squirt bottles, temporary storage containers, beakers, flasks, bottles and vials, or any container that a chemical from an original container is transferred into must be properly labeled with the hazard characteristics (ignitibility, corrosivity, reactivity, and toxicity) of that chemical in order to satisfy federal and state regulations (6 NYCRR §372.2 (a) (2); 40 CFR §262.11). If the material:

1. Is flammable (flash point under 141^{o} F),
2. Is an oxidizer,
3. Reacts with water or air,
4. Spontaneously combusts or polymerizes,
5. Has a pH less than 2 or greater than 12,
6. Is explosive, or
7. Contains heavy metals,

then the container label must indicate that specific hazard. Any organic solvent must also be listed. **Use the "Waste Determination/Labeling Guide" found in Appendix N to ensure a container is properly labeled for hazards. Hazard warning labels are essential for making proper waste determinations. Contact your EHSO if you require further assistance.**

For small containers, such as vials and Eppendorf tubes, laboratory personnel can group them by class into a larger vessel and simply label the outside of the vessel once listing all hazards present. While this type of system is available for laboratory personnel to use, using such a system for hazardous chemicals is not recommended. Such a system would be more appropriate for non-hazardous compounds such as agar and buffer solutions. Examples of similar systems can be found below:

- Placing the vial or small container in a Ziploc bag or other type of overpack container (e.g., a beaker or plastic bottle) and labeling the overpack container with the chemical name and hazard characteristics.

- 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, number, letter, or color 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 instead of each vial.

- For sample storage in refrigerators, laboratory personnel should label sample containers with one of the above methods.

- For preserved specimens, bottles should be labeled with the preservative (e.g., ethanol or formaldehyde). A large number of these labels could be easily generated by computer using mailing labels.

Please Note: Some laboratory workers may be color-blind. This fact must be taken into consideration BEFORE a color-coding system is used.

7.9 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 can release hazardous vapors that are detrimental to the health of laboratory personnel.

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

7.9.1 General Storage Guidelines

It is recommended that laboratories adhere to the following guidelines regarding the 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 laboratory space in a more efficient manner.

- All chemical containers must be labeled. Labels should include any hazards present and, if possible, the full name of the chemical constituent(s). Be sure to check chemical containers regularly and replace any labels that are deteriorating or falling off and/or relabel with another label before the chemical becomes an unknown.

- Keep all containers of chemicals closed when not in use.

- Every chemical should have an identifiable storage place and should be returned to that location after use.

- The storage of chemicals on bench tops should be kept to a minimum to help prevent clutter and spills and to allow for adequate working space.

- Chemical storage in fume hoods should be kept to a minimum 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 towards the back and smaller bottles should be stored up front where they are visible. Chemical bottles should be turned with the labels facing out so they can be easily read.

- EPA and FDNY regulations prohibit chemical storage on the floor. If it is necessary to store bottles on the floor, then the bottles should be placed in secondary containment, such as a tub or bin, which can fully contain any spill. Bottles should be placed away from aisle spaces because of the potential for them to be knocked over.

- For multiples of the same chemical, older containers should be stored in front of newer chemicals and partially-filled containers. This allows for older chemicals to get used up first and helps to minimize the number of chemical containers in the storage area.

- Do not store chemicals in direct sunlight or next to heat sources.

- Laboratories should strive to keep only the minimum quantity of chemicals necessary. When ordering new chemicals, laboratories should only order enough stock needed for the experiment or the quantity that will get used up within 2 semesters at most.

- Liquid chemical containers should be stored in secondary containment to minimize the potential for bottle breakage and spills.

- Always segregate and store chemicals according to compatibility and hazard classes (see Appendix L)

- Chemical containers should be dated when they arrive and should be checked regularly and disposed of when they reach their expiration date. **Please note that because of the potential explosion hazard, peroxide forming chemicals must be tested periodically for peroxides in accordance with the timetable found in Appendix J. Dates of tests must also be recorded on the container label.**

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

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

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

- FDNY prohibits any type of storage within 18 inches (457 mm) of sprinkler head deflectors in areas of buildings protected by a sprinkler system and within 24 inches (610 mm) of the ceiling in areas not protected by a sprinkler system (see Fire Code §315.2).

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

- Highly toxic chemicals 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).

- Organic and mineral acids must be stored separately

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

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

- Consumable items being used for laboratory purposes, such as sugar, soda, and vinegar, should be clearly labeled with the words "NOT FOR CONSUMPTION".

7.9.2 Chemical Storage Limits

The nature of laboratory work requires quantities of chemicals to be on hand for easy access. It is incumbent upon laboratory workers, however, to minimize the quantities of chemicals stored on bench tops, under fume hoods, or in other exposed areas. Under no circumstances shall the total quantities of hazardous chemicals stored in a laboratory exceed those permitted under FDNY Fire Code §2706 and/or 3 RCNY §4827-01 (previously 3 RCNY §10-01):

Lab Type	**Fire Rating**	**Fire Protection**	**Flammable Liquids**	**Flammable Solids**	**Oxidizing Materials**	**Unstable Reactives**
I	2 hour	Sprinklers	30 gallon	15 pound	50 pound	12 pound
II	1 hour	Sprinklers	25 gallon	10 pound	40 pound	6 pound
III	2 hour	No sprinklers	20 gallon	6 pound	30 pound	3 pound
IV	1 hour	No sprinklers	15 gallon	3 pound	20 pound	2 pound

7.10 Transporting Chemicals

When transporting chemicals between laboratories within the same building or contiguous buildings, it is recommended the following guidelines be adhered to for protection of people and the environment, and to minimize the potential for spills to occur:

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

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

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

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

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

Please contact the EHS Office if chemicals are to be transported between laboratories in non-contiguous buildings.

Please Note: If chemicals are being transported off the main campus, be aware that there are specific procedures, training and other legal requirements that must be followed. For more information, refer to the Shipping Hazardous Materials section.

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8.0 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 hazards. Several factors can influence how a chemical will behave, the hazards the chemical presents, and the severity of the response including:

- 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.); and
- Other processes (improper storage, addition of moisture, storage in sunlight, refrigeration, etc.).

The following sections describe general information and safety precautions about specific hazard classes. The chemical hazards listed are based on the Department of Transportation (DOT) hazard class system. 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 MSDSs and other resources before working with any chemical.

8.1 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; however, there are a number of chemicals that can become unstable and/or potentially explosive over time through exposure to 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. These compounds may be shock, heat, and friction sensitive. Instead, contact your EHS Office immediately!

Explosives can result in damage to surrounding materials, 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 P.I. to use such chemicals. After obtaining prior approval from your P.I., thoroughly read the MSDSs and any other chemical resources related to the potentially explosive compound(s) to minimize hazards.

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 properly rated safety shield.

- Be sure to remove any unnecessary equipment and other chemicals (particularly highly toxic and flammable) 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, or scraping with potentially explosive compounds. Non-sparking plastic devices should be used instead.

- Ensure that other safety devices such as high temperature controls and water overflow devices are used to help minimize any potential incidents.

- Dispose of any hazardous waste properly 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 (e.g., Picric acid or 4-Dinitrophenyl hydrazine). 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 your EHSO for 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
- Metal Picrate Salts
- 2,4-Dinitrophenylhydrazine (dry)
- Benzoyl peroxide (dry)
- Metal Perchlorate Salts

8.2 Flammable and Combustible Liquids

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

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

The 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 that 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
Classification	**Flash Point**	**Boiling Point**

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 commonly used at CUNY and are important in a number of laboratory processes. However, in addition to the flammable hazard, some flammable liquids also may possess other hazards such as being toxic and/or corrosive.

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

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

When pouring flammable liquids, it is possible to generate enough static electricity to cause the flammable liquid to ignite. If possible, make sure that 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, it is possible for the vapors to travel along floors and, if an ignition source is present, result in a flashback fire.

8.2.1 Flammable Storage in Refrigerators/Freezers

Flammable liquids must be stored only in specially designed flammable storage refrigerators/freezers or explosion-proof refrigerators/freezers, as per NFPA 45 and article 501 in NFPA 70. 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 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 additional information, please refer to ANSI/UL 1203-1994 entitled, “Explosion-Proof and Dust-Ignition-Proof Electrical Equipment for Use in Hazardous (Classified) Locations.”

For most laboratory applications, a flammable storage refrigerator/freezer is acceptable. However, some operations may require an explosion-proof refrigerator/freezer. If a laboratory cannot purchase a flammable storage refrigerator for the laboratory’s own use, departments and laboratory groups on each floor are strongly encouraged to consider purchasing a communal flammable storage refrigerator for the proper and safe storage of flammable liquids.

8.2.2 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 of thumb, if you have more than 10 gallons of flammable liquids, including materials in use, then you should store the flammable liquids in a properly rated flammable liquid storage cabinet. All flammable liquids not in use should be kept in the flammable liquid storage cabinet. For stand-alone flammable cabinets (as opposed to cabinets underneath fume hoods), there are vent holes on each side of the cabinet (called bung holes) that must have the metal bungs screwed into place for the cabinet to maintain its fire rating. Venting of flammable cabinets is NOT required, however, if a flammable cabinet is vented, it must be vented properly according to the manufacturer’s specifications and NFPA 30. Typically, proper flammable cabinet ventilation requires that air be supplied to the cabinet and the air be taken away via non-combustible pipes. If you are planning on venting your flammable storage cabinet, please contact your EHSO for more information.

8.3 Flammable Solids

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

Under the DOT Hazard Class System, flammable solids are listed as Hazard Class 4. Flammable solids are further broken down into three subcategories:

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

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

8.4 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-Butyl lithium 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.

8.5 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 that 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, or other material that comes into contact with these materials should be quenched with water before being disposed 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, please contact your EHSO for more assistance.

8.6 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 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 because of their ability to promote and enhance the potential for fires in labs.

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

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

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

As with any chemicals, but particularly with oxidizers and organic peroxides, quantities stored on hand should be kept to a minimum. Whenever planning an experiment, be sure to read the MSDS and other reference documents to understand the hazards and special handling precautions that may be required, including use of a safety shield. Also be aware of the melting and autoignition temperatures for these compounds and ensure that any device used to heat oxidizers has a temperature 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 that 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 your EHS Office. Indicate on the hazardous waste tag that the chemical is an oxidizer or organic peroxide and that you suspect contamination.

8.7 Peroxide Forming Compounds

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

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

1) Each peroxide forming chemical container MUST be dated when received and opened. A list of common peroxide forming chemicals can be found in Appendix J. Those compounds in the appendix listed in Table A should be disposed of within 3 months of opening and those compounds in the appendix listed in Tables B, C, and D should be disposed of within 12 months of opening.[5]

2) Each peroxide forming chemical container must be tested for peroxides when opened and periodically thereafter (see Appendix J for testing time schedule). 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 a variety of safety supply vendors. An alternative to peroxide test strips is the KI (potassium iodide) test. 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, then peroxides are present. Light blue test results may be acceptable for use if your procedure does not call for concentrating, evaporating or distilling. Containers with darker blue test results

[5] Please note that this list is not exhaustive, as there are numerous other chemicals that can form peroxides. Be sure to read chemical container labels, MSDSs, and other chemical references.

must be deactivated or disposed of. You can test older test strips for efficacy with a dilute solution of hydrogen peroxide.

4) Because of 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 that 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 that there are no peroxides present. Never distill peroxide forming chemicals to dryness. Leave at least 10-20% still bottoms to help prevent possible explosions.

Please Note: 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 your EHS Office immediately.

8.8 Poisons

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

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

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

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

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

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

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

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

If you think you may have received an exposure to a poisonous substance, seek medical attention immediately by alerting Public Safety and/or calling the Poison Control Center at 1(800) 222-1222. If possible, bring a copy of the MSDS with you. After receiving medical attention, complete an **Injury/Illness Report**.

8.9 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 Class 8.

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

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

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

Some chemicals can react with acids and liberate toxic and/or flammable vapors. When working with corrosive materials, ensure that the proper amount of spill cleanup material is available for neutralization, such as Calcium carbonate for acids and Citric acid for bases. Contact your EHS Office for assistance.

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

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

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

PLEASE NOTE: Some chemicals, such as Hydrofluoric acid, requires the use of a special antidote (such as Calcium gluconate gel) and special emergency procedures. Read the MSDSs for any chemical(s) you work with to determine if a special antidote is needed if a chemical exposure occurs.

8.9.1 Hydrofluoric Acid

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

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

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

Because of the serious hazard of working with HF, the following guidelines are recommended:

- All users of HF must receive Hydrofluoric Acid Safety training from their EHS Office as well as training from their supervisor.

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

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

- **First Aid** - A HF first aid kit that includes 2.5% calcium gluconate gel must be available. 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 because 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 P.I. Lab personnel planning to use HF should be able to answer the following in the affirmative:
  - Has read the MSDS for HF
  - Has read the HF Use SOP developed by the lab
  - Has read the Hydrofluoric acid section in this Lab Safety Manual
  - Is aware of the designated area for HF use
  - Knows the first aid procedure in case of an HF exposure
  - Knows what to do in case of an HF spill

- 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

The following are safe practice guidelines when working with HF:

- Never work alone with HF. Have a buddy system.
- Use a plastic tray while working with HF for containment in case of a spill.
- Keep containers of HF closed. HF can etch the glass sash and make it hard to see through (if the hood sash becomes fogged and hard to see though because of etching, please contact EHS about installing a polycarbonate sash)
- Material Safety Data Sheet (MSDS) – A MSDS for HF must be available.
- All containers of HF must be clearly labeled.
- The stock HF should be stored in plastic secondary containment and the cabinet should be labeled. HF should be stored in lower cabinets near the floor.
- Wash gloves off with water before removing them.

8.9.2 Perchloric Acid

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

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

9.0 PARTICULARLY HAZARDOUS SUBSTANCES

The OSHA Laboratory Standard requires that the Chemical Hygiene Plan include provisions for additional employee protection 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 Laboratory Standard states that for work involving particularly hazardous substances, specific consideration should 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.

General guidelines and recommendations for the safe handling, use, and control of hazardous chemicals and particularly hazardous substances can be found in MSDSs and other references such as Prudent Practices in the Laboratory and Safety in Academic Chemistry Laboratories. Contact your EHS Office for additional information.

9.1 Establishment of a Designated Area

Laboratories should establish a designated area where particularly hazardous substances can be used. In some cases, a designated area could be an entire room out of a suite of rooms or could mean one particular fume hood within a laboratory. The idea is to designate one area that everyone in the laboratory is aware of where only the particularly hazardous substances can be used.

P.I.s 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 addressed 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. Any special precautions should be included within the lab's SOPs.

9.2 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 your EHS Office 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.

9.3 Decontamination Procedures

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

9.4 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 keep exposures to a minimum.
- Always obtain prior approval from the P.I. before ordering any particularly hazardous substances.
- Plan your experiment out in advance, including layout of apparatus and chemical and waste containers may be necessary.
- Before working with any particularly hazardous substance, review chemical resources for any special decontamination/deactivation procedures and ensure that 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 your EHSO).

- 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 in 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, and thoroughly clean up and decontaminate working surfaces.

- Whenever possible, use secondary containment, to conduct your experiment in and to store particularly hazardous substances.

- Particularly hazardous substances should be stored by themselves in clearly marked trays or containers indicating the hazard (e.g., “Carcinogens” or “Reproductive Toxins”).

- 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, use only High Efficiency Particulate Air (HEPA) filters 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 that information related to the experiment is included in any SOPs.

9.5 Prior Approval

The 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 your EHS Office 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 P.I. or laboratory supervisor.

P.I.s and 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 the guidelines, procedures, and approval processes that would be required. This information should be documented in the laboratory's or department's SOPs. Additionally, P.I.s and laboratory supervisors are strongly encouraged to have written documentation, such as "Prior Approval" forms that are completed, signed by the laboratory worker, signed by the P.I. or laboratory supervisor, and kept on file.

Examples where P.I.s and laboratory supervisors should consider requiring their 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 quantity of chemicals to be used for a routine experiment, such as an increase of 10% or greater than the quantity of chemicals normally used.

- When a new piece of equipment is brought into the lab that requires special training in addition to the normal training provided to laboratory workers.

  When a laboratory worker is planning on working alone on an experiment that involves highly hazardous chemicals or operations.

9.6 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 immediate apparent harmful effects.

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

(i) It is regulated by OSHA as a carcinogen; or

(ii) 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

(iii) It is listed under Group 1 ("carcinogenic to humans") by the International Agency for Research on Cancer (IARC); or

(iv) It is listed in either Group 2A or 2B by IARC or under the category, "reasonably anticipated to be carcinogens" by NTP, and causes statistically significant tumor incidence in experimental animals in accordance with any of the following criteria:

(A) After inhalation exposure of 6-7 hours per day, 5 days per week, for a significant portion of a lifetime to dosages of less than 10 mg/m(3);
(B) After repeated skin application of less than 300 (mg/kg of body weight) per week; or
(C) After oral dosages of less 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 “lifestyle” factors such as:

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

More information on carcinogens, including numerous useful web links such as a listing of OSHA regulated carcinogens, can be found on the OSHA Safety and Health Topics for Carcinogens webpage. The State of California has developed an extensive list of “Carcinogens known to the State of California through Prop 65”. Please note that this list is being provided as supplemental information to the OSHA, NTP, and IARC chemical lists and is not legally mandated by New York State.

9.7 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.

It is important to be aware of the threats to reproductive health and prevent potential reproductive hazard exposures for male and female employees and students who work with known and suspected reproductive toxins including chemical, biological, radiological, and physical agents. Your EHSO is available to respond to concerns or questions on reproductive hazards, conduct workplace hazard assessments, and provide recommendations to address or eliminate specific reproductive risks. As with any particularly hazardous substance, work involving the use of reproductive toxins should adhere to the Guidelines for Working with Particularly Hazardous Substances.

More information on reproductive toxins can be found on the OSHA Safety and Health Topics for Reproductive Hazards webpage. The State of California has developed an extensive list of "Reproductive Toxins known to the State of California through Prop 65". Please note that this list is being provided as supplemental information to the OSHA, NTP, and IARC chemical lists and is not legally mandated by New York State.

9.8 Acute Toxins

OSHA defines a chemical as being 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 MSDSs and other chemical references.

As with any particularly hazardous substance, work involving the use of acute toxins should adhere to the Guidelines for Working with Particularly Hazardous Substances. In addition to following 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.
- Give 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, including numerous useful web links, can be found on the OSHA Safety and Health Topics for Hazardous and Toxic Substances webpage.

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10.0 HAZARDOUS CHEMICAL WASTE DISPOSAL

Hazardous waste disposal is highly regulated. The laws and regulations that apply to laboratories located in New York City include:

1) *The Federal Resource Conservation and Recovery Act (RCRA).* The Resource Conservation and Recovery Act (RCRA) was passed by Congress in 1976. It requires the Environmental Protection Agency (EPA) to establish a "cradle-to-grave" system for the proper management of hazardous waste. A cradle-to-grave system tracks a material from the time it is generated until the time it is destroyed. On May 19, 1980, the EPA issued regulations implementing RCRA. These regulations are found in Title 40 of the Code of Federal Regulations (40 CFR) Parts 260•272. They establish the minimum standard for hazardous waste management in the United States. RCRA allows states to enact their own more stringent legislation.

2) *The New York State Environmental Conservation Law.* The New York State (NYS) Environmental Conservation Law was passed in 1978 and is enforced by the NYS Department of Environmental Conservation (DEC). The NYS program includes regulations covering the three stages of the waste stream: the generation; the transportation; and the treatment, storage, and disposal. The requirements for generators of hazardous waste are found in the Part 370 series of Title 6, New York Code of Rules and Regulations.

3) *NYC Rules and Regulations Relating to the Use of the Public Sewers.* In addition to federal and state laws, campuses must also adhere to NYC Sewer Regulations which apply to wastes that are poured down the drain into the sanitary sewer system or that flow through our campuses into the storm sewer system. The NYC Department of Environmental Protection (DEP) is responsible for enforcing the sewer regulations. The regulations list many materials that cannot be discharged into the NYC Sewer System. They include flammables, explosives, acids with a pH below 5.0, bases with a pH above 12.0, and toxic materials in concentrations that would be harmful to humans, animals, or aquatic life.

Contact your EHS Office for hazardous waste disposal procedures specific to your campus.

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11.0 HAZARDOUS MATERIAL SHIPPING

CUNY has the responsibility to comply with US Department of Transportation (DOT) and International Air Transportation Association (IATA) regulations for shipping hazardous materials. To ensure the safe transportation of these materials and to comply with applicable regulations, the following guidelines must be followed regarding all shipments of hazardous materials. Hazardous materials are articles or substances which pose an unreasonable risk to health, safety, or personal property.

11.1 Regulated Hazardous Materials

Anyone who offers for shipment (including land, air, and water) hazardous materials or dangerous goods must have the appropriate DOT training, even when the transporter/carrier (i.e. Federal Express) completes the necessary paperwork.

Examples of these materials include:

- Laboratory chemicals, cryogenic materials, and samples containing flammable, toxic, explosive, radioactive, oxidizer, and/or corrosive materials;
- Biological Substances: Examples would include- Infectious substances (substances known to contain pathogens such as viruses, bacteria, fungi), HHS/USDA Select Agents, animal and human tissue, blood, genetically modified organisms (plants, bacteria, animals, viruses that have been genetically modified).
- Paints, stains, thinners, refrigerants, aerosols, medicines, pesticides, disinfectants, fuels (diesel, gasoline, ethanol, etc.), and ammunition; or
- Equipment containing hazardous materials, such as mercury, compressed gases, batteries (wet, lithium, and dry batteries containing sodium, potassium hydroxide), etc

11.2 Hazardous Materials Transportation Requirements

If hazardous materials or dangerous goods must be shipped then contact the EHS office for guidance and assistant. If your department will ship hazardous materials or dangerous goods on a frequent basis, the EHS office can provide the appropriate training to designated personnel.

It is the responsibility of the P.I.s or laboratory supervisors to ensure that any employee working under their supervision who ships or prepares shipments of

hazardous materials has received the proper initial training (a refresher is needed every 3 years). Contact your EHSO if you have any questions.

12.0 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. Two categories of pesticides are:

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

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

All CUNY 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, state, and NYC regulations.

It is essential that teaching, research, and ground maintenance involving pesticide use adhere to the regulations and provide for adequate protection of the pesticide applicator, other employees, staff, students, and the environment.

The responsibility for ensuring that all work with pesticides at CUNY is conducted safely and in compliance rests with the individual user.

12.1 Pesticide Certification

All individuals handling pesticides as part of a university program must be New York State Certified Pesticide Applicators.

12.1.1 Exemptions from Pesticide Certification

As per federal and state regulations, a number of exemptions exist from 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 non-dispersive manner (e.g., microgram quantities used inside a fume hood) are exempt from the requirements. As with all other chemical use in the laboratory, use of laboratory quantity pesticides is regulated by the Laboratory Standard and

other applicable rules and regulations.

3) Testing of materials for pesticide efficacy, toxicity, or other properties may also be exempt. For clarification, refer to 40 CFR part 172.3.

4) Teaching/demonstrating pesticide application(s) is exempted from the certification requirements. However, the individual engaged in such activities is responsible for ensuring that these activities meet all federal and state 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 CUNY Laboratory Compliance Manual. For more information regarding pesticide use requirements and exemptions, please contact your EHSO.

13.0 BIOHAZARDS

Work involving biological materials typically involves agent specific strategies designed to manage the agent and associated risks. Researchers are often guided by pressures from funding sources, standards of practice, guidelines, communal intellect, and their own knowledge base with no specific regulatory or authoritative doctrine to govern practice. To complicate matters further, biological research often involves the use of chemicals, radiological materials, LASERs, animal model systems, and physical hazards that must also be managed safely. Creating a biosafety framework that is capable of anticipating, evaluating, and managing the various aspects of the work being performed means developing internal procedures aimed at managing risks.

The standard for laboratories working with infectious agents is the CDC-NIH publication entitled *Biosafety in Microbiological and Biomedical Laboratories (BMBL).* Now in its 5th edition, the BMBL has become the code of practice for biosafety. Each director and/or P.I. is strongly encouraged to use the BMBL as a reference in addressing the safe handling and containment of infectious microorganisms and hazardous biological materials. As with all other areas of lab safety, all federal, state, and local regulations regarding biohazards must be met.

It is the responsibility of the directors and P.I.s of all microbiological and biomedical laboratories at CUNY to perform a biological risk assessment and develop a separate plan suited for each of these laboratories.

13.1 Institutional Biosafety Committee

Each college's 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.

13.1.1 Recombinant DNA

CUNY requires that all recombinant DNA work done by university employees or affiliates that is not exempt from NIH Guidelines be registered with the college's IBC. 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.

13.1.2 Infectious and Pathogenic Agents

Agents infectious and pathogenic to humans are classified as risk group 2, 3, or 4 in the following categories: bacterial, fungal, parasitic, viral, rickettsial, chlamydial, and prion.

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)

Bloodborne pathogens can impact workers who are exposed to blood and other potentially infectious materials. Bloodborne pathogens refer to pathogenic microorganisms present in human blood that can cause disease. Bloodborne pathogens include the hepatitis B virus (HBV); the human immunodeficiency virus (HIV), which causes AIDS; the hepatitis C virus (HCV); and pathogens that cause malaria.

In recognition of these potential hazards, OSHA has implemented a regulatory standard [Bloodborne Pathogens 29 CFR 1910.1030] to prevent the transmission of bloodborne diseases within potentially exposed occupations.

According to the standard, employers must perform an employee exposure evaluation. The finding of employee exposure triggers requirements the employer must fulfill, such as the development of an Exposure Control Plan, offering training sessions, and providing the HBV vaccine. The Exposure Control Plan calls for engineering controls, work practices and procedures for housekeeping, medical evaluations, hazard communication, and recordkeeping. Employers are also required to provide training to employees at the time of initial assignment to a job with occupational exposure. The training should be provided during working hours and at no cost to the employee. Employees must be retrained annually and additional training should be offered at any time that existing tasks are modified or new tasks are required that may affect the worker's occupational exposure. Training records must be maintained for a minimum of three years.

Although no vaccine exists for the HCV and HIV, a vaccine does exist for the Hepatitis B Virus (HBV). Employers are required to offer the vaccine within 10 working days of initial assignment to all employees at risk of exposure. The vaccination must be performed free of charge and at a reasonable time and place, and it must be given by a licensed healthcare professional. Employees who decline the vaccination must sign a declination form. If the employee initially declines but later decides to accept the vaccination, it must be provided.

It is the responsibility of P.I.s and laboratory supervisors to ensure that 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.

13.1.3 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. See the National Select Agent Registry website for more information. This registry is jointly maintained by the CDC and the Animal Plant Health Inspection Service (APHIS) of the United States Department of Agriculture (USDA). If you wish to work with these agents, you must first notify and register with your EHS Office. Unregistered possession and use may result in significant fines and criminal prosecution.

13.2 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.

Federal regulations and standards stipulate that personnel must be trained so they are qualified to perform research on animals. Each college is responsible for providing training to perform research on animals, and the college's IACUC must ensure that personnel are qualified to perform the procedures. **All CUNY-affiliated college IACUCs now require that researchers and other key personnel involved in animal research complete a prescribe list of CITI (Collaborative Institutional Training Initiative) computer-based training modules.**

Researchers and personnel handling wild animals are strongly encouraged to get a pre-exposure Rabies vaccination. See the NYC DOHMH website for more information.

13.3 Human Participants

Each college's Institutional Review Board (IRB) exists as a safeguard to promote ethical and responsible treatment of human subjects/participants in research. In accordance with CUNY policy, 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 CUNY's Human Research Protections Program Policies and Procedures. Only the IRB can designate a research project as "exempt." The CUNY-wide IRB serves CUNY's principal investigators, the Research Foundation's principal investigators, and reviews multi-campus projects. In addition, this body hears final appeals of disapprovals.

The Office of Research Conduct (ORC), located within the CUNY Office of Academic Affairs, reports to the Vice Chancellor for Research and works in concert with the President of the Research Foundation (RF) to oversee and carry out the CUNY Human Research Protection Program (HRPP). The ORC is responsible for the protection of the rights and welfare of all human subjects in research projects conducted at CUNY or by CUNY faculty, staff, students, and RF CUNY staff, and for the 21 Institutional Review Boards. These oversight responsibilities include: monitoring compliance of any ongoing research involving human subjects with federal, state, and university regulations; monitoring university compliance with these regulations; and leading educational efforts CUNY-wide regarding human subject protection.

All CUNY 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 college IRB. On July 1, 2005, CUNY implemented a mandatory computer-based training program. **CITI is now the required program to be taken by all CUNY researchers and key personnel involved in human subjects research, regardless of whether the research is funded or non-funded.**

The ultimate responsibility for treatment of human research subjects rests with the P.I. The P.I.'s informed participation in this process helps to ensure a positive, ethical, and responsible climate for scholarly research at CUNY.

13.4 Shipping Biological Materials

Shipping certain biological materials, such as human or animal infectious agents or diagnostic/clinical samples—collectively referred to as dangerous goods—must be performed by a trained individual. The trained individual is responsible for classifying, identifying, packaging, marking, labeling, and documenting shipments for transport by air or ground. The U.S Department of Transportation enforces training and other regulatory requirements.

Categories of regulated materials include:

- Infectious substances: Substances known or reasonably expected to contain pathogens. Pathogens are defined as microorganisms, including bacteria, viruses, rickettsiae, 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 the 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 the USDA or the Food and Drug Administration.

Contact your EHS Office for training inquires and alternative shipping options.

13.4.1 Permits for the Import and Export of Biological Materials

Permits issued by federal agencies such as the US Department of Agriculture (USDA) or the Centers for Disease Control and Prevention (CDC) are required to import disease causing agents for humans, animals, vectors, plant pests, and animal and plant products. In terms of exports, the Department of Commerce regulates certain microorganisms and toxins.

13.4.1.1 Agents Regulated for Import

Center for Disease Control and Prevention (CDC)
Agents of human disease and any materials, including live animals or insects which may contain them, require a permit from the CDC. Examples include:

- Any infectious agent known or suspected to cause disease in humans.
- 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 humans. Importation of live turtles of less than 4 inches in shell length and all non-human 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 humans.
- Any snail species capable of transmitting a human pathogen.

For more information or to download a permit application, visit the CDC's Etiologic Agent Import Permit Program.

US Department of Agriculture (USDA)
Import and interstate transport of materials that could potentially harm U.S. agricultural products, including livestock, poultry, and crop, require a permit from the Animal and Plant Health Inspection Service (APHIS), an agency of USDA. 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. ***GMOs that are not regulated may still be held at customs.***

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.

13.4.1.2 Agents Regulated for Export

An export license may be required from the Department of Commerce 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. For more information, consult the Commerce Department's Export Control webpage.

13.5 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 your EHS Office to determine the appropriate cabinet for your applications and space.

PLEASE NOTE: As a general rule, BSCs are not suitable when working with hazardous materials. Work with hazardous materials should be conducted under a fume hood. For more information, refer to the description of the differing types of BSCs on the following pages.

13.5.1 Biological Safety Cabinet Certifications

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

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

This certification must be performed by a contractor that is trained to National Sanitation Foundation (NSF) Standard No. 49. Your EHSO **does not** certify biological safety cabinets.

It is the responsibility of the P.I.s or laboratory supervisors to ensure that biological safety cabinets within laboratories under their supervision are certified annually.

13.5.2 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, 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 and vacuum pumps, 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 its protective envelope and containment properties. Slow movement of arms in and out of the cabinet will reduce the risk of potential contamination.

13.5.3 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.

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 5 -10 minutes.

3) Assemble material. Introduce only those items that are required to perform the procedures and arrange the items so that work "flows" from the least to the most contaminated item. Avoid having to reach for supplies or discard items outside of the cabinet. Place pipette discard trays (containing disinfectant), biohazard bags and sharps containers <u>inside</u> 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 or equipment, 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, being sure not to block the rear exhaust grille with any operations or equipment.

7) Avoid using open flames inside the cabinet. This can create turbulence and disrupt the pattern of air, compromise the safety of the operator and affect product 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. If a burner is absolutely 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 in 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 because 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.

13.5.4 Use of Ultraviolet Lights in the BSC

Ultraviolet (UV) 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 (e.g., serious eye and skin injury) associated with the use 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, EHS does not recommend the use of UV lights to maintain a clean working environment. Instead, a more effective strategy to reduce or eliminate contamination should include good aseptic techniques, operational procedures as outlined in this manual, and thorough decontamination procedures before and after BSC use.

13.5.5 Types of Biological Safety Cabinets

Biological safety cabinets are divided into 3 classifications:

- <u>Class I:</u> The Class I biological safety cabinet (BSC) 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 it can be used with an attached armhole front panel, with or without attached rubber gloves. Although Class I cabinets are simple and economical, and provide protection for radioisotopes and some toxic chemicals (if the exhaust is ducted to the outside), filtered air is not provided over the work area. These cabinets also <u>do not</u> protect your materials from contaminants introduced by the environment or the operator.

- <u>Class II:</u> The Class II cabinet, the most common type of cabinet used on campus, 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.

- Class IIA1: Air, at a face velocity of 75 linear feet per minute (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 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.

- Class III: The Class III cabinet is designed for total (100%) containment of the material and any particulates.

13.6 Biohazardous Waste (Regulated Medical Waste)

In New York State, the Department of Health 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, and disposable gloves).
- Human pathological wastes including tissue, organs and other body parts, and specimens of body fluids and their containers.
- Human blood and blood products.
- Sharps, such as syringes and needles, razor blades, scalpels, and blood vials.
- Animal wastes, including carcasses, body parts, body fluids, blood, and bedding originating from animals known to be contaminated with (zoonotic organisms) or intentionally inoculated with infectious agents.

13.6.1 Hypodermic Syringes and Needles

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

- All non-medical and non-veterinary use of syringes and needles (e.g., teaching and research) require a DOH Certificate of Need. Generally, individual academic departments at CUNY possess Certificates that cover all members within the respective department. Please consult with your administrative manager, department chair, or EHS Office.
- The P.I. or supervisor of the laboratory or work area should assign an individual who is responsible for storage, security, and recordkeeping.
- Individual users are responsible for securing hypodermic syringes and needles not in use in a locked drawer or cabinet, and for maintaining a written log of use and distribution.
- Follow the regulatory guidelines for waste segregation and disposal.

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14.0 RADIATION HAZARDS

Ionizing radiation is a form of energy, but 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 particles that can be stopped by a thin layer of plastic, glass, wood, metal or most other common materials. X-rays and Gamma rays are very similar to sunlight in that they do not contain particles, just electromagnetic waves. While sunlight will pass through only a few materials, such as window glass, X-rays and Gamma rays can penetrate easily through most materials, unless they are blocked by a sufficiently thick lead barrier.

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 short distance away from someone handling radioactive material can greatly reduce your exposure.

14.1 Where Ionizing Radiation is Used

Small amounts of radioactive material are used and stored in dozens of laboratories across CUNY campuses. 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. Often, radioactive material is found in small vials of radioactively labeled chemicals in solution. These labeled chemicals are widely used in research and in veterinary medicine. Typically, only very small amounts of radioactive material are used, and levels of radiation exposure are 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 low because of shielding.

14.2 Control of Ionizing Radiation

All use of material or equipment that produces ionizing radiation requires prior approval by the College Radiation Safety Committee. This group of faculty and staff set policies and personally review each operation to ensure safety and compliance with federal, state, and local regulations. Your EHS Office or, if named, your Radiation Safety Officer can provide training and other services to help individuals work safely. He or she can perform routine inspections of all use areas, identifying violations of radiation safety that require correction. It is strongly recommended that each college using material or equipment that produces ionizing radiation have a Radiation Safety Manual which gives detailed, written information on a college's radiation safety program.

The performance of the radiation safety program should be reviewed continuously. The Radiation Safety Committee should meet a minimum of twice a year to keep policies up-to-date, resolve compliance issues, and monitor the level of radiation exposure to individuals on campus. In addition, the New York City Department of Health and Mental Hygiene (DOHMH) performs on-campus inspections every two years. Article 175 of the NYC Health Code applies to all radiation equipment and radioactive material within the jurisdiction of the DOHMH. Article 175 aims to protect the public, as well as workers in certain radiation installations, from the hazards inherent in the use of ionizing radiation. The Article is intended to serve as a framework for coordination of radiation control activities with the U.S. Atomic Energy Commission, the U.S. Food and Drug Administration, the NYS Department of Labor, the NYS Department of Health, the NYS Atomic Energy Council, the NYS Department of Environmental Conservation, and other federal and state agencies, as well as with other NYC agencies.

The information presented here is only a brief overview of how sources of ionizing radiation are used at CUNY. While CUNY has demonstrated that it has a solid and consistent safety program, it is important not to take safety for granted. If you have questions or concerns about the use of ionizing radiation where you work, your P.I. or laboratory supervisor is willing and able to help you, and you should feel free to speak with them. They understand that many individuals have never had formal training regarding radiation safety. If you need additional assistance or have any other questions, please contact your EHS Office.

14.3 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 can cause chemical damage to body tissues. 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 can cause an increased lifetime risk of cancer.

14.3.1 How to Protect Yourself

Responsibility for protecting themselves, co-workers, and others from exposure to ionizing radiation is delegated by the College Radiation Safety Committee to the P.I. 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. For any room containing a source of ionizing radiation, each entrance must be plainly marked by warning labels in accordance with Article 175 of the NYC Health Code. In addition, labels and warning tape must be posted on each piece of radiation producing equipment and in all areas used to work with or store radioactive materials. 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.

It is the responsibility of the P.I. or laboratory supervisor who has sources of ionizing radiation in their laboratories to ensure that all equipment producing ionizing radiation has been registered with the EHS Office and all employees using this equipment and/or radioactive material have received the appropriate training.

14.4 Radioactive Waste Disposal

Radioactive material cannot be disposed of in the regular trash. Radioactive waste is divided into several distinct categories and should be separated accordingly. Please refer to your college's *Radiation Safety Manual* for proper procedures in preparing your radioactive waste for pickup. A radioactive waste pickup may be requested by contacting your EHSO.

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15.0 LASER HAZARDS

The EHSO Council recognizes the American National Standard for the Safe Use of LASERs, ANSI Z136.1-2007, and New York Department of Labor's Part 50, LASER Regulation. ANSI Z136.1-2007 requires that all class 3b and 4 LASER users must attend LASER safety training. Your EHS Office should offer training to meet this requirement, which includes topics such as LASER hazards, LASER classifications, signage/labeling, medical monitoring, safety guidelines, and what to do in case of an exposure incident. Additionally, any class 3b and 4 LASERs that are in use must be registered with your EHS Office.

For additional information regarding LASER safety, please contact your EHS Office or see the OSHA Safety and Health Topics webpage for LASER hazards.

It is the responsibility of the P.I. or laboratory supervisor with class 3b or 4 LASERs in laboratories under their supervision to ensure that the class 3b or 4 LASERs have been registered with the EHS Office and employees using these LASERs have received the appropriate training.

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16.0 PHYSICAL HAZARDS

In addition to the chemical hazards found in laboratories, there are also numerous physical hazards encountered by laboratory staff on a day-to-day basis. As with chemical hazards, awareness of these hazards, planning, use of appropriate Personal Protective Equipment (PPE), and following basic safety rules can prevent accidents involving physical hazards.

It is the responsibility of the P.I. 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.

16.1 Electrical Safety

Electricity travels in closed circuits through a conductor. Electric shock occurs when the body becomes a part of the electric circuit. It can cause direct injuries, such as electrical burns, arc burns, and thermal contact burns, and it can also cause indirect injuries when involuntary muscle reaction from the electric shock causes bruises, bone fractures, or even death resulting from collisions or falls. Shock normally occurs when a person is in contact with ground and then comes in contact with:

- Both wires of the electric circuit;
- 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; and
- The length of time the body is in 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. 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 on the next page shows the general relationship between the degree of injury and the amount of amperage for a 60-cycle hand-to-foot path of a one second duration of shock.

EFFECTS OF ELECTRIC CURRENT ON THE BODY

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

As the table above illustrates, a difference of less than 100 milliamperes (mA) 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 mA for 3 seconds is equivalent to a current of 900 mA 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, and the individual is down or unconscious and not breathing, **CALL Public Safety or 911 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). If time or circumstances prevent taking this option, be sure to use a nonconductive item, such as a dry board, to remove the victim from the power source. Failure to think and react properly could make you an additional victim.

16.1.1 Common Electrical Hazards and Preventative Steps

Many common electrical hazards can be easily prevented. Some steps that can be taken include:

- 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 trained individuals.

- All electrical devices fabricated for experimental purposes must meet all federal, state, and local 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 PPE based on potential hazards present. Before use, inspect safety glasses and gloves for signs of damage including wear and tear.

- 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 (GFCIs) protecting the circuit. Do not use aluminum ladders while working with electricity; choose either wood or fiberglass.

- Do not work on energized circuits. The accidental or unexpected starting of electrical equipment can cause severe injury or death. Before any inspections or repairs are made, the current must be turned off at the switch box and the switch padlocked or tagged out in the off position. At the same time, the switch or controls of the machine or the other equipment being locked out of service should be securely tagged to show which equipment or circuits are being worked on. Test the equipment to make sure there is no residual energy before attempting to work on the circuit. **Employees must follow their college's lock-out/tag-out procedures.**

- If you need additional power supply, have additional outlets installed by trained professionals. Do not use extension cords or power strips as a substitute for permanent wiring.

- Extension cords and power strips may be used for experimental or developmental purposes on a temporary basis only. Extension cords can only be used for portable tools or equipment and must be unplugged after each use. Do not use extension cords for fixed equipment such as computers, refrigerators, and freezers. In these cases, use a power strip as described in the next bullet. In general, the use of power strips is <u>preferred</u> over the use of extension cords.

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

- Ensure that any power strips or extension cords are listed by a third-party testing laboratory, such as Underwriters Laboratory (UL). Make sure the extension cord thickness is at least as big as the electrical cord for the tool. For more information on extension cords, see the Consumer Product Safety Commission (CPSC) - 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 equipment. Do not use equipment having worn or damaged power cords, plugs, switches, receptacles, or cracked casings. Do not run electrical cords under doors or rugs, through windows, or through holes in walls.

- All department-purchased electrical equipment must be 3-prong grounded unless it is not an option.

- 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 and frayed, cracked, or broken wires. If you notice any of these problems, have a qualified electrician address the issue immediately.

- To protect against electrical hazards and to respond to electrical emergencies, it is important to identify the electrical panels that serve each room. Access to these panels must be unobstructed; a minimum of 3 feet of clearance is required in front of every electrical panel. Each panel must have all the circuit breakers labeled to identify the equipment.

- 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 that your outlets or circuit breakers are Ground Fault Circuit Interrupter (GFCI) protected.

- Fuses, circuit breakers, and GFCIs are three well-known examples of circuit protection devices.

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

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

- The Ground Fault Circuit Interrupter (GFCI) is designed to shut off electric power within as little as 1/40 of a second, thereby protecting the person, not just the equipment. It works by comparing the amount of current going to an electrical device against the amount of current returning from the device along the circuit conductors. A fixed or portable GFCI should be used in high-risk areas such as wet locations and construction sites.

- Entrances to rooms and other guarded locations containing exposed live parts must be marked with conspicuous warning signs forbidding unqualified persons to enter. Live parts of electric equipment operating at 50 volts or more must be guarded against accidental contact. Guarding of live parts may be accomplished by:
  - Location in a room, vault, or similar enclosure accessible only to qualified persons.
  - Placement of permanent, substantial partitions or screens to exclude unqualified persons.
  - Location on a suitable balcony, gallery, or platform elevated and arranged to exclude unqualified persons, or
  - Elevation of 8 feet or more above the floor.

For additional information, see the following resources:

1) OSHA Pamphlet 3075
2) 29 CFR 1910.303 through 29 CFR 1910.335
3) Electrical Safety Foundation International
4) National Electric Code 2002
5) National Fire Protection Association (NFPA) 70E

16.1.2 Safe Use of Electrophoresis Equipment

Electrophoresis units present several possible hazards including electrical, chemical, and radiological hazards. All of these hazards must be addressed before using the units. The following guidelines have been prepared to assist researchers in operating electrophoresis units safely.

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 easily seen. 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 GFCIs. GFCIs act as very sensitive circuit breakers and, in the event of a short circuit, will stop the power before it can hurt a person. You can identify GFCIs by their "test" and "reset" buttons. They are found on some outlets or breaker boxes. 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 that 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 or contact your EHSO for information on individuals approved to perform retrofitting.

3) Training and Work Procedures

P.I.s 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 appropriate PPE, and applicable emergency procedures. As with all safety training, this instruction should be documented. Employees must wear all appropriate PPE 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.**

16.2 Machine Guarding

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

Requirements for safeguards:

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

16.2.1 Machine Safety Responsibilities

The following responsibilities are assigned to employees:

<u>Management</u>

- Ensure that all machinery is properly guarded.
- Properly train supervisors on the college's lock-out/tag-out procedures.

<u>Supervisors</u>

- Properly train employees on specific machine guarding rules in their areas, as well as the college's lock-out/tag-out procedures, and ensure these rules and procedures are being followed.
- Ensure that machine guards remain in place and are functional.
- Immediately correct machine guard deficiencies.

<u>Employees</u>

- Do not remove guards unless authorized by a supervisor.
- Report machine guard problems to supervisors immediately.
- Do not operate equipment unless guards are in place.

Operators should receive the following training:

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

Hazards to machine operators that can't be accommodated by the design of the machine must be shielded to protect the operator. Guards, decals, and labels that 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.

16.2.2 Common Machine Hazards

Common machine hazards occurring around moving parts include:

1) <u>Pinch Points</u>

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) <u>Wrap Points</u>

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.

3) <u>Shear Points</u>

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. Recognize the potential hazards of cutting and shear points on implements and equipment that are not designed to cut or shear.

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. Follow your college's blocking and lock-out/tag-out procedures 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.

16.3 Lighting

Having a properly lighted work area is essential to working safely. Points to remember about proper lighting include:

- 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.
- If the risk of electrocution exists when changing light bulbs, practice lock-out/tag-out.
- For proper disposal of fluorescent bulbs ("universal waste"), contact the EHS Office.
- As an energy conservation measure, please remember to turn off the lights when you leave the lab.

16.4 Compressed Gases

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

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

- Unsecured cylinders can be easily knocked over, causing serious injury and damage. Impact can shear the valve from an uncapped cylinder, causing a catastrophic release of pressure leading to personal injury and extensive damage.

- Mechanical failure of the cylinder, cylinder valve, or regulator can result in rapid diffusion of the pressurized contents of the cylinder into the atmosphere; leading to explosion, fire, runaway reactions, or burst reaction vessels.

Because of the hazards that compressed gases present, consider obtaining the smallest quantities possible.

16.4.1 Handling Compressed Gas Cylinders

Standard practices for handling compressed gas cylinders safely include:

- The contents of any compressed gas cylinder must be clearly identified. Such identification should be stenciled or stamped on the cylinder, or a label or tag should be attached. Do not rely on the color of the cylinder for identification because color-coding is not standardized and may vary with the manufacturer or supplier.

- When transporting cylinders:
  - Always use a hand truck equipped with a chain or belt for securing the cylinder.
  - A protective cap must be used to cover the cylinder valve.
  - Never transport a cylinder while a regulator is attached.
  - Always use caution when transporting cylinders – **cylinders are heavy!**

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

- Do not move compressed gas cylinders by carrying, rolling, sliding, or dragging them across the floor.

- Do not transport oxygen and combustible gases at the same time.

- Do not drop cylinders or permit them to strike anything.

- Dispensing of compressed gases (notably cryogenic materials) shall be conducted in accordance with FDNY Fire Code §3205. In such dispensing areas, oxygen sensors equipped with an audible alarm shall be provided to continuously monitor the level of oxygen in the area (see §3205.4.1.1.1).

16.4.2 Safe Storage of Compressed Gas Cylinders

Standard practices for the 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 because in a fire, straps may melt or burn. Be sure the chain is high enough (at least half way up) on the cylinder to keep it from tipping over.

- Do not store incompatible gases next to each other. Cylinders of oxygen must be stored at least 20 feet away from cylinders of hydrogen or other flammable gases, 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.

- All cylinders must have passed a hydrostatic pressure test within the past 10 years (FDNY code/NFPA 45).

- 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.

- To prevent accidental ignition of stored flammable liquids and gases, all electrical equipment must meet the requirements of the NYC Electrical Code [refer to §27-3198(4) and §27-3197(1)].

16.4.3 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 because this may actually prevent the metal seal from forming properly. Always test the connection for leaks.

In accordance with FDNY's Fire Code, torch operations using oxygen and flammable gases can only be performed by a G-38 Certificate of Fitness holder.

Basic operating guidelines include:

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

- Adjust the gas flow to the system by using the flow control valve or another flow control device between the regulator and the experiment.
- 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.
- When the cylinder is empty, mark it as "Empty." Store empty cylinders separate from full cylinders.
- Attach a "Full/In Use/Empty" tag to all cylinders. These tags are perforated and can be obtained from the gas cylinder vendor or safety equipment suppliers.

Precautions to follow:

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

16.4.4 Return of Cylinders

Ensure that you have an S.O.P. in place for the management and ultimate disposal of cylinders and lecture bottles. Firstly, make sure that all cylinders and lecture bottles are labeled and included in your chemical inventory. Disposal of cylinders and lecture bottles is expensive, especially if the contents are unknown. Before you place an order for a cylinder or lecture bottle, determine if the manufacturer will take back the cylinder or lecture bottle when it becomes empty. **If at all possible, only order from manufacturers who will accept cylinders or lecture bottles for return**.

16.4.5 Hazards of Specific Gases

1) Inert Gases
- Examples include helium, argon, and nitrogen.
- Inert gases can cause asphyxiation by displacing the air necessary for the support of life.

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

3) Oxidizers
- Examples include oxygen and chlorine.
- Oxidizers vigorously accelerate combustion; therefore, keep them separate 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.

4) Flammable Gases
- Examples include methane, propane, hydrogen, and acetylene.
- Flammable gases present serious fire and explosion hazards. FDNY prohibits the storage of flammable gases in the laboratory unit unless it is needed for ongoing operations. In addition, FDNY states that in labs with ongoing operations that require flammable gases, storage will be allowed for only that amount sufficient to meet the operating requirements of the equipment in that laboratory unit plus an equal reserve. Unless there is reason to believe otherwise, it is suggested that the operating requirements be defined as the amount necessary to sustain ongoing operations for one semester. Therefore, when counting an equal reserve, a laboratory would, following this reasoning, possess no more flammable gas at any one time than could be exhausted in two semesters. FDNY also requires that

flammable gases within laboratory settings be stored in accordance with the following table:

Area of Laboratory in square feet (Sq. Ft.)	**up to 500 Sq. Ft.**	**per additional 100 Sq. Ft**	**Maximum per Laboratory Unit**
Maximum Capacity in cubic feet (Cu. Ft.)*	9.24	1.54	15.4

*Water container capacity

- Do not store near open flames or other sources of ignition.
- Cylinders containing acetylene should always be stored upright.
- 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 the ground, travel to a source of ignition, and result in a flashback fire.

5) Corrosive Gases

- Examples include chlorine, hydrogen chloride, and 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.
- Because of the corrosive nature of the gases, corrosive cylinders should only be kept on hand for 6 months (up to one year maximum). Order only the minimum amount needed for your experiments.

6) Poison (Toxic) Gases

- Examples include arsine, phosphine, and phosgene.
- Poison gases are extremely toxic and present a serious hazard to laboratory staff.
- Poisonous gases require special ventilation systems and equipment and must only be used by trained personnel. There are also special Building and FDNY code regulations that must be followed concerning the permissible quantities.
- Consult your EHSO before purchasing poisonous gases.

16.5 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 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 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: handheld eyewash bottles do not meet this criteria.**
- A class B rated fire extinguisher must be readily available. If none is available, contact your EHSO.
- Ensure that 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 appropriate equipment for charging.
- Store unused batteries in secondary containment to prevent spills.
- Have an acid spill kit available. The waste from a spill may contain lead and neutralized wastes may be toxic. Contact your EHSO for hazardous waste disposal guidance.
- Properly dispose of your used batteries.

16.6 Heat and Heating Devices

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

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

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

- Heating devices should have backup power cutoffs or temperature controllers to prevent overheating. If a backup controller is used, an alarm should notify the user that the main controller has failed.
- Make sure that reaction temperatures do not cause violent reactions and that a means to cool the dangerous reactions is available.
- Post signs to warn people of the heat hazard.

When using **ovens**, follow these additional guidelines:

- Heat generated should be adequately removed from the area.
- If toxic, flammable, or otherwise hazardous chemicals are generated by the oven, then only use ovens with a single pass through design where air is ventilated out of the lab and the exhausted air is not allowed to come into contact with electrical components or heating elements.
- Heating flammables should only be done with a heating mantle or steam bath.

When using **heating baths**, follow these additional guidelines:

- Heating baths should be durable and set up with firm support.
- Because combustible liquids are often used in heating baths, the thermostat should be set so that the temperature never rises above the flash point of the liquid. Check the MSDS of the chemical to determine the flashpoint. Compare that flashpoint with the expected temperature of the reaction to gauge the risk of starting a fire.

16.6.1 Heat Stress

In a high heat condition, if your body cannot regulate its temperature, it overheats and suffers some degree of heat stress. This can occur very suddenly and, if left unrecognized and untreated, can lead to very serious health effects.

Heat stress disorders may range from mild disorders, such as fainting, cramps, or prickly heat, to more dangerous disorders, such as heat exhaustion or heat stroke. Symptoms of mild to moderate heat stress can include: sweating, clammy skin, fatigue, decreased strength, loss of coordination and muscle control, dizziness, nausea, and irritability. If you witness someone suffering from heat stress, you should move the victim to a cool place and immediately seek medical assistance. While awaiting assistance, you might sponge him/her with cool water and offer a conscious person a half glass of cool water every 15 minutes.

16.7 Cold Traps

Some general safety guidelines to follow when using cold traps include:

- Because many chemicals captured in cold traps are hazardous, care should be taken and appropriate PPE 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. Because 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 PPE. 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, refer to section16.12, "Glass Under Vacuum."
- Refer to section 16.10 for safety advice when working with cryogenic materials.

16.8 Autoclaves

Autoclaves have the following potential hazards:

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

Some general safety guidelines to follow when using autoclaves include:

- All users should be given training in proper operating procedures for using the autoclave.

- Read the owner's manual before using the autoclave for the first time.
- Operating instructions should be posted near the autoclave.
- Follow the manufacturer's directions for loading the autoclave.
- Be sure to close and latch the autoclave door.
- Some kinds of bottles containing liquids can crack in the autoclave or when they are removed from the autoclave. Use a tray to provide secondary containment in case of a spill and add a little water to the tray to ensure balanced heating.
- 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 so as to allow for enough space between items for the steam to circulate.
- Be aware that liquids, especially in large quantities, can be superheated when the autoclave is opened. Jarring them may cause sudden boiling and result in burns.
- At the end of the run, open the autoclave slowly: first open the door only a crack to let any steam escape slowly for several minutes, and then open all the way. Opening the door suddenly can scald a bare hand, arm, or face.
- Wait at least five minutes after opening the door before removing items.
- Large flasks or bottles of liquid removed immediately from the autoclave can cause serious burns by scalding if they should break in your hands. Immediately transfer hot items with liquid to a cart; never carry them in your hands.
- Wear appropriate PPE, including eye protection and insulating heat-resistant gloves.

16.9 Centrifuges

Some general safety guidelines to follow when using centrifuges are:

- Be familiar with the manufacturer's operating procedures and keep the operating manual near the unit for easy reference. If necessary, contact the manufacturer to replace manuals.
- Handle, load, clean, and inspect rotors as recommended by the manufacturer.

- Pay careful attention to instructions on balancing samples—tolerances for balancing are often very restricted. Check the condition of tubes and bottles. Make sure you have secured the lid to the rotor and the rotor to the centrifuge.

- Maintain a logbook of rotor use for each rotor, recording the speed and length of time for each use.

- To avoid catastrophic rotor failure, many types of rotors must be "de-rated" (limited to a maximum rotation speed that is less than the originally set maximum rotation speed) after a specified amount of use. If it is determined the rotor has reached the end of its useful life, it should be taken out of service and discarded.

- Use only the types of rotors that are specifically approved for use in a given centrifuge unit.

- Maintain the centrifuge in good condition. Broken door latches and other problems should be repaired before using the centrifuge.

- Whenever centrifuging biohazardous materials, always load and unload the centrifuge rotor in a Biosafety cabinet.

16.9.1 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; and
    - Decontaminating the rotor after use with radioactive or biological materials.
- Remove any rotor from use that has been dropped, shows any sign of defect or wear and tear and report it to a manufacturer's representative for inspection.

16.10 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 direct personal exposure to cryogenic fluids include:

- Frostbite - Potential hazards in handling liquefied gases and solids result because they are extremely cold and can cause severe cold contact burns by the liquid, and frostbite or cold exposure by the vapor.

- Asphyxiation - The ability of the liquid to rapidly convert to large quantities of gas associated with evaporation of cryogenic liquid spills can result in asphyxiation. For instance, nitrogen expands approximately 700 times in volume going from liquid to gas at ambient temperature. Total displacement of oxygen by another gas, such as carbon dioxide, will result in unconsciousness, followed by death. Exposure to oxygen-deficient atmospheres can cause dizziness, nausea, vomiting, loss of consciousness, and even death. Such symptoms may occur in seconds without warning. Death may result from errors in judgment, confusion, or loss of consciousness that prevents self-rescue.

  Working with cryogenic substances in confined spaces, such as walk-in coolers, can be especially hazardous. Where cryogenic materials are used, a hazard assessment is required to determine the potential for an oxygen-deficient condition. Controls such as ventilation and/or gas detection systems may be required to safeguard employees.

- Toxicity - Many of the commonly used cryogenic gases are considered to be of low toxicity, but still pose an asphyxiation hazard. Check the properties of the gases you are using because some gases are toxic (e.g., carbon monoxide, fluorine, and nitrous oxide).

- Flammability and Explosion Hazards - Fire or explosion may result from the evaporation and vapor buildup of flammable gases such as hydrogen, carbon monoxide, or methane. Liquid oxygen, while not itself a flammable gas, can combine with combustible materials and greatly accelerate combustion. Oxygen clings to clothing and cloth items, and presents an acute fire hazard.

- High Pressure Gas Hazards - Potential hazards exist in highly compressed gases because of the stored energy. In cryogenic systems, high pressures are obtained by gas compression during refrigeration, by pumping of liquids to high pressures followed by rapid evaporation, and by confinement of cryogenic fluids with subsequent evaporation. If this confined fluid is suddenly released through a rupture or break in a line, a significant thrust may be experienced. Over-pressurization of cryogenic equipment can also occur because of the phase change from liquid to gas if not vented properly. All cryogenic fluids produce large volumes of gas when they vaporize.

- Materials and Construction Hazards - The selection of materials calls for consideration of the effects of low temperatures on the properties of those materials. Some materials become brittle at low temperatures. Brittle materials fracture easily and can result in almost instantaneous material failure. Low temperature equipment can also fail because of thermal stresses caused by differential thermal contraction of the materials. Over-pressurization of cryogenic equipment can occur because of the phase change from liquid to gas if the container is not properly vented. All cryogenic fluids produce large volumes of gas when they vaporize.

16.10.1 Cryogenic Safety Guidelines

1) Responsibilities
The FDNY requires that a G-97 Certificate of Fitness holder be present whenever cryogenic liquids are used or stored in quantities greater than 60 gallons (230 liters). In addition, an oxygen (O_2) sensor must also be installed in the storage or dispensing area. Dewars are included in the gallon count. Personnel who are responsible for any cryogenic equipment must conduct a safety review prior to the commencement of operation of the equipment. Supplementary safety reviews must follow any system modification to ensure that no potentially hazardous condition is overlooked or created and that operational and safety procedures remain adequate.

2) Personal Protective Equipment (PPE)
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. If lab coats are unavailable, shirt sleeves should be rolled down and buttoned over glove cuffs in order to prevent liquid from spraying or spilling inside the gloves. Trousers should have no cuffs.

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 safety practices.
   - Transfer operations involving open cryogenic containers such as dewars must be conducted slowly to minimize boiling and splashing of the cryogenic fluid. Transfer of cryogenic fluids from open containers must occur below chest level of the person pouring the liquid.

- Only conduct such operations in well-ventilated areas, such as the laboratory, to prevent possible gas or vapor accumulation that may produce an oxygen-deficient atmosphere and lead to asphyxiation. **If this is not possible, an oxygen (O_2) sensor must be installed per FDNY code.**

- Equipment and systems designed for the storage, transfer, and dispensing of cryogenic fluids must be constructed of materials compatible with the products being handled and the temperatures encountered.

- All cryogenic systems, including piping, must be equipped with pressure relief devices to prevent excessive pressure build-up. Pressure reliefs must be directed to a safe location. It should be noted that two closed valves in a line form a closed system. The vacuum insulation jacket should also be protected by an overpressure device if the service is below 77 degrees Kelvin. In the event that a pressure relief device fails, do not attempt to remove the blockage; instead, call your EHS Office.

- The caps of liquid nitrogen dewars are designed to fit snugly to contain the liquid nitrogen but also to allow the periodic venting that will prevent an overpressurization of the vessel. Never attempt to seal the caps of liquid nitrogen dewars. Doing so can present a significant hazard of overpressurization that could rupture the container and cause splashes of liquid nitrogen and, depending on the quantity of liquid nitrogen that may be spilled, cause an oxygen deficient atmosphere within a laboratory from 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) <u>First Aid</u>

Workers will rarely, if ever, come into contact with cryogenic fluids if proper handling procedures are used. In the unlikely event of contact with a cryogenic liquid or gas, a contact “burn” may occur. The skin or eye tissue will freeze. The recommended emergency treatment is as follows:

- If the cryogenic fluid comes in contact with the skin or eyes, flush the affected area with generous quantities of cold water. Never use dry heat. Splashes on bare skin cause a stinging sensation, but, in general, are not harmful.

- If clothing becomes soaked with liquid, it should be removed as quickly as possible and the affected area should be flooded with generous quantities of cold water. 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 Public Safety or 911 for additional treatment if necessary.
- Complete an Injury/Illness Report.

16.10.2 Cryogenic Chemical Specific Information

A) Liquid Helium

Liquid helium must be transferred via helium pressurization in properly designed transfer lines. Liquid helium should not come 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

Because 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). In addition, if the mixture is exposed to radiation, ozone is formed, which freezes and becomes very unstable. An explosion can result if this ice is disturbed. For this reason, air should not be admitted to enclosed equipment that is below the boiling point of oxygen unless specifically required by a written procedure approved by the P.I. or laboratory supervisor.

Any transfer operations involving open containers such as wide-mouth dewars 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 from their EHS Office.
- Because of its wide flammability range and ease of ignition, special safety measures must be followed when using liquid hydrogen.

- Liquid hydrogen must be transferred by helium pressurization in properly designed transfer lines 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 are permitted to perform transfer operations. Transfer lines in liquid hydrogen service must be purged with helium or gaseous hydrogen before using.
- Safety principles to follow when using liquid hydrogen include:
  - 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; and
  - Limiting the amount of hydrogen "cryopumped" in the vacuum system.

16.11 Extractions and Distillations

<u>Extractions</u>

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

<u>Distillations</u>

- Avoid bumping (sudden boiling) because the force can break apart the apparatus and result in splashes. Bumping can be avoided by even heating and by using a heat mantle. Stirring can also prevent bumping. Boiling stones can be used only if the process is at atmospheric pressure.
- Do not add solid items, such as boiling stones, to liquid that is near boiling since it may result in the liquid boiling over spontaneously.
- Organic compounds should never be allowed to boil to dryness, which can result in an explosion hazard, unless they are known to be free of peroxides.

Reduced pressure distillation

- Do not overheat the liquid. Superheating can result in decomposition and uncontrolled reactions.
- Superheating and bumping often occur at reduced pressures, so it is especially important to avoid bumping and to ensure even, controlled heating. Inserting a nitrogen bleed tube may help alleviate this issue.
- Evacuate the assembly gradually to minimize bumping.
- Allow the system to cool and then slowly bleed in air. Air can cause an explosion in a hot system (pure nitrogen is preferable to air for cooling).
- Refer to section 16.12 for vacuum conditions.

16.12 Glass Under Vacuum

Some general guidelines for glass under vacuum include:

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

Specific guidelines regarding vacuum pumps include:

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

16.13 Glassware Washing

In most cases, laboratory glassware can be cleaned effectively by using detergent and water. In some cases it may be necessary to use strong chemicals for cleaning glassware. Strong acids should be avoided unless necessary. In particular, chromic acid should not be used because of its toxicity and disposal concerns. One product that may be substituted for chromic acid is “Nochromix Reagent,” an inorganic oxidizer. Unused Nochromix Reagent can be neutralized to a pH between 5.5 and 9.5. Acid/base baths should have appropriate labeling and secondary containment. In addition, an SOP should be established, and proper PPE and spill materials should be available.

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

If your department has a glass washing service, there are certain protocols that must be followed before sending the glassware to be washed. It is the responsibility of the lab to empty and rinse all glassware before it leaves the lab. Although the contents may not be hazardous, the washroom support staff cannot be certain of the appropriate PPE to wear, applicable disposal regulations, or possible incompatibilities with items received from other researchers. It is the responsibility of the glassware washing staff to reject or return glassware that is found to be broken or contain chemicals. For this reason, glassware should be labeled with the name of the person who is responsible for it.

PLEASE NOTE: Areas outside the laboratory are governed by OSHA's Hazard Communication Standard, which established more stringent chemical labeling requirements than OSHA's Laboratory Standard.

16.14 General Equipment Set Up

The following recommended laboratory techniques for general equipment are from the American Chemical Society's booklet – Safety in Academic Chemistry Laboratories.

16.14.1 Glassware and Plasticware

- Borosilicate glassware (e.g., Pyrex) is recommended for all lab glassware, except for special experiments using UV or other light sources. Soft glass should only be used for reagent bottles, measuring equipment, stirring rods, and tubing.
- Any glass equipment being evacuated, such as suction flasks, should be specially designed with thick 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 holding hazardous chemicals must be transported in rubber bottle carriers or buckets to protect them from breakage and contain any spills or leaks. Plastic containers should also be transported this way because they can break or leak as well.

16.14.2 Preparation of Glass Tubing and Stoppers

Follow these safety precautions when cutting 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 its circumference.
- Cover the tubing with cloth and hold the tubing in both hands away from the body. Place thumbs on the tubing 2 to 3 cm opposite the nick and extended toward each other.
- Push out on the tubing with the thumbs as you snap the sections apart. 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 glass tubing.
- All glass tubing, including stir rods, should be fire polished before use. Unpolished tubing can cut skin as well as inhibit insertion into stoppers. After polishing or bending glass, give ample time for it to cool before grasping it.

Follow these guidelines 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 with the fingers while 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. 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-half of the stopper is inserted.
- Glassware with ground joints is preferable. Glass stoppers and joints should be clean, dry, and lightly lubricated.

16.14.3 Insertion of Glass Tubes or Rods into Stoppers

Follow these guidelines to 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. Be sure to 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.

16.14.4 Assembling Apparatus

Follow these recommendations to help make apparatus assembly easier and equipment safer:

- Keep your work space free of clutter.
- Keep your apparatus clean, dry, firmly clamped, and well back from the edge of the lab bench. Allow adequate space between your apparatus and the equipment of others. Choose sizes that can properly accommodate the operation to be performed.
- Use only equipment that is free from flaws such as cracks, chips, frayed wire, and obvious defects. Glassware can be examined in polarized light for strains. Even the smallest crack or chip can render glassware unusable. Cracked or chipped glassware should be repaired or discarded.
- A properly placed pan under a reaction vessel or container will act as secondary containment to confine spilled liquids in the event of glass breakage.
- Do not work with flammable gases or liquids near burners or other ignition sources. Use appropriate traps, condensers, or scrubbers to minimize release of material to the environment. If a hot plate is used, ensure that the temperatures of all exposed surfaces are below the autoignition temperature of the chemicals likely to be released and that the temperature control device and the stirring / ventilation motor (if present) do not spark.
- Whenever possible, use controlled electrical heaters or steam instead 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 should be secured with wire or clamps.

- Stirrer motors and vessels should be secured to maintain proper alignment. Magnetic stirring is preferable. Only non-sparking motors, such as air motrors, should be used in chemical laboratories.

- 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 provisions 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 aisles to avoid creating a tripping hazard.

- Never heat a closed container. Provide a vent as part of the apparatus for chemicals that are to be heated. Prior to heating a liquid, place boiling stones in unstirred vessels (except test tubes). If a burner is used, distribute the heat with a ceramic-centered wire gauze. Use the thermometer with its bulb in the boiling liquid if there is the possibility of dangerous exothermic decomposition, as may occur in some distillations. This will provide a warning and may allow time to remove the heat and apply external cooling.

- Whenever hazardous gases or fumes are likely to be emitted, an appropriate gas trap should be used and the operation should be confined to a fume hood.

- Fume hoods are recommended for all operations in which toxic or flammable vapors are emitted, 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 very long distances and, if flammable, an ignition can cause a flash back to the source of vapors. Once diluted with significant amounts of air, vapors move in air as it circulates.

- Use a fume 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 should be secured near the top. Proper eye and face protection must be worn even when using safety shields or fume hoods.

16.14.5 Mercury Containing Equipment

Elemental mercury (Hg) or liquid mercury is commonly seen in thermometers, barometers, diffusion pumps, sphygmomanometers, thermostats, high intensity microscope bulbs, fluorescent bulbs, UV lamps, batteries, Coulter Counters, boilers, ovens, and welding machines. Most of these items can be substituted with non-mercury containing equipment, thus greatly decreasing the hazard potential. Larger laboratory equipment may be more difficult to identify as "mercury containing" because of the fact that mercury can be hidden inside inner components such as switches or gauges.

Follow these recommendations to minimize the potential for mercury spills and possible exposures:

- Identify and label "Mercury Containing Equipment".
- Develop an SOP for handling mercury containing equipment
- Train personnel on proper use, maintenance, transport and disposal.
- Conduct periodic inspections of equipment to ensure that no leaks or spills have occurred.
- Consider replacing mercury with electronic or other replacement components.
- Provide proper PPE, such as nitrile gloves.
- Use secondary containment, such as trays, as a precaution for spills.
- Plan for an emergency, such as a spill or release of mercury.
- Decontaminate and remove mercury before long-term storage, transport, or disposal.
- For new equipment purchases, please attempt to procure instruments with no mercury

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APPENDIX A: CHEMICAL HYGIENE PLAN REQUIREMENTS

The Occupational Safety and Health Administration (OSHA) 29 CFR 1910.1450, "Occupational Exposure to Hazardous Chemicals in Laboratories" mandates the development of a Chemical Hygiene Plan (CHP) 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 Laboratory Standard requires that a CHP be in place for each laboratory workplace existing on a college campus.** The following required elements of a CHP are excerpted from the Laboratory Standard.

1910.1450(e)(3) The Chemical Hygiene Plan shall include each of the following elements and shall indicate specific measures that the employer will take to ensure laboratory employee protection:

(e)(3)(i) ***Standard operating procedures*** relevant to safety and health considerations to be followed when laboratory work involves the use of hazardous chemicals;

(e)(3)(ii) Criteria that 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;

(e)(3)(iii) A requirement that ***fume hoods and other protective equipment*** are functioning properly and specific measures that shall be taken to ensure proper and adequate performance of such equipment;

(e)(3)(iv) Provisions for ***employee information and training*** as prescribed in paragraph (f) of this section;

(e)(3)(v) The circumstances under which a particular laboratory operation, procedure or activity shall require *prior approval* from the employer or the employer's designee before implementation;

(e)(3)(vi) Provisions for ***medical consultation and medical examinations*** in accordance with paragraph (g) of this section;

(e)(3)(vii) Designation of ***personnel responsible for implementation*** *of the Chemical Hygiene Plan* including the assignment of a Chemical Hygiene Officer, and, if appropriate, establishment of a Chemical Hygiene Committee; and

(e)(3)(viii) ***Provisions for additional employee protection for work with particularly hazardous substances***. These include "select carcinogens," reproductive toxins and substances with a high degree of acute toxicity. Specific consideration shall be given to the following provisions which shall be included where appropriate:
(e)(3)(viii)(A) Establishment of a designated area;
(e)(3)(viii)(B) Use of containment devices such as fume hoods or glove boxes;
(e)(3)(viii)(C) Procedures for safe removal of contaminated waste; and
(e)(3)(viii)(D) Decontamination procedures.
(e)(4) The employer shall review and evaluate the effectiveness of the Chemical Hygiene Plan at least annually and update it as necessary.

(f) ***Employee information and training***.
(f)(1) The employer shall provide employees with information and training to ensure that they are apprised of the hazards of chemicals present in their work area.
(f)(2) 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. The frequency of refresher information and training shall be determined by the employer.
(f)(3) ***Information***. Employees shall be informed of:
(f)(3)(i) The contents of this standard and its appendices which shall be made available to employees;
(f)(3)(ii) the location and availability of the employer's Chemical Hygiene Plan;
(f)(3)(iii) The permissible exposure limits for OSHA regulated substances or recommended exposure limits for other hazardous chemicals where there is no applicable OSHA standard;
(f)(3)(iv) Signs and symptoms associated with exposures to hazardous chemicals used in the laboratory; and
(f)(3)(v) The location and availability of known reference material on the hazards, safe handling, storage and disposal of hazardous chemicals found in the laboratory including, but not limited to, Material Safety Data Sheets received from the chemical supplier.
(f)(4) ***Training.***
(f)(4)(i) Employee training shall include:
(f)(4)(i)(A) Methods and observations that may be used to detect the presence or release of a hazardous chemical (such as monitoring conducted by the employer, continuous monitoring devices, visual appearance or odor of hazardous chemicals when being released, etc.);
(f)(4)(i)(B) The physical and health hazards of chemicals in the work area; and
(f)(4)(i)(C) 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 personal protective equipment to be used.
(f)(4)(ii) The employee shall be trained on the applicable details of the employer's written Chemical Hygiene Plan.

(g) ***Medical consultation and medical examinations***.
(g)(1) The employer shall provide all employees who work with hazardous chemicals an opportunity to receive medical attention, including any follow-up examinations which the examining physician determines to be necessary, under the following circumstances:
(g)(1)(i) Whenever an employee develops signs or symptoms associated with a hazardous chemical to which the employee may have been exposed in the laboratory, the employee shall be provided an opportunity to receive an appropriate medical examination.
(g)(1)(ii) Where exposure monitoring reveals an exposure level routinely above the action level (or in the absence of an action level, the PEL) for an OSHA regulated substance for which there are exposure monitoring and medical surveillance requirements, medical surveillance shall be established for the affected employee as prescribed by the particular standard.
(g)(1)(iii) Whenever an event takes place in the work area such as a spill, leak, explosion or other occurrence resulting in the likelihood of a hazardous exposure, the affected employee shall be provided an opportunity for a medical consultation. Such consultation shall be for the purpose of determining the need for a medical examination.
(g)(2) All medical examinations and consultations shall be performed by or under the direct supervision of a licensed physician and shall be provided without cost to the employee, without loss of pay and at a reasonable time and place.
(g)(3) Information provided to the physician. The employer shall provide the following information to the physician:
(g)(3)(i) The identity of the hazardous chemical(s) to which the employee may have been exposed;
(g)(3)(ii) A description of the conditions under which the exposure occurred including quantitative exposure data, if available; and
(g)(3)(iii) A description of the signs and symptoms of exposure that the employee is experiencing, if any.
(g)(4) Physician's written opinion.
(g)(4)(i) For examination or consultation required under this standard, the employer shall obtain a written opinion from the examining physician which shall include the following:
(g)(4)(i)(A) Any recommendation for further medical follow-up;
(g)(4)(i)(B) The results of the medical examination and any associated tests;
(g)(4)(i)(C) Any medical condition which 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; and
(g)(4)(i)(D) 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.
(g)(4)(ii) The written opinion shall not reveal specific findings of diagnoses unrelated to occupational exposure.

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APPENDIX B: CONTACT LIST

Campus: ____________

	Name	Phone Number
Chemical Hygiene Officer		
Associate Chemical Hygiene Officer		
Chemical Inventory Contact		
Hazardous Materials Specialist		
Hazardous Materials Shipping Program Coordinator		
Radiation Safety Officer		
Biological Safety Officer		
LASER Safety Officer		
EHS Officer		
Public Safety		

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APPENDIX C: COMPILED LAB SAFETY RESPONSIBILITIES

1) It is the responsibility of the P.I.s 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 (SOPs) and any department or college level laboratory safety manuals, policies, and procedures. (Section 1.1)

2) It is the responsibility of the P.I.s and laboratory supervisors to be in compliance with all federal, state, and local regulatory requirements as well as with any other department, college, or university-specific policies. (Section 1.2)

3) It is the responsibility of laboratory personnel to report malfunctioning protective equipment, such as fume hoods, or mechanical problems to their EHSO as soon as any malfunctions are discovered. (Section 2.1)

4) P.I.s, laboratory supervisors, departments, and colleges should establish minimum PPE requirements for personnel working in and entering their laboratories. Be sure to check with your EHSO to see if there is any department or college-specific requirements for PPE. (Section 3.1)

5) It is the responsibility of the P.I.s and laboratory supervisors to ensure that 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. (Section 3.2)

6) The P.I.s and laboratory supervisors are strongly encouraged to make eye protection a mandatory requirement for all laboratory personnel, including visitors, working in or entering laboratories under their control. (Section 3.3)

7) The P.I.s and laboratory supervisors are strongly encouraged to forbid 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 3.5)

8) The P.I.s and laboratory supervisors are strongly encouraged 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 3.8)

9) It is the responsibility of the P.I.s and laboratory supervisors 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 4.0)

10) It is the responsibility of the P.I.s and laboratory supervisors to ensure that 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 protect against exposure. In addition, P.I.s and laboratory supervisors must ensure that personnel working in laboratories under their supervision have been trained on those SOPs. (Section 4.1)

11) It is the responsibility of the P.I.s and laboratory supervisors to ensure that laboratories under their supervision are maintained in a clean and orderly manner and that personnel working in the lab practice good housekeeping. (Section 4.3)

12) It is the responsibility of the P.I.s and laboratory supervisors to ensure that procedures for working alone are developed and followed by personnel working in laboratories under their supervision. (Section 4.6)

13) It is the responsibility of the P.I.s and laboratory supervisors to ensure that procedures for unattended operations are developed and followed by personnel working in laboratories under their supervision. (Section 4.8)

14) It is the responsibility of the Department Chairperson, P.I., and/or laboratory supervisor to restrict access of visitors and children to areas under their supervision when potential health and physical hazards exist. (Section 4.9.1)

15) It is the responsibility of laboratory personnel to activate (flush) emergency showers and eyewash units once a week. (Section 5.5.1)

16) It is the responsibility of the P.I.s and laboratory supervisors to ensure that all injuries are reported to campus officials through the use of their college injury/illness reporting system. (Section 5.5)

17) It is the responsibility of the P.I.s and laboratory supervisors to ensure that 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 6.0)

18) It is the responsibility of P.I.s 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 MSDSs (and other sources of information) for all hazardous chemicals used in laboratories under their supervision.(Section 7.3)

19) While your EHSO 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 P.I. or laboratory supervisor. (Section 9.5)

20) It is the responsibility of the P.I.s and laboratory supervisors to ensure that personnel working in laboratories under their supervision are familiar with and follow hazardous chemical waste container requirements and have attended Chemical Waste Disposal training. (Section 10.0)

21) It is the responsibility of the P.I.s and laboratory supervisors to ensure that any employee working under their supervision who ships or prepares shipments of hazardous materials have received the proper training. (Section 11.0)

22) It is the responsibility of the P.I.s and laboratory supervisors to ensure that all work with pesticides at CUNY is conducted properly and legally. When using pesticides in a non-dispersive manner in a laboratory setting, one must follow the safety rules outlined in the CUNY Laboratory Safety Manual. (Section 12.0)

23) It is the responsibility of the P.I.s and laboratory supervisors to ensure that biological safety cabinets within laboratories under their supervision are certified annually. (Section 13.5.1)

24) It is the responsibility of the P.I.s and laboratory supervisors with class 3b or 4 LASERs in laboratories under their supervision to ensure that the class 3b or 4 LASERs have been registered with your EHS Office, and that employees using these LASERs have received the appropriate training. (Section 15.0)

25) It is the responsibility of the P.I.s and laboratory supervisors 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 16.0)

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APPENDIX D: STANDARD OPERATING PROCEDURE EXAMPLES

The following links are examples of SOPs from other university websites:

Disclaimer: The accuracy of the information contained within these links and SOPs has not been verified. It is the responsibility of the laboratory personnel to ensure that the accuracy of these non-CUNY SOPs.* ***These links are being provided only as examples and each lab should write an SOP that is specific to their processes and procedures.*

- A list of SOP examples and resources on the web from the University of Maryland
- The SOP library (with numerous examples) from the University of California - Irvine
- The Michigan State University SOP webpage (with a number of examples)
- A blank form that can generate a custom SOP online – Michigan State University.
- Example of a chemical specific information sheet type SOP (generic – not lab specific) – University of California, Irvine
- A blank template for chemical specific or chemical group SOP - University of California, Irvine
- An example of a chemical list SOP (generic – not lab specific) – University of Pennsylvania

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APPENDIX E: LAB MOVE GUIDE

This document provides general guidance to those laboratory personnel preparing to move their laboratory work to another technical facility or to a new facility. Moving a research laboratory can be a complex process, especially if hazardous materials are involved. However, the steps outlined below can help to ensure a safe and smooth transition. If you are moving your laboratory and have specific questions, contact your EHSO.

GENERAL CONSIDERATIONS

- Once you have made the decision to move your lab, inform your EHSO as soon as possible, well in advance of your planned move. Your EHSO can help provide useful information and resources to help facilitate the moving process. If you will be moving to another facility in a different department, identify and contact the new EHSO and let them know you are planning a lab move to their facility.

- When cleaning up your old lab, please be considerate of the next occupants (custodial staff, maintenance workers, and new laboratory staff) and ensure that all items are removed from the lab (or scheduled to be removed), including items in drawers, cabinets, fume hoods, refrigerators, and freezers.

- Keep in mind the value of limited laboratory space when cleaning out your old lab. Now is the time to discard old equipment, paper, boxes, and other materials that have not been used in a long time (and will not be used in the foreseeable future). For any surplus equipment or furniture that you plan on discarding, check with your EHSO to see if these items should remain in the lab you are leaving or if they could be donated to someone else in your department or on your campus.

- Before the actual move occurs, visit the new facility and identify where equipment from the old facility will be located. Check to see if the correct electrical, water, gas, and space requirements are available for your new equipment and processes. Conducting this type of preplanning will greatly facilitate the moving process and occupation of your new facility.

- When moving equipment and materials to the new facility, keep in mind that no equipment, boxes, or other materials may be stored in hallways, stairwells, or other egress points used in the event of a fire or other emergency. If you do need to temporarily store these items in the hallway, please contact your EHSO so proper arrangements can be made. All items must be removed from the hallways by the end of each day so as not to accumulate. At no time may hazardous materials (chemical, biological, or radiological) be left in the hallways unattended.

- When you arrive at the new facility, identify the location of emergency eyewashes and safety showers, fire extinguishers, and other safety equipment before bringing hazardous materials to the new lab. Do not block access to emergency eyewashes and safety showers at any time. Do not stack boxes under or around emergency eyewashes or safety showers, even on a temporary basis.

- If fire extinguishers are not present in the new facility, alert your EHSO immediately. If you have not been trained in the use of fire extinguishers, you can obtain this training from your EHSO.

- For laboratories with fume hoods, keep in mind that fume hoods come in a variety of designs and can function differently than hoods at your old facility. Familiarize yourself with the new hoods before conducting any work involving hazardous materials.

- As part of your move, update your standard operating procedures.

- At the completion of your move, return all keys to the old facility to your current EHSO and provide her/him with your contact information at your new facility in case questions arise during laboratory renovation of your old facility.

<u>CHEMICALS</u>

- Before preparing to move chemicals to your new lab, now is the time to inventory all of your chemicals or update your current chemical inventory form.

- Only move those chemicals that will be needed for your research at the new facility or those chemicals you expect to use in the near future. Before your move, now is the time to get rid of old, outdated chemicals or chemicals that do not have any foreseeable use in the new facility. For those chemicals that are in good condition, contact your EHSO to see if anyone in your department could use the chemicals or if the chemicals could be included in the campus chemical recycling program. All other chemicals that cannot or will not be used in the new facility should be disposed of properly.

- Do not move containers of chemical wastes to your new facility. Contact the EHS Office for proper disposal of any hazardous wastes laboratory cleanouts. The EHSO can provide assistance with making waste determinations including hazardous waste, universal waste, biomedical waste, radioactive waste, and oil waste.

- Only trained laboratory workers may move chemicals. Any highly toxic or hazardous chemicals should only be moved by personnel who have received special training. When moving highly toxic or highly hazardous chemicals, it is recommended to use a "buddy system" in the event of a spill or other emergency.

- When moving chemicals, be sure all containers are properly labeled and all are securely closed. When transporting chemicals, it is best to use DOT approved shipping containers. **Please note that there are special regulations associated with transporting hazardous chemicals off campus**. When packaging chemicals, use a packing material (such as vermiculite, ground corn cobs, shipping peanuts, cardboard, or absorbent clay) that is compatible with the chemicals to prevent bottle breakage during transport. Only place chemicals that are compatible with each other in the same container and do not overload containers of chemical bottles.

- When transporting chemicals, it is best to use carts with lips or trays to prevent containers from being knocked off. Other items that are useful for transport include rubber bottle carriers, five gallon pails, or other forms of secondary containment.

- When moving chemicals, wear appropriate PPE such as safety glasses (splash goggles for corrosives), lab coat, and gloves. Remember to remove gloves when touching door knobs, latches, and elevator buttons. If possible, avoid using passenger elevators. If you must use a passenger elevator, request that no passengers ride along with you.

- After removing all chemicals and waste from your old lab facility, ensure that all spills have been cleaned up and all potentially contaminated surfaces have been cleaned with water and detergent thoroughly. This includes bench tops, fume hoods, storage cabinets, and drawers (both inside and outside), shelving, and the outside of large equipment that is scheduled to be moved by a moving company. Remember to clean out refrigerators and freezers thoroughly and defrost freezers. Please keep in mind the next immediate occupants of your old lab will be custodians and maintenance workers. Please be considerate of their health and safety by thoroughly cleaning up any potentially hazardous (chemical, biological, and radiological) contamination.

- When storing chemicals in your new lab, remember to segregate and store chemicals according to hazard class. To help prevent spills, use some form of secondary containment, such as trays, buckets, or bottle carriers, when storing chemicals.

COMPRESSED GAS CYLINDERS

- Before moving to your new facility, be sure to make arrangements for the removal of any compressed gas cylinders that will no longer be used or for any empty cylinders. If you need assistance having the cylinders removed, contact your EHSO.

- Before moving any compressed gas cylinders, remove the regulator and replace the safety cap over the cylinder valve. Only use an appropriate cylinder handcart to move compressed gas cylinders. Do not attempt to "roll" cylinders from one area to another.

- Any compressed cylinders containing highly toxic or highly reactive gases should only be moved by staff with special training in the use and hazards of these materials.

- After moving compressed gas cylinders, secure them with a strap or chain at once (chains are preferred). Do not leave compressed gas cylinders unsecured for any period of time, even temporarily. Any new gas distribution systems, using metal or plastic tubing, must be pressure tested (leak tested) before use. All cylinders must either have a regulator or a cap depending on if it is in use or stored.

BIOHAZARDOUS MATERIALS

- All biohazardous materials must be properly packaged and only moved by properly trained laboratory staff. Non-laboratory personnel (including moving company staff) or untrained laboratory personnel are not permitted to move biohazardous materials.

- All potentially contaminated equipment and surfaces, such as bench tops, fume hoods, storage cabinets and drawers (both inside and outside), shelving, refrigerators, freezers, incubators, and the outside of large equipment that is scheduled to be moved by a moving company, must be thoroughly decontaminated. Please be considerate of the health and safety of future occupants by thoroughly cleaning up any potentially hazardous (chemical, biological, and radiological) contamination.

- Before moving to the new facility, dispose of all biohazardous waste properly.

- Keep in mind that certain types of research, such as that with recombinant DNA and some pathogens, may need to have prior approval or registration for use at your new location. Check with the appropriate college or university committee well in advance of your move to see if campus prior approval is required.

- If you are having your Biosafety Cabinet (BSC) moved to your new location, thoroughly decontaminate both the inside and outside of the cabinet. You will also need to have the BSC recertified by a third party. Check with the manufacturers guidelines before moving your BSC.

RADIOACTIVE MATERIALS

- PLEASE NOTE: All of the following steps must be coordinated through the appropriate EHS staff member. Please keep in mind that advance notification of your planned move is required.

- Please remember that no space may be occupied for the use of radioisotopes until the area has been setup by the Radiation Safety Officer (RSO). Contact your EHS office for more information.

- Any equipment to be handled by movers and not by laboratory staff must be certified as contamination free before the equipment is moved.

- Only properly trained staff may move radioactive materials and small equipment used with radioactive materials. All materials must be properly packaged and shielded.

- Before your planned move, properly dispose of any radioactive waste. Do not bring full containers of radioactive waste to your new lab.

- All vacated rooms must be certified by the RSO as contamination free before they are turned over to custodians, maintenance workers, or new lab occupants.

DECOMMISSIONING FACILITIES AND EQUIPMENT

Laboratory renovations may require more formal decommissioning procedures of both facilities and equipment depending on the extent of renovation and the past use of the room and/or facility. Decommissioning procedures include:

- Standardized processes, strategies, and validation methods for screening and characterization of hazardous debris and other regulated waste streams and for compliance with hazardous waste regulations;

- Strategies to minimize the generation of regulated wastes, to encourage on-site treatment and the use of decontamination technologies, and to maximize recycling/recovery of materials; and

- Cost-benefit analysis of decontamination and recycling versus disposal without decontamination.

Areas and materials of concern for decommissioning of facilities and equipment include:

- Asbestos containing materials including floor tiles, insulation, fireproofing, and fume hood panels;
- Chemical and biological contamination and/or spills;
- Fluorescent light bulbs;
- Fume hoods;
- Gas cylinders and lecture bottles;
- Lead shielding;
- Mercury sources including sink traps, thermometers, and switches;
- PCBs found in window caulking, transformers, and ballasts;
- Perchloric acid hoods;
- Reaction chambers;
- RCRA heavy metals;
- Unknown chemicals; and
- Vacuum pumps.

<u>SPECIFIC ROLES AND RESPONSIBILITIES FOR DECOMMISSIONING ACTIVITIES</u>

<u>EHS roles/responsibilities include:</u>

- Provide the initial EHS assessment;
- Provide technical guidance and advice;
- Advise on decontamination and hazardous chemical waste disposal;
- Ensure compliance with laws, regulations, policies, and guidelines;
- Provide continuous EHS related updates of the plan or project on the basis of new evidence, findings, or information;
- Provide continual review of project decommissioning as new information is obtained; and
- Perform or review appropriate risk assessment.

<u>Research staff members' roles/responsibilities include:</u>

- Provide advice on needs, concerns, and issues with lab decommissioning to EHS;
- Provide EHS with historical use of biohazardous materials, radioactive materials, and hazardous chemical usage for decontamination analysis;

- Identify and label materials (both biological and chemical) and create an inventory to be submitted to EHS;
- Segregate chemicals in accordance to the compatibility and pack them into a sturdy container/box for transportation. EHS can provide research groups with information and assistance with segregation and proper packaging of hazardous chemicals;
- Clean work and storage surfaces with soap and water, giving special attention to areas with visible decontamination; and
- Identify biological/chemical contaminated area(s) that cannot be cleaned and work with EHS to facilitate decontamination of the area(s).

Additional guidance on decommissioning procedures can be found in the ANSI standard – Z9.11-2008 – Laboratory Decommissioning. If you have additional questions or would like more information, then please contact your EHSO.

SUMMARY

In conclusion, the above steps are ways laboratory staff can ensure that a planned move to a new facility goes smoothly. The guidelines mentioned above and the following key points will help to provide a safe and successful transition to your new laboratory facility:

- Plan the move well in advance, including providing proper notification where required.

- Pre-plan where items and equipment in your new lab will be placed before you begin the move.

- Take advantage of the move to dispose of old or discontinued items, equipment, and chemicals.

- Keep your current (and new) EHSO informed of the progress of the move.

- Contact your EHSO if you have any questions.

- Once in your new lab, check with Facilities Management to find out about any building specific procedures.

Please be courteous to the new occupants of your old lab. Leave your old lab in the condition you want your new lab to be in when you arrive.

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APPENDIX F: 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)
Polyoxyethylene-sorbital-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'-Tetramethyl-benzidine (TMB)	Nitrile	Nitrile, double glove
N,N,N',N'-Tetramethyl-ethylenediamine (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, The City University of New York has not investigated the accuracy of the information contained within the WebPages.

All Safety Products, Inc – Glove Selection Chart

Ansell Protective Products – See Ansell Chemical Resistance Guide

Best Gloves - Comprehensive Guide to Chemical Resistant Best Gloves

Cole Parmer – Safety Glove Selection Guide

Kimberly Clark Professional – Chemical Resistance Database

Mapa Professional – Chemical Resistance Guide

Microflex – Chemical Resistance Guide

North Safety - Chemical Resistance Guide

Argonne National Laboratory – Glove Selection Guideline

Oklahoma State University – Chemical Guide

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APPENDIX G: LABORATORY SELF-INSPECTION CHECKLIST

Department: ……………….. Room: ....

Principal Investigator: ....

Today's Date: ....

Telephone No. ....

Certificate of Fitness #...

Expires: ....

Y = Yes N = No N/A = Not Applicable

I. Laboratory signs	Y	N	N/A
"Laboratory"	☐	☐	☐
"Flammable Gases"	☐	☐	☐
"LASER Operating"	☐	☐	☐
"Radioactive Materials"	☐	☐	☐
"Water-Reactive Chemicals"	☐	☐	☐
"Biohazard"	☐	☐	☐
"Fire Extinguisher"	☐	☐	☐
"No Smoking"	☐	☐	☐
"Class IV Laboratory Limits"	☐	☐	☐
"No Smoking Eating or Drinking in the Lab."	☐	☐	☐
"Safe Hood Operation"	☐	☐	☐
"Eyewash"	☐	☐	☐
"Safety Shower"	☐	☐	☐
"Spill Cleanup Materials"	☐	☐	☐
"Caution-Food Must Not Be Stored In This ..."	☐	☐	☐
"Store No Flammables Flashing Below 100^0 F.."	☐	☐	☐
"Caution - Do Not Use For Food"	☐	☐	☐
"Flammable - Keep Fire Away" +/or "Corrosive"	☐	☐	☐

II. Emergency Preparedness:			
Emergency telephone numbers posted	☐	☐	☐
All exits clear and unobstructed	☐	☐	☐
Fire Extinguishers:			
Locations clearly visible/unobstructed	☐	☐	☐
Inspected within the last year	☐	☐	☐
Correct for flammable hazards present	☐	☐	☐
Safety showers present and working	☐	☐	☐
Eyewash stations present and working	☐	☐	☐

III. Housekeeping:			
Counters & floors are uncluttered	☐	☐	☐
Passageways are clear	☐	☐	☐
Broken glass/syringe disposal containers provided where needed & clearly labeled	☐	☐	☐
No storage within 18" of sprinkler heads	☐	☐	☐
Warning signs current, no frivolous warnings are posted	☐	☐	☐

IV. Compressed Gas			
No long-term storage of corrosive gases	☐	☐	☐
All cylinders secured in place	☐	☐	☐
Oxygen & flammable gases are stored separately from each other	☐	☐	☐
Cylinders hydrostatically in the past 10 years	☐	☐	☐

V. Mechanical Hazards			
Machine guarding is in place (e.g., vacuum pumps, lock-out/tag-out of equipment	☐	☐	☐

VI. Electrical Hazards			
Electrical equipment is double insulated or grounded (e.g., 3-prong plug)	☐	☐	☐
Electric cords in good condition	☐	☐	☐
Exposed circuits are barricaded when energized	☐	☐	☐
Electrical service panels unobstructed	☐	☐	☐

VII. Ventilation (Lab Hoods):			
Hood sash is in place & operable	☐	☐	☐
Sash is used at proper working height	☐	☐	☐
Equipment positioned at least 6" into hood	☐	☐	☐
Airflow unobstructed by equipment./material	☐	☐	☐
Lab doors are kept closed	☐	☐	☐
Hood interior is clean and uncluttered	☐	☐	☐
Airflow indicator is used	☐	☐	☐

VIII. Personal Protective Equipment:	Y	N	N/A
Safety goggles are available and worn	☐	☐	☐
Face shields & safety shields available	☐	☐	☐
Appropriate gloves are available and used	☐	☐	☐
Lab coats/aprons are worn	☐	☐	☐
Appropriate shoes are worn	☐	☐	☐
Hearing protection worn when noise interferes with normal speech	☐	☐	☐

IX. Chemical Storage			
Chemical stocks kept at a minimum	☐	☐	☐
FDNY flammable/combustible liquid limits are observed	☐	☐	☐
Grounding straps used appropriately with flammable gases/liquids	☐	☐	☐
Chemical compatibilities are recognized & observed in storage design	☐	☐	☐

	Y	N	N/A
Containers and closures are in good condition	☐	☐	☐
Highly reactive substances are disposed of before expiration date, or when no longer needed (THF, Ether …)	☐	☐	☐
All chemical containers are properly labeled (chemical name, hazardous properties, date, name of owner)	☐	☐	☐

X. Waste Management

	Y	N	N/A
Efforts are made to minimize waste generated (scaling down reaction size, reuse of solvents when feasible, etc.)	☐	☐	☐
Waste Containers are sound	☐	☐	☐
Waste Containers are compatible with waste	☐	☐	☐
Waste containers properly labeled, including the words Hazardous Waste?	☐	☐	☐
The contents of the container clearly listed	☐	☐	☐
Container closed with a properly fitting cap	☐	☐	☐
Waste containers are in secondary containment trays	☐	☐	☐
Waste in same secondary containment trays compatible with each other	☐	☐	☐
The waste containers located in the lab (not in hallway or storeroom)	☐	☐	☐
Less than 55 gallons of waste in the laboratory	☐	☐	☐
Waste located away from floor drains or sinks	☐	☐	☐
Full containers being taken to the main accumulation area for proper disposal	☐	☐	☐
Hoods are not used for waste disposal	☐	☐	☐

XII. Hazards Intrinsic to Our Work:

	Y	N	N/A
....	☐	☐	☐
....	☐	☐	☐
....	☐	☐	☐
....	☐	☐	☐
....	☐	☐	☐
....	☐	☐	☐
....	☐	☐	☐
....	☐	☐	☐
....	☐	☐	☐
....	☐	☐	☐

XI. Spill Cleanup

	Y	N	N/A
Lab workers know where spill cleanup procedures & materials are available	☐	☐	☐
Lab workers are trained in spill cleanup	☐	☐	☐

Additional Safety Concerns Observed:

....

....

....

....

....

....

General Comments:

....

....

....

APPENDIX H: HOW TO UNDERSTAND AN MSDS

Chemical manufacturers are required by law to supply "Material Safety Data Sheets" (OSHA Form 174 or its equivalent) upon request by their customers. These sheets have nine sections giving a variety of information about the chemical. The following is a section-by-section reproduction and explanation of a Material Safety Data Sheet (MSDS).

U.S. DEPARTMENT OF LABOR
Occupational Safety and Health Administration
MATERIAL SAFETY DATA SHEET
Required For compliance with OSHA Act of 1970
Public Law 91-596 (CFR 1910)

SECTION I	
Product Name	Size
Chemical Name	
Formula	
Manufacturer	
Address	
For Information on Health Hazards Call	
For Other Information Call	
Signature and date	

This section gives the name and address of the manufacturer and an emergency phone number where questions about toxicity and chemical hazards can be directed. Large chemical manufacturers have 24-hour hotlines manned by chemical safety professionals who can answer questions regarding spills, leaks, chemical exposure, fire hazard, etc. Other information that may be contained in Section I includes:

Trade Name: This is the manufacturer's name for the product.

Chemical Name and Synonyms: This refers to the generic or standard names for the chemical.

Chemical Family: This classification allows one to group the substance along with a class of similar substances, such as mineral dusts, acids, caustics, etc. The potential hazards of a substance can sometimes be gauged by experience with other chemicals of that hazard class.

SECTION II - HAZARDOUS INGREDIENTS OF MIXTURES		
Principal Hazardous component(s)	%	TVL (Units)

This section describes the percent composition of the substance, listing chemicals present in the mixture. It lists Threshold Limit Values for the different chemicals that are present. Threshold Limit values (TLV's) are values for airborne toxic materials that are used as guides in the control of health hazards. They represent concentrations to which nearly all workers (workers without special sensitivities) can be exposed to for long periods of time without harmful effect. TLV's are usually expressed as parts per million (ppm), the parts of gas or vapor in each million parts of air. TLV's are also expressed as mg/m^3, the milligrams of dust or vapor per cubic meter of air.

SECTION III - PHYSICAL DATA			
Boiling Point (^oF)		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			

This section gives information about the physical characteristics of the chemical. This information can be very useful in determining how a chemical will behave in a spill situation and what appropriate steps should be taken.

Vapor Pressure: Vapor pressure (VP) can be used as a measure of how volatile a substance is…how quickly it evaporates. VP is measured in units of millimeters of mercury (mm Hg). For comparison, the VP of water (at 20^o Centigrade) is 17.5 mm Hg. The VP of Vaseline (a nonvolatile substance) would be close to zero mm Hg, while the VP of diethyl ether (a very volatile substance) is 440 mm Hg.

Vapor Density: Vapor density describes whether the vapor is lighter or heavier than air. The density of air is 1.0. A density greater than 1.0 indicates a heavier vapor, a density less than 1.0 indicates a lighter vapor. Vapors heavier than air (gasoline vapor for instance) can flow along just above the ground and can collect in depressions where they may pose a fire and explosion hazard.

Specific Gravity: Specific gravity describes whether the liquid is lighter or heavier than water. Water has a specific gravity of 1.0.

Percent Volatile by Volume: Describes how much of the substance will evaporate.

<table>
<tr><th colspan="5">SECTION IV - FIRE AND EXPLOSION HAZARD DATA</th></tr>
<tr><td>Flash Point (°F)</td><td colspan="2">Flammable Limits in Air (% by Vol.)</td><td>Lower</td><td>Upper</td></tr>
<tr><td colspan="2">Extinguisher Media</td><td colspan="3">Autoignition Temperature (°F)</td></tr>
<tr><td colspan="5">Special Fire Fighting Procedures</td></tr>
<tr><td colspan="5">Explosion Hazards</td></tr>
</table>

This section gives information, which is important for preventing and extinguishing fires and explosions. If a fire does occur, this information should be made available to fire fighters.

Flash Point: Flash point is the lowest temperature at which a liquid gives off enough vapor to ignite when a source of ignition is present. A fire or explosion hazard may exist if the substance is at or above this temperature and used in the presence of spark or flame.

Flammable Limits: In order to be flammable, a substance must be mixed with a certain amount of air (as in an automobile carburetor). A mixture that is too "lean" (not enough chemical) or too "rich" (not enough air) will not ignite. The Lower Explosive Limit (LEL) and the Upper Explosive Limit (UEL) define the range of concentration in which combustion can occur. The wider the range between the LEL and UEL, the more flammable the substance is.

SECTION V - HEALTH HAZARD DATA
Threshold Limit Value
Effects of Overexposure
Acute Overexposure
Chronic Overexposure
Emergency and First Aid Procedures
Inhalation
Eyes
Skin
Ingestion

This section describes the potential health effects resulting from overexposure to the chemical and gives emergency and first aid procedures. The symptoms and effects listed are the effects of exposure at hazardous levels. Most chemicals are safe in normal use and the vast majority of workers never suffer toxic effects. However, any chemical can be toxic in high concentrations, and the precautions outlined in the MSDS should be followed.

The health hazards section often contains information on the toxicity of the substance. The data most often presented are the results of animal experiments. For example, "LD50 (mouse) = 250 mg/kg." The usual measure of toxicity is dose level expressed as weight of chemical per unit body weight of the animal-usually milligrams of chemical per kilogram of body weight (mg/kg). 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 of thumb, 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.

Health hazard information may also distinguish the effects of acute and chronic exposure. Acute toxicity is generally thought of as a single, short-term exposure where effects appear immediately and the effects are often reversible. 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.

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		

This section gives information on the reactivity of the chemical – with other chemicals, air, or water which is important when responding to a spill or fire. Chemical substances may be not only hazardous by themselves, but may also be hazardous when they decompose (break down into other substances) or when they react with other chemicals.

Stability: Unstable indicates that a chemical can decompose spontaneously under normal temperatures, pressures, and mechanical shocks. Rapid decomposition may be hazardous because it produces heat and may cause a fire or explosion. **Stable** compounds do not decompose under normal conditions.

Incompatibility: Certain chemicals should never be mixed because the mixture creates hazardous conditions. Incompatible chemicals should not be stored together where an accident could cause them to mix.

Hazardous Decomposition Products: Other chemical substances may be created when a chemical burns or decomposes.

Hazardous Polymerization: Some chemicals can undergo a type of chemical reaction (rapid polymerization) which may produce enough heat to cause containers to explode. Conditions to avoid are listed in this section.

SECTION VII - SPILL OR LEAK PROCEDURES
Steps to be Taken in Case Material is Released or Spilled
Waste Disposal Method

This section can provide specific information about how to clean up a spill of the chemical and how the chemical should be properly disposed.

<table>
<tr><th colspan="4">SECTION VIII - SPECIAL PROTECTION INFORMATION</th></tr>
<tr><td colspan="4">Respiratory Protection (Specify type)</td></tr>
<tr><td>Ventilation</td><td colspan="2">Local Exhaust</td><td>Special</td></tr>
<tr><td></td><td colspan="2">Mechanical (general)</td><td>Other</td></tr>
<tr><td colspan="2">Protective Gloves</td><td colspan="2">Eye protection</td></tr>
<tr><td colspan="4">Other Protective clothing or Equipment</td></tr>
</table>

This section gives information for any special protection that needs to be taken when handling this chemical including ventilation requirements and the type of personal protective equipment that should be worn.

SECTION IX - SPECIAL PRECAUTIONS
Precautions to be Taken in Handling and Storing
Other Precautions

This section describes other precautionary measures that may need to be taken. Some of the precautions presented are intended for large-scale users and may not be necessary for use with small quantities of the chemical. Any questions about precautions or health effects should be referred to EHS.

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APPENDIX I: HAZARDS OF FUNCTIONAL GROUPS

The following information gives a basic overview of the hazards of functional groups. This information is not meant to replace material 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 EHS 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	Ethanol
	1-Butanol	Methanol
	Cyclohexanol	1-Propanol
	1,2-Ethanediol	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	Glutaraldehyde
	Acrolein	1-Hexanal
	Benzaldehyde	Isobutyraldehyde
	Formaldehyde	Propenal

ALIPHATIC AMINES

- The toxicity of most aliphatic amines may fall in the low to moderate category.
- The health hazard from amines arises 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	Methylamine
	Ethyleneimine	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	Methane
	Cyclohexene	n-Pentane
	Cyclopentane	

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	Magnesium
	Calcium	Potassium
	Lithium	Sodium

ALKALIES

- 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 alkalies 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 alkalies is governed by the metal ions.
- Hydroxides and carbonates of alkali-and alkaline-earth are noncombustible.
- Strong caustic alkalies 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 severe 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	Toluene
	Benzolalpyrene	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	Silver fulminate
	Hydrazoic acid	Silver nitride
	Lead azide	Sodium azide
	Mercury fulminate	

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	Oxalic acid
	Butyric acid	Propionic acid
	Formic acid	Succinic acid
	Methacrylic acid	Valeric acid

<u>EPOXY COMPOUNDS</u>

- 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	Glycidaldehyde
	Epichlorohydrin	Glycidol
	Ethylene oxide	Isopropyl glycidyl ether

<u>ESTERS</u>

- 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	Methyl formate
	Ethyl formate	n-Propyl acetate
	Methyl acrylate	
(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 because of 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 because of 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 because of 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 because of 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	Ethyl bromide
	Carbon tetrachloride	Fluorobenzene
	Chloroform	Methylene chloride
	1,2-Dichlorobenzene	

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 alkalies 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	Pyridine
Carbon tetrachloride	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 because of 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 because of the pressure built up from carbon dioxide, which is formed from reaction with moisture.

Examples:	n-Butyl isocyanate	Methyl isocyanate
	Hexamethylene diisocyanate	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 because of 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	Diisopropyl peroxydicarbonate
	Cumene hydroperoxide	Hydroperoxyenthanol
	Diacetyl peroxide	

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 because of their strong corrosive action on the skin and eyes.
- The toxicity depends on the metal ions in these molecules.

Examples:		
	Bromates	Inorganic peroxides
	Chlorites	Nitrates

Dichromates	Perchlorates
Hypochlorites	Periodates
Iodates	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 because of their irritant actions.

Examples:	Peroxyacetic acid	Peroxyformic acid
	Peroxybenzoic 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)

Reference:

Patnaik, Pradyot, *A Comprehensive Guide to the Hazardous Properties of Chemical Substances*, Van Nostrand Reinhold, 1992.

APPENDIX J: PEROXIDE FORMING CHEMICALS

SAFE STORAGE PERIODS FOR PEROXIDE FORMERS	
Unopened chemicals from manufacturer→	18 months or expiration date, whichever comes first
Opened containers:	*Test for Peroxide formation or discard after:*
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 dimethyl ether (diglyme)	2-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)phthalate	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 ether
Bis(2-methoxyethyl) Phthalate	Dimethylketene[f]	Methonxy-1,3,5,7-cyclo-octa-tetraene
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 ether	Di-*n*-propoxymethane[d]	*B,B*-oxydipropionitrile
B-Bromophenetole	1,2-Epoxy-3-isopropoxy-propane[d]	1-Pentene
o-Bromophenetole	1,2-Epoxy-3-phenoxy-Propane	Phenoxyacetyl chloride
p-Bromophenetole	*p*-Ethoxyacethophenone	*a*-Phenoxypropionyl chloride
3-Bromopropyl phenyl ether	2-Ethoxyethyl acetate	Phenyl *o*-propyl ether

1,3-Butadiyne	(2-Ethoxyethyl)-o-benzoyl 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-eicosa-tetraenoate
n-Butyl phenyl ether	1-Ethoxy-2-propyne	Sodium ethoxyacetylide[f]
n-Butyl vinyl ether	3-Ethoxyopropionitrile	Tetrahydropyran
Chloroacetaldehyde diethylacetal[d]	2-Ethylacrylaldehyde oxim	Triethylene glycol diacetate
2-Chlorobutadiene	2-Ethylbutanol	Triethylene glycol diprop-ionate
1-(2-Chloroethoxy)-2-phen-oxyethane	Ethyl *B*-ethoxypropionate	1,3,3-Trimethoxypropene[d]
Chloroethylene	2-Ethylhexanal	1,1,2,3-Tetrachloro-1,3-butadiene
Chloromethyl methyl ether[e]	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 peroxides 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.

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APPENDIX K: 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 it 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 Material Safety Data Sheet. *Rapid Guide to Chemical Incompatibilities*, by Pohanish and Greene, lists the incompatibilities of hundreds of chemicals.

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, hydroxyl-containing compounds, Ethylene glycol, Perchloric acid, peroxides and permanganates.
Acetone	Concentrated Nitric and Sulfuric acid mixtures.
Acetylene	Copper, Silver, Mercury and halogens, Fluorine, Chlorine, Bromine.
Alkali & alkaline earth metals (such as powdered Aluminum or Magnesium, Calcium, Lithium, Sodium, Potassium)	Water, Carbon tetrachloride or other chlorinated hydrocarbons, Carbon dioxide, and halogens.
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, Propane, Gasoline, Turpentine, etc.)	Fluorine, Chlorine, Bromine, Chromic acid, 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.

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APPENDIX L: CHEMICAL SEGREGATION SCHEME

Explosives:	EACH container is a SEPERATE, 2 hour fire rated cabinet
Nitric Acid:	Always by itself in an appropriate cabinet.
Perchloric Acid:	Always by itself in an appropriate cabinet.
Oxidizers:	Stored as a group, separated from all other chemical groups, place on shelving compatible with oxidizing materials (not wood or metal). **Bleach** should be stored with the Oxidizers. Cannot be stored above, below, or next to flammables.
Flammables:	Stored as a group in a two hour fire rated container approved for flammable materials.
Organic Acids:	Store with flammables unless contraindicated by MSDS.
Inorganic Acids:	Store as a group in an appropriate cabinet or on shelving compatible with acids (not unprotected metal). Cannot be stored above, below, or next to bases or oxidizers.
Bases:	Store as a group in an appropriate cabinet or on shelving compatible with bases (not unprotected metal). Cannot be stored above, below, or next to acids or oxidizers.
Poisons / Carcinogens:	Store as a group away from the above materials.
Compressed Gasses:	Store MINIMAL amount of material in laboratory. Cylinders must be secured to prevent tipping. Cylinders of inhalation poisons should be small enough to fit inside of fume hoods.
Radioactive Materials:	Stored separately from other materials behind appropriate shielding an in chemically compatible containers.
Other Materials :	Stored away from the above materials on secure shelving. Chemicals must not be stored on the floor or above eye level.

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APPENDIX M: 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 and Chemical Waste Disposal training?

Name	Initials	Date

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APPENDIX N: WASTE DETERMINATION/LABELING GUIDE

Waste Name: ____

Point of Generation: _______________________________________

1. Is it a liquid, other than an aqueous solution containing less than 24 percent alcohol by volume and has a flash point less than 60°C (140°F); or is it not a liquid and capable, under standard temperature and pressure, of causing fire through friction, absorption of moisture or spontaneous chemical changes and when ignited, burns so vigorously and persistently that it creates a hazard; or is it an ignitable compressed gas or oxidizer?

YES, this waste must be labeled ignitable. Continue.
NO. Continue with the form.

2. Is it aqueous and has a pH less than or equal to 2 or greater than or equal to 12.5?

YES, this waste must be labeled corrosive
NO. Continue with the form.

3. Is it normally unstable and readily undergoes violent change without detonating, or reacts violently with water; does it form potentially explosive mixtures with water, generates toxic gases, vapors or fumes in a quantity sufficient enough to present a danger to human health or the environment; or is a cyanide or sulfide bearing waste which, when exposed to pH conditions between 2 and 12.5, can generate toxic gases or is capable of detonation or explosive decomposition or reaction at STP?

YES, this waste must be labeled reactive. Continue.
NO. Continue with the form.

4. Does the material have a toxic component (See Table 1)?

YES, this waste must be labeled toxic. Include the chemical from table 1 that the material contains. Continue.
NO. Continue with the form.

5. Is the material listed as a Hazardous Waste from a non-specific source? (See Table 2.)

YES, this waste has the EPA Hazardous Waste Number associated with it from table 2. Continue.
NO. Continue with the form.

6. Is the material listed as an unused or off-spec chemical for disposal?
YES, give this material to your EHS officer.
NO. Waste determination is complete.

APPENDIX N (cont.): WASTE DETERMINATION/LABELING GUIDE

TABLE 1: Maximum Concentration of Contaminants for the Toxicity Characteristic

Regulatory HW No.	Contaminant	CAS No.	Level (mg/L)
D004	Arsenic	7440-38-2	5.0
D005	Barium	7440-39-3	100.0
D018	Benzene	71-43-2	0.5
D006	Cadmium	7440-43-9	1.0
D019	Carbon tetrachloride	56-23-5	0.5
D020	Chlordane	57-74-9	0.03
D021	Chlorobenzene	108-90-7	100.0
D022	Chloroform	67-66-3	6.0
D007	Chromium	7440-47-3	5.0
D023	o-Cresol	95-48-7	200.0
D024	m-Cresol	108-39-4	200.0
D025	p-Cresol	106-44-5	200.0
D026	Cresol		200.0
D016	2,4-D	94-75-7	10.0
D027	1,4-Dichlorobenzene	106-46-7	7.5
D028	1,2-Dichloroethane	107-06-2	0.5
D029	1,1-Dichloroethylene	75-35-4	0.7
D030	2,4-Dinitrotoluene	121-14-2	0.13
D012	Endrin	72-20-8	0.02
D031	Heptachlor (and its epoxide)	76-44-8	0.008
D032	Hexachlorobenzene.	118-74-1	0.13
D033	Hexachlorobutadiene	87-68-3	0.5
D034	Hexachloroethane	67-72-1	3.0
D008	Lead	7439-92-1	5.0
D013	Lindane	58-89-9	0.4
D009	Mercury	7439-97-6	0.2
D014	Methoxychlor	72-43-5	10.0
D035	Methyl Ethyl Ketone	78-93-3	200
D036	Nitrobenzene	98-95-3	2.0
D037	Pentrachlorophenol	87-86-5	100.0

D038	Pyridine	110-86-1	5.0
D010	Selenium	7782-49-2	1.0
D011	Silver	7440-22-4	5.0
D039	Tetrachloroethylene	127-18-4	0.7
D015	Toxaphene	8001-35-2	0.5
D040	Trichloroethylene	79-01-6	0.5
D041	2,4,5-Trichlorophenol	95-95-4	400.0
D042	2,4,6-Trichlorophenol	88-06-2	2.0
D017	2,4,5-TP (silvex)	93-72-1	1.0
D043	Vinyl Chloride	75-01-4	0.2

APPENDIX N: WASTE DETERMINATION/LABELING GUIDE (Cont.)

TABLE 2: Waste from Non-specific Sources

The following spent halogenated solvents: (T)

Tetrachloroethylene,
methylene chloride,
trichloroethylene,
1,1,1-trichloroethane,
chlorobenzene,
1,1,2- trichloro-1,2,2-trifluoroethane,
ortho-dichlorobenzene,
trichlorofluoromethane,
1,1,2- trichloroethane;
all spent solvent mixtures and blends containing any of the above.

The following spent non-halogenated solvents: (I*)
Xylene,
acetone,
ethyl acetate,
ethyl benzene,
ethyl ether,
methyl isobutyl ketone,
n-butyl alcohol,
cyclohexanone,
methanol;
Cresols and cresylic acid,
nitrobenzene;
Toluene,
methyl ethyl ketone,
carbon disulfide,
isobutanol,
pyridine,
benzene,
2- ethoxyethanol,
2-nitropropane;
all spent solvent mixtures and blends containing any of the above.

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1) Reference materials identified in the OSHA Lab Standard

2) In addition, the following reference materials are recommended:

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