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THE CITY UNIVERSITY OF NEW YORK

LABORATORY SAFETY MANUAL

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OFFICE OF ENVIRONMENTAL, HELATH SAFETY AND RISK MANAGEMENT | 205 East 42nd Street, New York, NY 10017

PUBLIC SAFETY AND 911 IN ANY EMERGENCY THAT REQUIRES IMMEDIATE POLICE, FIRE, OR MEDICAL RESPONSE TO PRESERVE A LIFE.

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 laboratory 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],[2] 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 other 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 in the notes section. 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.

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[1] CUNY EHSRM gratefully acknowledges the generosity of Cornell University's Office of Environmental Health and Safety for allowing CUNY to use its own Laboratory Safety Manuel as the base for this document.

[2] 29 CFR 1910.1450. Accessible on-line. https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_id=10106&p_table=STANDARDS

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LIST OF ACRONYMS AND ABBREVIATIONS

ABSA	American Biological Safety Association
ACGIH	American Conferenceof Governmental Industrial Hygienists
AIHA	American Industrial Hygiene Association
ANSI	American NationalStandards 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 EnvironmentalConservation
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,Safetyand RiskManagement
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 ParticulateAir
IACUC	Institutional Animal Care and Use Committee
IBC	Institutional Biosafety Committee
IRB	Institutional Review Board
LASER	Light Amplification by Stimulated Emission of Radiation
SDS	Safety Data Sheets
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 chemicals that can pose harm while they are working in a given laboratory. This regulation applies to all employers engaged in the laboratory use of hazardous chemicals as defined by OSHA. A few key definitions follow and a complete list of definitions applicable to laboratories can be found in the OSHA Laboratory Standard:[3]

> 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.
>
> 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 any chemical which is classified as health hazard or simple asphyxiant in accordance with the Hazard Communication Standard (§1910.1200)
>
> Health hazard means a chemical that is classified as posing one of the following hazardous effects: Acute toxicity (any route of exposure); skin corrosion or irritation; serious eye damage or eye irritation; respiratory or skin sensitization; germ cell mutagenicity; carcinogenity; reproductive toxicity; specific target organ toxicity (single or repeated exposure); aspiration hazard.

In other words, a hazardous chemical is a chemical for which there is statistically significant evidence based on at least one study conducted in accordance with established scientific principles that acute or chronic health effects may occur in exposed employees. Appendix A[4] and Appendix B[5] 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.

Most laboratories at CUNY using chemicals are subject to the requirements of the Laboratory Standard. Other areas where chemicals are used but do not fall under the OSHA definition of "laboratory" must comply with OSHA regulation 29 CFR 1910.1200 – "Hazard Communication Standard."[6]

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[3] 29 CFR 1910.1450(b)
[4] https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=10100
[5] https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=10108
[6] https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=standards&p_id=10099

In addition to those employees who ordinarily work full-time within a laboratory space, other employees (such as office, custodial, maintenance and repair personnel) regularly spend a significant amount of their time within a laboratory environment as part of their duties. These employees may fall under the requirements of the Laboratory Standard. OSHA also considers paid graduate students who work in laboratories employees. As long as these students continue in this capacity they are subject to the requirements of the Laboratory Standard.

The main goals of the OSHA Laboratory Standard is to protect employees from health hazards associated with use of hazardous chemicals. To facilitate this 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 safe work procedures and the location of the Chemical Hygiene Plan.

OSHA requirements, including the CHP, seek to keep exposures below the permissible exposure limits.[7] 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."[8]

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.[9] The New York Department of Labor is designated as the agency responsible to administer 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 employees working with hazardous chemicals in a laboratory must know the

[7] As specified in 29 CFR Part 1910, subpart Z–Toxic and Hazardous Substances and other resources such as NIOSH and ACGIH. https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=10147
[8] 29 CFR 1910.1450(e)(3)(ii) https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=10106
[9] New York promulgated and adopted an alternative approach to recordkeeping requirements under 12 NYCRR section 801 and administrative instructions 901.

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[a] 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 laboratory specific standard operating procedures as well as any department or college level laboratory safety manuals, policies, and procedures.

1.2 Laboratory Safety Responsibilities

The ultimate responsibility for health and safety within laboratories lies with each individual who works in the laboratory; however, it is the responsibility of the Principal Investigator (P.I.), faculty, and the 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 the laboratories under their control.

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. There are numerous resources at the disposal of those responsible to ensure a safe and healthy laboratory that is compliant with federal, state, and local regulations.

1.2.1 New York City Laboratory Requirements

<u>Laboratory Permits</u>

It is unlawful to operate a laboratory or storage room in which flammable liquids, flammable solids, flammable gases, oxidizing materials, explosive materials, unstable or reactive chemicals are used in testing, research, experimental or instructional work, without a permit from the Fire Department for the City of New York.[10]

If your laboratory or storage area contains chemicals in quantities that **meet or exceed** one or more of the following criteria, you must have a permit for that area:

- 32 ounces or greater of a flammable liquid
- ½ pound or greater of a solid oxidizing agent

[10] FDNY, Fire Code Section 105, Permits and Other Approvals. Available online: http://www.nyc.gov/html/fdny/pdf/firecode/2009/fire_code_ll26_2008_amended_ll37_41_64_2009_final_complete.pdf

- 20 inch high and 6 inch diameter or greater flammable gas cylinder
- 10 gallons or greater of a combustible liquid
- 15 gallons or greater of an acid

If your laboratory contains chemicals that meet or exceed one or more of the quantities above, but does not have an FDNY permit, please contact your campus Environmental Health and Safety Officer.

Throughout the City of New York, the FDNY performs inspections for the proper storage of hazardous chemicals. Inspections are performed annually to enforce regulations that protect the public and property exposed to a potential incidence of fire caused by improperly stored chemicals. If there are no violations found during the inspection, the laboratory is approved for permit renewal. If a violation is found, then a notice of violation (NOV) will be issued. Once an NOV is written, there are 35 days from the violation date to correct the violation and submit a self-certification (information certifying that the violation was corrected) to the FDNY. Once the violation is corrected and the self-certification is received by the FDNY, the laboratory or storage room permit will be renewed.

Current laboratory permits must be posted in a conspicuous location on the premises designated therein at all times and must be readily available for inspection by any representative of the FDNY.[11] Suggested posted areas include on the inside of the laboratory door or inside the laboratory near the door at eye-level.

The new Fire Code for the City of New York, Title 29 of the Administrative Code of the City of New York, became effective on July 1, 2008. Conditions lawfully existing on June 30, 2008, may, with certain exceptions, be maintained under the prior laws and regulations.[12] The Chemical Hygiene Plan specific to each campus shall incorporate the proper Fire Code requirements.

Please contact your campus Environmental Health and Safety Officer for further information clarification on issues related to conditions existing prior to June 30, 2008.

Certificate of Fitness (C-14)

The FDNY requires that all chemical laboratory units be supervised by an FDNY "Certificate of Fitness" holder whenever laboratory operations are being conducted. The "Certificate of Fitness for the Supervision of Chemical Laboratories" is referred to as a C-14 by the FDNY. It is required that all laboratory supervisors, principal investigators, and adjuncts who qualify for the certificate obtain one. The FDNY requires that the C-14 certification be renewed every 3 years.

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[11] Fire Code §105.3.5 "Posting the Permit"

[12] See FDNY Fire Code 102.3; lawfully existing conditions as of June 30, 2008.

Laboratories must have a sufficient number of staff with C-14 Laboratory Certificates of Fitness to provide coverage for all times when the laboratory is in operation. This is becoming even more important now that FDNY is performing unannounced laboratory inspections on weekends and off-hours.

Qualification requirements, study materials, and other test information can be found on FDNY's website.

1.3 Roles at CUNY

The individuals involved in laboratory safety may vary in number and title at a specific CUNY campus. Outlined here are roles foundational to campus laboratory safety. Sample descriptions of specific responsibilities associated with these roles can be found In Appendix C along with a complied list of laboratory safety responsibilities. Campuses should clearly define and share responsibilities associated with specific roles.

Environmental, Health, Safety and Risk Management

The City University of New York's Office of Environmental, Health, Safety and Risk Management (EHSRM) is committed to fostering a safe and healthy environment for the CUNY community and to reducing the University's risks. A clear and necessary step toward this goal is ensuring that CUNY is and remains 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.

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 Office will maintain the campus Chemical Hygiene Plan and the institutional Chemical Hygiene Officer responsibilities.

Chemical Hygiene Officer(CHO)

The role of the Chemical Hygiene Officer (CHO) is to facilitate the implementation of the campus Chemical Hygiene Plan as well as this Laboratory Safety Manual across campus labs and facilities. The CHO also serves 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 Chemical Hygiene Officer has a number of major duties

Deans, Directors, and Department Chairpersons

The Deans, Directors, and Department Chairpersons are responsible for laboratory safety within their department(s). Specific roles and responsibilities vary from campus to campus but in general involve facilitating communication between EHS staff, Principal Investigators, Faculty and Supervisors and support of participation in guidelines, internal audits, and programs to ensure compliance and identify opportunities for improvement.

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

P.I.s, faculty, and laboratory supervisors are responsible for safety in their research or teaching laboratories. They must follow regulatory requirements and ensure the guidelines identified within this manual are communicated and adopted. Individuals in these roles must provide, among other tasks, the EHS with a current chemical inventory on an annual basis. Aspects of these duties can be delegated to other qualified personnel within the laboratory but the responsibility remains with the P.I., faculty or laboratory supervisor responsible for the area.

Laboratory Employees

Laboratory employees are all those personnel who conduct their work in a laboratory and are at risk of possible exposure to associated hazards 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. All laboratory employees have safety duties. They must be aware of these responsibilities and any required compliance activities. They also must participate. As appropriate, in activities outlined in the, Laboratory Standard, Chemical Hygiene Plan and this manual.

Facilities Management

Facilities Management[13] serves as an important partner in laboratory operation and safety as well as a conduit for information with regard to building-wide issues. This includes coordinating routine maintenance issues, scheduling building shutdowns, communicating building-wide maintenance and repairs, and informing occupants of building system shutdowns. Facilities Management departments have a number of laboratory safety responsibilities and are key partners in maintain environmental, health and safety on CUNY campuses.

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

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."[14] 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, to Facilities Management.

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 or when the potential for fire exists. Laboratory personnel may conduct a dry ice capture test when using new materials or whenever substantial changes have been made to an experimental setup, such as the addition of apparatus.

Adhering to a few requirements will help to obtain optimum performance and achieve the greatest protection when using a fume hood. All fume hoods must be inspected annually. Fume hoods that do not pass inspection or are found to be malfunctioning must be labeled as such and are not to be used. When in use, always work with the fume hood sash as low as possible and minimize materials stored in hoods. Using fume hoods to evaporate hazardous waste is illegal. Be sure to wash both the working surface and hood sash frequently, cleaning up all spills immediately. NYC Fire Code does not allow the use of ductless fume hoods, therefore, they are not to be installed in CUNY establishments. Appendix O contains detailed guidance.

[14] 29 CFR 1910.1450(e)(3)(iii)
https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=10106

2.1.1 Perchloric Acid Use

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 ductwork. This could result in an explosion during maintenance work on the ventilation system. Perchloric acid fume hoods should be clearly labeled. 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 Radioactive Material Use

Fume hoods for use with radioactive materials must be clearly labeled and used where radioisotopes are handled. Do not use hot perchloric acid, hot concentrated acids, unstable or explosive materials in this type of hood. The cabinet housing the hood must provide shielding of the radioactive material and be constructed of stainless steel or other materials that will not be corroded by the chemicals used. Radioactive material fume hoods must provide the means for containing minor spills.

2.1.3 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 annually and when requested 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. Optimum working height for the sash, the height at which it was tested, will also be labeled with arrow stickers.

If your fume hood does not have an inspection sticker or if a year or more has passed since the hood was last inspected, contact your EHSO immediately to schedule an inspection. Testing must be done annually in accordance with NFPA 45, A.8.4.7.[15] Follow FDNY guidance, keep track of hood location, issues and compliance.

If a hood fails inspection, a clear sign must be posted. Under no circumstances should laboratory personnel use a fume hood that has not passed an EHS inspection, even if it appears to have airflow.

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[15] https://www.nfpa.org/codes-and-standards/all-codes-and-standards/list-of-codes-and-standards/detail?code=45

2.1.4 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 a building's ventilation system. They may also interfere with the proper functioning of other fume hoods and impact ventilation in the laboratory. Fume hoods shall be located within a laboratory in such a way that their performance is not adversely affected by cross drafts. Cross currents, drafts and air currents from open windows, doorways, and personnel traffic flow may directly influence hood containment ability.

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 installations 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 or contact your EHSO.

2.1.5 Removal of Existing Fume Hoods

Removal of fume hoods or any capture devices requires prior consultation with your Facilities Management and EHS Office. This is to ensure that building ventilation systems are not impacted and that utility services such as electrical lines, plumbing systems and water and gas supply lines are properly disconnected.

Asbestos may be present within the fume hood as well as in pipe insulation associated with ductwork. Any asbestos must be properly removed and disposed of by a certified asbestos removal company. In addition, cup sinks may contain mercury and should be checked. 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.

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.

Any additional installations or adjustments should not be undertaken without first consulting with Facilities Services, the EHS Office, and the appropriate campus service shops.

2.2.1 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. [16]

Regular maintenance and inspection is essential to ensure that a glove box is adequately protecting the user, environment, product and/or process. Routine maintenance procedures and the frequency of inspection (or certification) should follow the manufacturers and related 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 and should be regularly inspected for cuts, tears, cracking, pin-hole leaks or other damage. If defects are found, the box should not be used until the gloves are replaced. Note that there are many different types of gloves that vary in thickness, material or size. Choose the correct one for the glove box and application.

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[16] 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.

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 gloveboxes and testing, see: AGS (American GloveBox Society) 2007 Guide for gloveboxes – Third Edition. AGS-G001-2007.[17]

2.3 Water Protection in Labs

Laboratory personnel must ensure that any piece of equipment or laboratory apparatus connected to the water supply utilizes backflow protection or is connected to a faucet with a vacuum breaker. The purpose of backflow prevention and vacuum breakers is to prevent water used in an experimental process or with a piece of equipment from 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).

Two common water protection problems are found in labs

- A tube attached to a faucet without a vacuum breaker
- Drainage tubing hanging down into a 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 a vacuum breaker. These sink faucets are easily identifiable from standard faucets by the vacuum breaker head attached to the spout. If no vacuum breaker or other type of back flow protection is present, make sure any hose connected to the faucet is short enough to prevent pooled water from creating the potential for back flow. If you have questions, contact your EHSO or Facilities Management.

3.0 PERSONAL PROTECTIVE EQUIPMENT

Personal Protective Equipment (PPE) should be considered a major line of defense protecting laboratory personnel against chemical hazards. PPE is not a substitute for good engineering, 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.

[17] https://www.gloveboxsociety.org/2007_Guidelines_Table_of_Contents.pdf

The OSHA Personal Protective Equipment standard, 29 CFR 1910, Subpart I [18] requires the following areas be addressed:

- Hazard assessment and equipment selection
- Employee training
- Record keeping requirements
- Guidelines for selectingPPE
- Hazard assessment certification

More information on PPE can be found on the OSHA Safety and Health Topics page on Personal Protective Equipment.[19]

3.1 Laboratory Personnel Responsibilities

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 but is not limited to items such as gloves, eye protection, laboratory coats, face shields, aprons, boots, and hearing protection. PPE must be readily available to all employees who require it and most equipment is provided at no cost to the employee.

When deciding on the appropriate PPE for a particular operation or experiment, a number of factors must be taken into consideration:

- Chemicals involved, including concentration and quantity
- Hazards posed by chemicals in use
- Routes of exposure for chemicals involved
- PPE construction including permeation and degradation rates of specific chemicals on the materials used in PPE
- Length of time the PPE will be in contact with chemicals and in use

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

Specifics regarding the PPE required to carry out procedures within a laboratory using hazardous chemicals mustbe included in the laboratory's Standard Operating Procedures. Your EHS Office can provide information and training, assist with conducting hazard assessments, share department or college-specific requirements and help select proper PPE.

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[18] https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=9777
[19] https://www.osha.gov/SLTC/personalprotectiveequipment/

3.2 Training for Personal Protective Equipment

Laboratory personnel must be trained in the selection, proper use, limitations, 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 the following:

- When PPE must be worn
- What PPE is necessary to carry out a procedure or experiment
- How to properly don, doff, adjust and wear required PPE
- Proper cleaning, care, maintenance and limitations of PPE
- Useful life and disposal of PPE

PPE training must be documented, including a description of the information covered during the training session, a copy of the sign-in sheet and dates when training occurred. The campus EHS Office maintains employee training records.

It is the responsibility of the P.I. or laboratory supervisor 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 that laboratory personnel use proper PPE when working in laboratories under theirsupervision.

3.3 Eye Protection

Eye protection is one of the most important and easiest forms of PPE to wear. Laboratory personnel should wear eye protection to prevent issues from many chemical and physical hazards including flying particles, broken glass, molten metal, acids or caustic liquids, chemical liquids, gases or vapors, or potentially injurious light radiation.

P.I.s and laboratory supervisors are strongly encouraged to make the 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. [20]

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

[20] https://www.osha.gov/SLTC/eyefaceprotection/

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. 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 and those associated with 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. Woodworking goggles can be identified by the numerous small holes throughout the face piece through which chemicals could enter resulting in exposure. Ensure that the goggles you choose are rated for use with chemicals in use.

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. The dual protective eyecups house 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. They typically consist of adjustable headgear and a "window" made of either tinted or transparent material of varying thickness 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. Eyewear must be selected for the specific type of laser to block or attenuate output in the appropriate wavelength range. 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 temperature extremes (heat/cold). Gloves must be worn whenever significant potential hazards from any of these categories are present. Gloves must be worn when using chemicals that are easily absorbed through the skin and/or using 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 totally resists degradation or permeation by all chemicals. As a result, all gloves must be replaced periodically. The frequency of replacement depends 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 identifying 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 glove manufacturers' glove selection charts. Different glove manufacturers use different formulations so check the specific manufacturer's chart for the glove you plan to use. Charts typically include specific chemicals used to test that manufacturers' glove types.

If the manufacturer's glove chart does not list the specific chemical you will be using, call the glove 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 the following:

- 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 and discard any gloves found to be questionable immediately.
- Replace gloves 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 appropriately after each use and whenever they become contaminated.
- Remove gloves before leaving the laboratory. Potential chemical contamination may not always be visible. 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, one over the 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 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 outer glove. Alternatively, you could wear a heavier glove as an under glove and wear a thinner, disposable glove as the outer glove. 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 before choosing which types of gloves 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 available for laboratory personnel that serve different functions.

<u>Fabric Gloves</u>
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 skin, resulting in a chemical exposure.

<u>Leather Gloves</u>
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 skin, resulting in a chemical exposure.

<u>Metal Mesh Gloves</u>
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.

<u>Cryogenic Gloves</u>
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.

<u>Chemically Resistant Gloves</u>

Chemically resistant gloves come in a wide variety of materials. Once the chemical makes contact with the gloved hand, the gloves should be removed and replaced. A glove type 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, glove selection charts, or contact your EHS Office.

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 laboratory 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.

Latex gloves are only appropriate for the following uses:

- Most biological materials
- Nonhazardous chemicals
- Clean room requirements
- Medical or veterinary applications
- Very dilute, aqueous solutions containing less than 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. A general purpose substitute for disposable latex gloves are disposable Nitrile gloves.

See Appendix F 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 laboratory 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, skirts or loose clothing 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 used in clothing 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.
- Disposable or reusable clothing will impact cost, maintenance and cleaning requirements.
- How quickly the clothing can be removed during an emergency may be a factor. It is recommended that laboratory 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 EHS Office for recommendations.

3.6 Respirators

Respiratory protection includes disposable respirators (such as N95 filtering face pieces, commonly referred to as “dust masks”) as well as 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 user’s breathing zone are preferred over the use of respirators in most laboratory environments. There are certain exceptions to this general rule, such as changing 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 **may not** purchase a respirator and bring it to any CUNY laboratory for personal use without prior approval from the campus EHS Office. Please refer to your college’s respiratory protection program or consult with your EHS Office.

It is important to note that most disposable respirators do not protect against chemical vapors and fumes; they are for nuisance dust only. The use of disposable respirators may or may not be regulated by OSHA depending upon the circumstances. 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 following are situations where respiratory protection would be appropriate for laboratory workers pending the campus EHS Office approval.

- Voluntary use of N-95 respirators in the laboratory but OSHA requires the following reading be completed before use: (Mandatory) Information for Employees Using respirators When not Required Under Standard – 29 CFR 1910.134 Appendix D[21]
- Use of large volumes of certain hazardous chemicals, such as formaldehyde in a room where dilution ventilation or capture devices do not offer adequate protection
- Changing out cylinders of hazardous gases (requires additional training)
- Cleaning up hazardous chemical spills (requires additional training)
- Reducing 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, then each chemical alone, or when the potential for an unknown exposure exists. However, laboratory staff should 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 coworkers have left the room to prevent possible exposure. Always thoroughly clean up and decontaminate working surfaces or alert them to your activities so they may take appropriate action.

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 in adequate 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

[21] https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=standards&p_id=9784

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,[22] exceed permissible levels and cannot be reduced through engineering or other controls, then hearing protective devices must be worn. Contact your EHS if you have questions about 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.[23]

3.8 Foot Protection

In areas where chemical, biological and physical hazards are present, laboratory and other personnel should wear foot protection at all times. There is the potential for exposure to toxic chemicals and/or physical hazards such as dropping equipment or broken glass. In general, shoes should be comfortable and preferably leather. Leather has better chemical resistance and tends to absorb fewer chemicals than cloth. However, leather shoes are not designed for long term exposure via direct contact with chemicals. In such instances, chemically resistant rubber boots are necessary. Chemically resistant boots or shoe covers may be required when working with large quantities of chemicals where the potential exists for large spills.

P.I.s and laboratory supervisors are strongly encouraged to require the use of closed-toed shoes for all laboratory personnel, including visitors, who enter or work in laboratories and laboratory support areas under their supervision.

In some cases, the use of steel-toed shoes may be appropriate if, for example, heavy equipment is involved.

4.0 ADMINISTRATIVE CONTROLS

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

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. Colleges, departments, P.I.s, and laboratory supervisors have the

22 https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=9735
23 https://www.osha.gov/SLTC/noisehearingconservation/

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."[24]

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 following topics:

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

While the OSHA Laboratory Standard specifies the requirement for SOPs for work involving hazardous chemicals, laboratories should also develop SOPs for work involving any piece of equipment or operation that may pose any physical hazards. This includes safe use and considerations of LASERs, cryogenic liquids and fill procedures and high voltage equipment as well as connecting regulators to gas cylinders and cylinder change outs.

SOPs do not have to be lengthy and it is perfectly acceptable to point laboratory personnel to other sources of information. Examples include: "To use this piece of equipment, see page 4 in the operator's manual (located in file cabinet #4)" or "The chemical and physical hazards of this chemical can be found in the SDS located in the SDS binder. Read the SDS before using this chemical."

It is the responsibility of the P.I. and laboratory supervisor to ensure that written SOPs 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

[24] 29 CFR 1910.1450€(3)(i)
https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=10106

laboratory supervisors must ensure that personnel working in laboratories under their supervision have been trained to use these SOPs. See Appendix D for additional information and templates. Your EHS Office also can assist laboratories with developing 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 space, in the reliability of experiments, and an increase in laboratory personnel's awareness of health and safety issues. Procedural controls are fundamental to instilling safe work behavior and help 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 a variety of tasks.

- Keeping all areas of the laboratory free of clutter, trash, extraneous equipment, and unused chemical containers. Areas to address include benches, hoods, refrigerators, cabinets, chemical storage cabinets, sinks, and trash cans.
- Keeping all containers of chemicals properly closed when not in use.
- Cleaning up all chemicals spills immediately, regardless of whether the chemical is hazardous or not. Look for any splashes that may have resulted on nearby equipment, cabinets, doors, and counter tops. See the Chemical Spill Procedures section.
- Keeping areas around emergency equipment and devices clean and free of clutter. This includes 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, electric cords and carts.
- 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 areas not protected by sprinklers.[25]

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 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 a clean, orderly workspace is maintained and personnel 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, good personal hygiene habits can prevent chemical exposure.

Recommended personal hygiene guidelines

- Do not eat, drink, chew gum, or apply cosmetics in any area where chemicals are used.
- Do not place food or drink in refrigerators where chemicals are stored. Use refrigerators labeled safe for storage of items intended for human consumption.
- 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.
- Always confine long hair, loose clothing and jewelry.
- Shorts and sandals should not be worn in a laboratory. They do not offer protection.
- Wear a lab coat whenever working with hazardous materials.
- Remove laboratory coats, gloves, and other PPE immediately if 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.
- Do not wear laboratory coats, scrubs, or other PPE (especially gloves) outside the laboratory. Remove before exiting the laboratory.

[25] See Fire Code § 315.2.

- Always wash hands with soap and water after removing gloves and before leaving the laboratory or touching items such as the phone, doorknobs, or elevator buttons.

- Always wash laboratory coats separately from personal clothing. Place the contaminated lab coat in a separate plastic bag and label the bag clearly.

- Smoking is prohibited on all CUNY campuses.

4.5 Eating, Drinking, and Applying Cosmetics in the Laboratory

Chemical exposure, both acute and chronic, can occur through ingestion of contaminated food or drink. This type of contamination can occur when food or drinks are brought into a laboratory or stored in refrigerators, freezers, or cabinets with chemicals. It is possible for the food or drink to absorb chemical vapors and lead to exposure when consumed. Eating or drinking in areas exposed to toxic materials is prohibited by the OSHA Sanitation Standard. [26]

A similar potential for chemical exposure holds true with regard to the application of cosmetics (make-up, hand lotion, etc.) in a laboratory setting. Cosmetics have the ability to absorb chemical vapors or incorporate dusts, and mists from the air and, when applied to the skin, result in exposure to chemicals.

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.”

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

4.6 Working Alone

While the university acknowledges that working alone is sometimes necessary, there are specific safety concerns to be addressed. Appendix A of OSHA standard 29 CFR 1910.1450,[27] the National Research Council (NRC) recommends that researchers, “(a)void working alone in a building; do not work alone in a laboratory if the procedures being conducted are hazardous.”[28]

Laboratories should establish guidelines and SOPs specifying when working alone is not allowed and develop notification procedures when working alone occurs. All work performed by someone working alone must be approved in advance by the P.I. or laboratory supervisor and include a

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[26] See 29 CFR 1910.141(g)(2) https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=9790
[27] https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=standards&p_id=10107
[28] *ibid*

monitoring system. High School Students are NEVER permitted to work alone in a research lab, even with non-hazardous materials. They must always have a mentor/supervisor present.

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.

Consider the following precautions when working alone.

- Working alone, especially after hours, should be avoided whenever possible.
- Conduct a Hazard Assessment of the work, risks, and emergency requirements
- A person working alone should have a phone immediately available and be in regular contact with a buddy. (see section 4.2.6)
- Individuals working alone in separate laboratories should make arrangements to check on each other periodically or ask Public Safety to check on them.

Examples of activities where working alone would be acceptable include:

- Office work such as calculations, computer work, and reading.
- Housekeeping activities such as general cleaning, or 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 laboratory functions that are part of a standard operating procedure, have been demonstrated to be safe, and do not involve hazardous materials.

Examples of activities where advance precautions and procedures should be in place include experiments or activities involving:

- Toxic or otherwise hazardous chemicals, especially those with poison inhalation hazards
- High-pressure equipment
- Large quantities of cryogenic materials
- Work with unstable (explosives) materials
- Class 3b or Class 4 LASERS
- High voltage
- Transfer of large quantities of flammables, acids, bases, or other hazardous materials
- Changing out compressed gas cylinders containing hazardous materials
- Certain machine shop activities

Working alone is not permitted by OSHA when it involves entry into a confined space. 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.

4.6.1 Working Alone - Responsibilities

The following responsibilities are assigned to employees when working alone is required.

P.I.s must

- Review all workplaces under their jurisdiction
- Identify individuals required to work alone
- Identify hazard(s) and assess risk(s)
- Take any necessary steps to eliminate the hazard(s)
- Use engineering controls, administrative controls, or a combination of the two
- Developa site-specific Working Alone Policyand Proceduresto addresstherisk(s)
- Communicate the site-specific Working Alone Policy and Procedure to all workers
- Ensure compliance with the Working Alone Policy and Procedure
- Review the site-specific Working Alone Policy and Procedure annually and when working conditions change
- Maintain documentation of the site-specific Working Alone Policy and Procedure on-site

Individuals working alone or in isolation will

- Comply with the site-specific Working Alone Policy
- Advise the supervisor of any concerns as they arise
- Advise the supervisor of any changes in work that impact safety

The EHS Office will provide guidance and act as a resource. This is also true of EHSRM.

4.6.2 Buddy System and Working Alone

A "buddysystem" shouldestablish a system of routine checks onpersonnel working alone (e.g., every 15–30 minutes). This can be accomplished several ways including physically walking to the engaged laboratory, contact by phone, or visual contact by CCTV. If the person working alone is engaged in highly hazardous work, the designated buddy should not enter the room unless they are properly trained and equipped.

If an emergency requires the buddy to leave prior to the completion of the partner's experiment and that experiment involves highly hazardous chemicals, the buddy should notify the campus Office of Public Safety of the partner's name, location, andendtime 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 "buddy."

PLEASE NOTE: For rooms that are locked, prior arrangements are required to facilitate access. Emergency responders and/or campus public safety may not have immediate access, which could result in delayed response. If the door to the laboratory does not have a window or if the window is covered, a person working alone in a locked laboratory and in jeopardy may not be discovered until someone enters the room.

4.6.3 C-14 Requirements for the Written Exam

In order to qualify to take the exam, the applicant must meet the base requirements and bring required documents. Applicants must:

- Be 18 years or older.
- Have a reasonable understanding of the English language.
- Provide two forms of identifications at least one of which must be government issued photo identification, such as a passport or valid driver's license.
- Provide a letter of recommendation from an employer, on official letterhead, state the applicant's full name, experience and work address. If the applicants are self-employed or the principal of the company, then a notarized letter must be submitted to attest to their qualifications.
- Applicants who are not currently employed, may take the exam without the recommendation letter. If the applicants pass the exam, a temporary letter with a picture for job seeking purposes will be issued by the FDNY. A card will only be issued once the applicant is employed and has provided a recommendation letter from their employer.[29]
- Completed Certificate of Fitness (A-20 Form) application

In addition, C-14 exam applicants must have one of the following:

- A B.S degree in Chemical, Mechanical, Environmental or Biomedical Engineering, Biology, Biochemistry, Chemistry, Environmental or Health Sciences, Medical Technology
- An A.A.S or A.S degree in Biochemistry, Chemistry, Biology, Environmental or Health Sciences, Medical Technology and Chemical, Environmental, Mechanical or Biomedical Engineering, or related field and a completion of a course on laboratory safety provided by the employer

[29] Applicants who are not currently employed, may take the exam without the recommendation letter. If the applicants pass the exam, a temporary letter with a picture for job seeking purposes will be issued by the FDNY. A card will only be issued once the applicant is employed and has provided a recommendation letter from their employer.

- 60 credits with a minimum of 21 credits in applicable science or engineering courses and a completion of a course on laboratory safety provided by the employer

- NY State Permanent Certification as a Chemistry or Biology (7-12) Teacher

- Evidence of academic degree(s) indicating specific course of study and/or transcript to verify college science courses must be presented by the applicant

- Any degree obtained in a language other than English or outside the USA will be evaluated by an independent evaluation service accepted by NYC Department of Citywide Administrative Services (DCAS). Additional information can be found here: http://www.nyc.gov/html/fdny/pdf/cof_study_material/foreign_education_evaluation_guide.pdf

Undergraduate students who do not have at least 21 credits in applicable science or engineering courses are considered ineligible for the C-14 exam.

Additional information can be found here: https://www1.nyc.gov/nycbusiness/description/cof-c14

4.6.4 Renewal Guidelines for Certificate of Fitness

The Certificate of Fitness must be renewed every three years. FDNY reserves the right to require the applicants to retake the full examination upon submission of renewal applications. You can renew online, by mail, or in person. A courtesy notice of renewal will be issued 90 days before the expiration date. It is your responsibility to renew your Certificate BEFORE it expires. If renewals are submitted 90 days after the expiration date the certificate holder will incur a $25 penalty in addition to the regular renewal fee. Any certificates allowed to remain expired for more than one year will not be renewed and new exams will be required.

4.7 Supervision in the Laboratories - Defined

Supervision is the act of critically watching and directing.

Direct Supervision is achieved when a faculty member, laboratory manager, principal investigator, or other assigned qualified supervisor is physically present when students or laboratory personnel are in laboratory areas.

A Qualified Supervisor is a laboratory worker, faculty member, graduate student, laboratory manager, or an investigator trained in and knowledgeable about specific hazards and work activities present in the laboratory.

4.8 Phone Access

All labs should have a means of communication in the event of an emergency. This can include a "landline" phone, cellphone (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.

4.9 Unattended Operations

Whenever it is necessary to have unattended operations occurring in a laboratory, it is important to ensure that safeguards are put into place in the event of an emergency. The following guidelines were taken from Appendix A of OSHA standard 29 CFR 1910.1450 and/or Prudent Practices in the Laboratory. [30]

For unattended operations involving highly hazardous materials, a light should be left on and an appropriate warning sign with a clear explanation should be placed on the laboratory door or in a conspicuous, easily seen location. The warning sign should list the following information:

- Nature of the experiment in progress
- Chemicals in use
- Hazards present (electrical, heat, or explosion)
- Name of the person conducting the experiment and contact number
- A second name and contact number (most likely the P.I.)

When setting up an experiment that will be left unattended, try to anticipate potential issues and take measures.

- Inspect all equipment to ensure that it is in proper working order prior to leaving an experiment unattended.
- Help contain potential spills through the use of secondary containment.
- Use safety shields and keep the hood sash low to contain chemicals and glass in case of an explosion.
- Remove any chemicals or equipment that are not necessary for the experiment.
- Remove items that could potentially react with chemicals or other materials being used.
- Use automatic shutoff devices such as loss of cooling water or over-temperature devices.
- Use emergency backup power outlets for any equipment negatively affected by utility interruptions.

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

[30] https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=standards&p_id=10107 and https://www.nap.edu/catalog/12654/prudent-practices-in-the-laboratory-handling-and-management-of-chemical

supervision. P.I.s should be aware at all times of all work being performed in laboratories under their supervision.

4.10 Access to Laboratories

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

4.10.1 General 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 untrained laboratory 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.

It is the responsibility of the Department Chairperson, P.I.s, and laboratory supervisors to restrict access to those are as under their supervision where potential health and physical hazards exist. This includes cases such as employee's children or students visiting classmates.

4.10.2 Visiting Scientists and Other Similar Users

There are potential risks associated with allowing a visiting scientist access to laboratories and equipment. These include questions of ownership of intellectual property, bodily injury, property damage and theft. Colleges and units should verify that all laboratory visitors have required training prior to access. It is the visitor's responsibility to obtain appropriate training prior to the visit.

4.10.3 Pets in Labs

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

4.11 Purchasing Chemicals

If it is necessary to purchase new chemicals, laboratory personnel should order the minimum required to carry out the experiment. Avoid ordering larger quantities simply because the chemical Before ordering new chemicals, search existing inventories and use those chemicals currently in stock. An accurate and up-to-date chemical inventory can help minimize unnecessary purchases. CUNY has an institutional subscription to the Chem Tracker chemical inventory system that can help facilitate maintaining a chemical inventory. To learn more about the ChemTracker system, contact your EHS Office.[31]

[31] https://chemtracker.org/

"might be needed in the future." Try to take advantage of chemical vendors' "Just-In-Time" delivery rather than stockpiling 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.

4.12 Ordering New Equipment

Purchasing equipment requires preplanning and consultation with Facilities Management and your EHS Office. Equipment may need to connect to building utility services such as electric, water, or gas. Facilities Management and the EHS Office will help to ensure that the building can support the new piece of equipment. Certain pieces of equipment require special installation such as fume hoods. Fume hoods, as well as other equipment, have the potential to impact a building's ventilation system and/or utilities. As a result, certain types of equipment cannot be installed by laboratory personnel, building managers, or private contractors without first consulting with Facilities Engineering and the EHSO.

Laboratory personnel are encouraged to give consideration to "Energy Star" energy efficient equipment to help conserve natural resources and long-term operating costs. For more information, see Energy Conservation in Laboratories.

4.13 Work Orders and Ticket Requests

If maintenance issues arise or repairs are needed, laboratory personnel should consult the manufacturer and review their service contract. Because of NYC building codes, laboratory personnel MUST NOT attempt to repair utility services (such as electrical, plumbing, or gas issues) by themselves. These repairs must be handled by qualified personnel only. 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. Follow campus procedures for submitting work requests.

4.14 Changes in Laboratory Occupancy

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

Failure to address the change in occupancy can result old, unlabeled chemicals, samples, or hazardous waste being left behind in refrigerators, freezers, and cabinets or valuable furniture or equipment being moved or thrown away. Also, changes in occupancy can leave unknown chemical spills, contamination or potential for both. These issues can result in costly remediation efforts and wasted resources. If you plan to leave your laboratory, a few simple steps can ensure a smooth transition:

- Notify your department chairperson and laboratory supervisor well in advance
- 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.
- Identify gaps in certification requirements and coverage for normal operations
- Review the Laboratory Move Guide.

4.15 Laboratory Design and Construction

It is important to take health and safety considerations into account during the design process, well BEFORE construction begins. This will improve laboratory working conditions and facilitate compliance. 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 as well as renovation. A list of chemicals, including approximate usage (weekly/monthly) and storage quantities will be needed to ensure proper ventilation rates and engineering controls. Consult with CUNY Facilities, Planning, Construction and Management (FPCM) for additional details.

If you are planning laboratory construction or renovation, please contact the Chemical Hygiene Officer and EHSO with the following information:

- Contact name, phone number and email
- Department, building and room(s) where the project will occur
- Expected start date for project
- Equipment to be installed, such as fume hoods, biosafety cabinet, other capture devices, eyewash and emergency showers, toxic gas cabinet and monitoring devices

4.16 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. The EHSO will then verify if the ventilation rate for a given room is appropriate for the type of research being conducted.

4.16.1 Room Air Pressure in Labs

Laboratory personnel should occasionally check to ensure that there is negative air pressure in their laboratories with respect to hallways. This means the fume hood is operating properly and removing more air from the room than is supplied to the lab. Conversely, positive air pressure, when more air is being supplied to the room versus being removed, may allow chemical vapors and dusts from the laboratory to be blown out into a hallway. This also can be detrimental to the fume hood's performance, which in turn may allow chemical odors to permeate hallways and surrounding rooms.

The following steps can be taken to test for negative air pressure in the laboratory: [32]

- Close the entrance door to the laboratory.
- Affix a sign outside the door instructing people to knock before entering. This will help avoid any interrupts to the test.
- Place a bowl of water on the floor immediately abutting the entrance door.
- Add dry ice to the bowl of water.
- Slowly move the bowl along the edge of the door, keeping it on the floor, while observing the path of dry ice vapors.
- Carefully pick up the bowl and move it along the vertical 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 UNDER the door and between the door and doorframe and into the hallway, then the laboratory is under positive air pressure.
- If you discover your laboratory is under positive air pressure, please contact Facilities Management or your EHSO for assistance.

4.17 Energy Conservation in Laboratories

Laboratories are energy intensive facilities, consuming energy at rates many times higher than the average academic space. They use large quantities of heated and cooled, one-pass air for ventilation and fume hoods as well as electricity to operate fans, lights, and specialized equipment. Laboratories also use large amounts of tap water, process-chilled water, and, in some cases, natural gas.

Many improvements to facility design improve energy conservation, including the computerized control of buildings. However, many improvements are only effective if those working in these new facilities participate. WHEN ATTEMPTING TO CONSERVE ENERGY IN THE LABORATORY, NEVER JEOPARDIZE THE HEALTH AND SAFETY OF YOURSELF OR YOUR COLLEAGUES. Additional information can be found on the Department of Energy's website. [33]

4.18 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;

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[32] Specifications for the dry ice test procedure are outlined by the ANSI/American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE) Standard 110-1995.

[33] https://energy.gov/eere/office-energy-efficiency-renewable-energy

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' compliance efforts, your EHS Office will conduct regular required inspections of all campus research areas. Inspections help those responsible identify and correct potential regulatory compliance issues. They also identify potential health and safety hazards that could pose unreasonable risks to laboratory personnel, students, and the campus community. Research areas are strongly encouraged to conduct their own regular self-inspections to address potential issues and provide training opportunities for research staff.

4.18.1 Self-Inspections

An important part of any research safety program is the implementation of self-inspections. Self-inspections help create a culture of safety within the lab and identify compliance issues that might arise during the course of day to day activities. Self-inspections Identify and address any potential issues before an inspection by a federal and state regulatory agency and serve as a vehicle for addressing faculty, staff, and student concerns.

Recommended Frequency for Self-inspections

Daily	Housekeeping
Weekly	Laboratory walkthroughs or "Friday afternoon cleanups"
Monthly	Include participation of research staff and/or safety committee members, and use of an inspection checklist (see Appendix G)
Semester	Research personnel should perform a formal self-inspection

The benefits of conducting inspections of laboratories on a regular basis cannot be overstated. Laboratory inspections can reduce liability by identifying potential issues and provide laboratory personnel the opportunity to look for and correct potential issues.

4.18.2 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 campus. The best way to prepare is to know what regulations apply to your area and how to comply with those regulations. You can obtain this information from this Laboratory Safety Manual, self-inspections and the campus EHS Office. If a federal or state inspector arrives at your work area unescorted, politely ask them to wait and contact your EHS Office immediately. EHS Officers should contact EHSRM as well.

4.19 Laboratory Security

Laboratory security is related to but different from laboratory safety. Security seeks to prevent unauthorized access to laboratories and the theft of equipment or materials. Laboratories must provide security against theft of highly hazardous materials and valuable equipment, while ensuring compliance with federal, state, and local regulations. The EHSO will work with each unit (college, department, and research group) to review and develop procedures. One easy way to increase security is to lock laboratory doors whenever the room is left unattended.

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

- Develop a site-specific security policy. Assess each laboratory area and reassess as necessary.
- Train laboratory group members. Training should include any assigned responsibilities.
- Know who is in the laboratory at any given time. Consider using a logbook, carded access devices or identification tags. Approach anyone unfamiliar and ask if you can help direct them. Call Public Safety if you have concerns.
- Be aware of hazardous chemicals that pose a security risk. The Centers for Disease Control and Prevention maintains lists of biological diseases and chemical agents.[34]
- Control access to areas where hazardous chemicals are used and stored. Limit laboratory access to only those required and restrict off-hours use to individuals authorized by the P.I.
- Lock freezers, refrigerators, storage cabinets, and other containers where stocks of biological agents, hazardous chemicals, or radioactive materials are stored.
- Do not leave hazardous materials unattended or unsecured at any time.
- Secure your highly hazardous materials. Consider using a logbook to sign hazardous materials in and out of secure storage areas.

[34] https://emergency.cdc.gov/agent/agentlist-category.asp

- Know what materials are being ordered and brought into the laboratory area. Screen packages before they are brought into your lab. Packages containing potentially infectious materials should be opened in a biological safety cabinet or other appropriate containment device.

- Track materials being used and removed from the laboratory, including the proper disposal of hazardous materials.
- Take periodic inventories of all highly hazardous chemicals, biological agents/toxins, and controlled substances (required for radioactive materials).[35]

- Report any missing inventory to the Office of Public Safety IMMEDIATELY.

- CLOSE and LOCK laboratory doors when no one is present.

- Develop an emergency plan that takes into account security measures. Do this in partnership with Public Safety as security measures might inhibit emergency response.

- SOPs should be in place for reporting and investing incidents, such as undocumented visitors, missing chemicals, or unusual or threatening phone calls or email.

- Review your protocols and emergency plans and update as necessary.

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.

5.0 EMERGENCY PREPAREDNESS

Emergencies can occur at any time and without warning. Careful planning and appropriate responses 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 EHS Office as well as Public Safety. Public Safety Officers are on duty 24 hours a day, 365 days a year. If you are working in your laboratory, during off-hours, please be sure to follow the guidelines in Section 4.6.

5.1 Emergency Procedures

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

- Flooding, tornadoes, earthquakes, or other natural disasters

[35] Laboratories must maintain a chemical inventory through ChemTracker or by some other means.

- Nearby chemical releases of hazardous materials to the environment
- Terrorist actions or civil unrest
- Loss of electricity, heat, water or other essential utilities
- Failure of mechanical equipment such as HVAC systems and emergency generators

5.2.1 Emergency Evacuation Procedures

Building occupants are required by law to evacuate the building when the fire alarm sounds.[36] Evacuation directions, fire alarm locations and escape routes must be posted throughout the building, at the base of stairways, elevator landings, and inside public doors. The specific location(s) of the building's designated evacuation meeting points should be included. Buildings designated with Class E occupancy code must have a fire safety plan on file with the FDNY.

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 stairway 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 until instructed to do so by emergency responders.

5.2.2 Laboratory Emergency Shutdown Procedures

Each facility should develop a non-fire emergency plan or incorporate non-fire emergencies into a master emergency response plan. Employees must be trained regarding all response plan details including non-fire procedures. Below is a sample set of steps for shutting down laboratories in non-fire emergency situations. This list is not comprehensive but gives steps to consider when developing procedures.

- Close fume hood sashes
- Close chemical containers
- Turn off all non-essential electrical devices. Leave refrigerators and freezers on confirming the doors are closed. Check disconnects of large LASERs, radiofrequency generators, NMRs, etc.
- Confirm essential equipment is plugged in to power outlets supplied by an emergency generator (usually orange or red).

[36] Pursuant to RNYC§27-4267 and FDNY Regulations

- Turn off all gas cylinders at the tank valves.
- Check all cryogenic vacuum traps (nitrogen, carbon dioxide, and solvent). 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 to secure those areas such as emergency power, ventilation, and other support may be required.
- 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 laboratory is reopened.
- Remember some equipment does not shut down automatically – such as large cryogenic magnets, sources of radioactivity, as well as other equipment. Check operating procedures for equipment before an emergency occurs.

PLEASE NOTE: If a low flow of inert gas is being used to "blanket" a reactive compound or mixture, the laboratory 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.

5.2.3 Medical Emergency Procedures

CALL 911 AND PUBLIC SAFETY FOR ANY EMERGENCY THAT REQUIRES IMMEDIATE POLICE, FIRE, OR MEDICAL RESPONSE TO PRESERVE A LIFE.

- Protect the victim from further injury by removing any persistent threat or by moving the victim to a safe place. Do not move the victim unnecessarily or delay obtaining trained medical assistance.

- Notify First Responders of the location, nature, and extent of the injury. Call Public Safety or 911. Always call from a safe location.

- Provide first aid until help arrives if trained and it is safe to do so.

- Send someone to escort emergency responders to the appropriate location, if possible.

5.2.4 First Aid Kits

There are no legal requirements to support first aid kits in work spaces on campuses, 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, the kit must contain items appropriate to mediate an injury that could happen in your work area.

There must be a trained, responsible person and their contact information must be posted on the kit. The kit must be maintained and refilled after use. An Injury/Illness report should be completed when a first aid kit is used.

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, using a Blue Light emergency box or an Emergency Telephone. Always call from a safe location.
- Evacuate the building using the Emergency Evacuation Procedure. Do not use elevators unless directed to do so by emergency responders.
- Notify emergency responders of the location, nature, and size of the fire once outside.
- Proceed to the designated evacuation meeting point.
- Wait for instructions from emergency responders.
- Do not re-enter until instructed to do so by the emergency responders.

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 beforehand. Consult the Building Emergency Procedure Plan for additional information.

If clothing ison fire:

- Stop, drop to the ground 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 injuries.

5.2.6 Fire Extinguishers

Portable fire extinguishers may be located in several places throughout a laboratory depending on the work being done. Extinguishers must undergo regular testing and inspection. In certain circumstances they must be replaced. See Appendix P for details. You must be trained before using a fire extinguisher. Any fire extinguisher that has been used, even if it was not fully discharged, must be reported to the EHSO so a replacement fire extinguisher can be provided. Contact your EHSO for information regarding training or replacement extinguishers.

Not all fires are the same. They are classified according to the type of fuel that is burning. There are corresponding fire extinguishers that are designed to respond to different classes of fire. Using the wrong class of fire extinguisher for the wrong fire can exacerbate the fire. It is therefore extremely important to understand the five different fire classifications.

Should the nature and size of the fire make it possible, use the appropriate extinguisher.

- **CLASS A** extinguishers are for ordinary combustible materials such as paper, wood, cardboard, and most plastics.

- **CLASS B** extinguishers should be used for flammable or combustible liquids.

- **CLASS C** extinguishers are used for fires involving electrical equipment. If possible, turn off the electrical power to the devices, and then use either the dry chemical extinguisher or a carbon dioxide or halon extinguisher, if available. Never use water to extinguish a CLASS C fire.

- **CLASS D** fire extinguishers are for fires that involve combustible metals such as sodium, potassium, magnesium, or any other flammable metal powders used in a laboratory. DO NOT USE pressurized water, carbon dioxide, dry-chemical or halon extinguishers on metal or organometallic fires. The use of these extinguishers may introduce reactive substances to the burning metal and may either make the fire grow or trigger an explosion.

- **CLASS K** fire extinguishers are for fires that involve cooking oils, trans-fats, or fats in cooking appliances and are typically found in restaurant and cafeteria kitchens.

5.2.7 Power Outage Procedures

In the case of a power outage, use the following procedures:

- Assess the extent of the outage. Is it restricted to part one laboratory or a wider area?
- Report the outage to Public Safety.
- Assist other building occupants if evacuation is required. Power loss to fume hoods may require 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.
- Turn off and/or unplug non-essential electrical equipment, computer equipment and appliances.
- Keep refrigerators and freezers closed 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, take prompt and appropriate action. The type of response will depend on the quantity of chemical spilled and the severity of associated hazards. The first action is to alert others in your laboratory 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 appropriate PPE should attempt to clean up incidental spills.

5.3.1 Incidental Spills

The following is intended for spills that occur within a building. A release to the outside environment may require a report to the responsible government agency. The EHS Office can make that determination. ALL the following criteria must be met for a spill to be considered incidental

Physical

- The spill is a small quantity of a known chemical.
- No resulting 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 those in the spill area. Prevent others from coming in contact with the spill (i.e., walking through the spilled chemical). Protect yourself and others first.

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

3. Stop the source of the spill if possible and safe to do so.

4. Try to prevent spilled chemicals from entering waterways. Build a dike around access points (sink, cup sinks, and floor drains) with absorbent material if you can safely do so.

5. Use the appropriate absorbent material for liquid spills (detailed in 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 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, outline the spill area 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

The following materials are recommended spill absorbent materials; however, they are not appropriate for every possible chemical spill. NEVER pour laboratory chemicals down the drain. When in doubt, contact your EHSO for advice.

For acid spills (except Hydrofluoric acid)

- Sodium carbonate
- Sodium bicarbonate (bakingsoda)
- Calcium carbonate
- Calcium bicarbonate
- DO NOT use absorbent clay for acid spills

For Hydrofluoric acid (HF) spills

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

For liquid base spills

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

For oil spills

- Use ground up corn cobs, vermiculite, or absorbent clay (kitty litter).

For most aqueous solutions

- Use ground corncobs.

For most organicliquid spills

- Use ground corncobs.

For oxidizing liquids

- 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

- Donotdisposeofmercuryormercurycontaminatedspilldebrisintheregulartrashor 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 youneedhelp collectingmercuryfroma spill, contact your EHSOffice. [Note: While powdered sulfur helps reduce mercury vapors, sulfur greatly complicates spill cleanup.]

5.3.3 Spill Kits

While commercial spill kits are available from a number of safety supply vendors, laboratory personnel can assemble spill kits specific to their needs. ALL laboratories must have spill kits available for use. Colleges and departments should consider distributing basic spill kits to all laboratories that can be expanded to fit the hazards present in any particular laboratory.

A spill kit can be assembled using a 2.5 or 5 gallon bucket, appropriate absorbent materials and equipment. 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 address.

Possible absorbent materials

- 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.

Possible equipment

- Wisk broom and dust pan
- 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

Clearly labeled the container's exterior "SPILL KIT" and a list of the contents. Include instructions and contact information for restocking the kit after use.

Laboratory personnel must be properly trained to do the following:

- Determine if they can or should clean up a spill.
    - If the answer to either question is NO, call the EHS office, Public Safety, or outside assistance.
- Locate the spill kit within the laboratory.
- Identify what items are in the kit and use the kit properly.
- Clean up different types of chemical spills.
- Dispose of spill cleanup material.
- Restock the kit.

For more information regarding assembling a spill kit or obtaining appropriate training contact your EHS Office.

5.3.4 Major Spills

Any time a researcher determines outside assistance is necessary to clean up a chemical spill safely, that spill is by definition major. In the case of a major spill, contact your EHS Office and Public Safety immediately.

5.3.4.1 *Major Spill Cleanup Procedures*

When a major spill occurs, the following procedures may be relevant.

1. Alert people in the immediate area and evacuate the room.
2. 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.
3. Confine the hazard by closing doors as you leave the room.
4. Use eyewash or safety showers as needed to rinse spilled chemicals off.
5. Evacuate any nearby rooms that may be affected. If the hazard will affect the entire building, pull the fire alarm.
6. 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 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 emergency responders, either in person or by phone

Once outside, confirm someone has notified emergency responders. 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. [37] 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 flow requirements, use of tempered water, inspection and testing frequencies, and training of laboratory personnel in the proper use. 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. NOTE: Because of the flow requirements outlined in the ANSI standard, hand held bottles do not qualify as approved eyewashes.

[37] https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_id=9806&p_table=STANDARDS

5.4.1 Testing and Inspection of Emergency Eyewash and Showers

The ANSI Standard states that plumbed emergency eyewash and safety showers should be activated weekly to verify proper operation and inspected annually. Laboratories are responsible for ensuring free access is available to eyewashes and emergency showers and that eyewash nozzle dust covers are in place. Dust or other particles can clog the nozzles, result in poor flow or force particles into the eyes when the eyewash is used.

It is the responsibility of laboratory personnel to activate (flush) units on a weekly basis. Weekly flushing ensures the units are operating properly, helps keep units free of clutter, and helps prevent the growth of bacteria in the plumbing lines. Allow the water to run for at least 3 minutes during testing. Laboratories are strongly encouraged to post an “Eyewash Testing Sheet” near the eyewash to document weekly activation.

Always report any malfunctioning eyewashes and emergency showers to Facilities Management immediately. If an emergency shower or eyewash is not working properly, hang a “Do Not Use” sign on the unit to alert others.

Annual inspection and testing should be conducted in accordance with FDNY Fire Code §2706 and Fire Code §105.3.8. [38] Tags shall be affixed to each station to document annual inspections, including the inspector’s initials and date of inspection. Your EHSO will perform annual inspections of eyewashes and emergency showers to test for compliance with ANSI Z358.1-2004. This annual test will include

- Testing water flow for proper quantity and spray pattern
- Testing water quality
- Ensuring the unit is the proper height from the floor
- Ensuring the unit is not obstructed
- Ensuring the unit has a tempering valve (If not, recommend repair in inspection report)
- Ensuring valves are working properly
- Verifying signs are posted indicating the location of units
- Checking the unit is free of corrosion

5.4.2 Installation of New Emergency Eyewash Stations and Showers

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

[38] http://www.nyc.gov/html/fdny/pdf/firecode/2009/fire_code_ll26_2008_amended_ll37_41_64_2009_final_complete.pdf

5.4.3 Using Emergency Eyewash and Showers

Always determine emergency procedures and 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.
2. Immediately go to the nearest eyewash station and push 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. The importance of flushing the eyes immediately and for at least 15 minutes cannot be overstated!
6. For accidents involving Hydrofluoric acid, follow the special Hydrofluoric acid precautions.
7. If you are alone, call Public Safety or 911 after you have finished flushing your eyes for at least 15 minutes.
8. Seek medical attention.
9. Complete an Injury/Illness Report.

If someone else in the laboratory needs an eyewash, help them locate the nearest station, activate the eyewash, and help them start flushing the affected areas using the procedures above and then call Public Safety. After calling, go back to assist the person helping them to continue flushing for 15 minutes or until help arrives.

Emergency Showers

1. If an accident results in the chemical contamination of your skin, yell for help.
2. Immediately go to the nearest emergency shower and pull the activation handle.
3. Once under the stream of water, remove your clothing to wash off all chemicals.
4. Keep flushing for at least 15 minutes. The importance of flushing for at least 15 minutes cannot be overstated!
5. If you spill Hydrofluoric acid on yourself, follow the special Hydrofluoric acid precautions.
6. If you are alone, call Public Safety or 911 after you have finished flushing for at least 15 minutes.
7. Do not be concerned about the damage from flooding. KEEP flushing.
8. Seek medical attention.
9. Complete an Injury/Illness Report.

If someone else in the laboratory needs an emergency shower (and it is safe for you to do so), assist them to the nearest emergency shower, activate the shower for them, and help them get started flushing using the procedures above and then call Public Safety. If you are assisting someone else, you should wear gloves to avoid contaminating yourself. After calling, go back to assist the person as they continue flushing for 15 minutes or until help arrives. NOTE: Although an emergency is no time for modesty, if a person is reluctant to use the emergency shower, assist them by using a lab coat or other barrier while they undress under the shower.

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 event occurs, medical consultations and examinations will be made available to laboratory workers as required. All work related medical examinations and consultations will be performed by or under the direct supervision of a licensed physician. They 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 when:

- An employee develops signs or symptoms associated with a hazardous chemical to which the employee may have been exposed.

- Airborne exposure monitoring reveals levels routinely above the action level for an OSHA regulated substance that has exposure monitoring and medical surveillance requirements. (In the absence of an action level, the Permissible Exposure Limit is used.)

- An event such as a spill, leak, or explosion results in the likelihood of exposure.

In the event of any of the above circumstances, the employee shall be provided an opportunity for a medical consultation. The consultation shall determine 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. [39]

5.6.1 Information Provided to the Physician

The physician shall be provided with the following information

[39] https://www.osha.gov/dsg/annotated-pels/

- The identity of hazardous chemical(s) to which the employee may have been exposed
- The Safety Data Sheets (SDS)
- The conditions under which the exposure occurred including quantitative exposure data, if available
- Any signs of exposure and symptoms that the employee is experiencing

5.6.2 The Physician's Written Opinion

The Physician's written opinion should include the following information

- Results of the medical examination and any associated tests
- Any medical condition(s) revealed during the course of examination and may place the employee at increased risk as a result of exposure
- Documentation that the employee has been fully informed by the physician of the consultation or medical examination results, including any medical condition(s) that may require further examination or treatment.

The physician's written opinion regarding the consultation or examination shall NOT include

- Any specific findings of diagnoses unrelated to the occupational exposure.

All records of medical consultations or examinations, including tests or written opinions, shall be maintained at the college health center in accordance with 12 CRR-NY Section 801 and administrative instructions 901.[40] Exposure monitoring records of contaminate levels in laboratories will be maintained at the EHS Office of each campus. For more information, contact your EHS Office.

6.0 EMPLOYEE INFORMATION AND TRAINING

Federal, state, and local laws require that all laboratory workers receive safety training and be informed of the potential health and safety risks potentially present in the workplace. Laboratory safety training must be obtained either through your EHS Office or through an EHS O approved source. The EHS Office maintains records of employee safety training and laboratory personnel must submit documentation of any training received from alternative sources.

The OSHA Laboratory Standard also requires employers provide employees with information and training. It also requires this information be provided at the time of an employee's initial assignment

[40] New York State promulgated and adopted an alternative approach to recordkeeping requirements from that in the OSHA Laboratory Standard. https://labor.ny.gov/workerprotection/safetyhealth/PDFs/PESH/Part801.pdf
http://www.nyc.gov/html/dcas/downloads/pdf/misc/cosh_sh900.pdf

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 Laboratory Standard and its appendices (Appendix A and 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 reference materials listing hazards, safe handling, storage, and disposal of hazardous chemicals found in the laboratory including, but not limited to, SDSs received from the chemical supplier

The Laboratory Standard goes on to state that 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

While the OSHA Laboratory Standard is specific to working with hazardous chemicals, laboratory employees must also be provided proper training and information related to other health and physical hazards in their work environment. This includes hazards described within this Laboratory Safety Manual and applicable details of the employer's written Chemical Hygiene Plan. 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 proper training, have received information about hazards they may encounter, and have been informed about how to protect themselves.

6.1 Training Options

P.I.s and laboratory supervisors have a number of options available to them to ensure employees under their supervision have received proper training. These options include in-house programs, on-line resources, outside vendor programs and other resources.

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.

Any training program must meet the following requirements:

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

7.0 SAFE CHEMICAL USE

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

7.1 Minimize Exposure to Chemicals

The best way laboratory personnel can protect themselves from chemical hazards is to minimize exposure. To minimize chemical exposure the following guidelines should be implemented where applicable:

- Do not underestimate the risk of exposure to chemicals, even for substances of no known significant hazard.
- Substitute less hazardous chemicals in experiments
- Always use the smallest possible quantity of chemical for all experiments and consider microscale experiments
- Minimize chemical exposures for 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
- Do not pipette or apply suction by mouth
- Do not smell or taste chemicals. When it is necessary to identify a chemical's odor, hold the chemical container away from the face and gently waft a hand over the container without inhaling large quantities of chemical vapor.
- To identify potential hazards, laboratory personnel should plan experiments in advance. These plans should include specific measures that will be taken to minimize exposure, proper positioning of equipment, and 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 is 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 and splashes regardless of whether the chemical is considered hazardous or nonhazardous.
- When working in cold rooms, keep all toxic and flammable substances tightly closed, as cold rooms have recirculated air.
- Be aware of a potential asphyxiation hazard when using cryogenic materials and compressed gases in confined areas such as cold rooms and environmental chambers. Install an oxygen monitor/oxygen deficiency alarm and/or toxic gas monitor before work begins.
- 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 shall be labeled "Not For Human Consumption." Refrigerators used to store food shall be labeled "For Food Only."
- Always wash hands with soap and water after handling chemicals and before leaving the laboratory – even if gloves were worn during chemical handling.
- Always remove personal protective equipment, such as gloves and laboratory coats, before leaving the lab.

Scaling-Up Experiments

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. It is advisable to let other laboratory group members check your setup prior to each run.

7.2 Understanding Chemical Hazards

Chemicals pose both health and physical hazards. 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."[41]

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."[42] Physical hazards are covered in other sections within this manual.

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.

[41] https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=10100
[42] https://www.osha.gov/dsg/hazcom/ghd053107.html

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." [43]

It is the responsibility of the P.I. and laboratory supervisor to ensure that staff and students under their supervision are provided with adequate information specific to the hazards found within their laboratories. In addition to required health and safety training as per the OSHA Laboratory Standard, other sources of information on chemical and physical hazards include:

- Safety Data Sheets(SDSs)
- CUNY Laboratory Safety Manual
- Known materials (videos, other department's safety manuals or websites)
- Container labels
- Laboratory Standard Operating Procedures
- Laboratory signage and postings
- Publications like the American Chemical Society's Safety in Academic Chemistry Laboratories

7.3 Safety Data Sheets (SDSs)

Safety Data Sheets (SDSs) are an important part of any laboratory safety program, communicating specific information to chemical users. 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 SDSs (and other sources of information) for all hazardous chemicals used in their laboratories.

SDSs provide important information

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

[43] 29 CFR 1910.1450(f)

Any chemical shipment received should be accompanied by an SDS (unless one has been shipped with a previous order). If you do not receive an SDS with your shipment, check the chemical manufacturer's website first, call the manufacturer directly, or contact your EHSO.

If you have questions regarding how to read an SDS, or questions about the terminology or data used, contact your EHS Office. Information regarding how to read an SDS, can be found in Appendix H. Information on the National Fire Protection Association - NFPA diamond and the Hazardous Materials Information Guide and Hazardous Materials Information System – HMIG and HMIS - is available. [44]

SDSs must be accessible at all times. A person working in a laboratory should be able to produce an SDS within five minutes. P.I.s and laboratory supervisors are strongly encouraged to keep paper copies of SDSs in the laboratory. Bookmarking SDS websites is acceptable as long as all employees are trained to use the computers and know where to find the SDSs. The SDS website links should be clearly visible.[45]

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

7.3.1 SDSs 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 SDS for newly synthesized chemicals. Please consult with your EHSO if you need assistance.

7.4 Routes of Chemical Entry

The potential health effects 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 mixing with other chemicals. In order to

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[44] https://www.osha.gov/Publications/OSHA3514.html;
http://www.chemsafetypro.com/Topics/USA/Hazardous_Materials_Identification_System_HMIS.html;
https://www.nfpa.org/codes-and-standards/all-codes-and-standards/list-of-codes-and-standards/detail?code=704;
https://www.osha.gov/Publications/OSHA3636.pdf

[45] 29 CFR 1910.1200(g)(8) The employer shall maintain in the workplace copies of the required safety data sheets for each hazardous chemical, and shall ensure that they are readily accessible during each work shift to employees when they are in their work area(s). (Electronic access and other alternatives to maintaining paper copies of the safety data sheets are permitted as long as no barriers to immediate employee access in each workplace are created by such options.)

understand how chemical hazards can affect you, it is important to first understand how chemicals can enter your body and cause damage. The four main routes of entry are inhalation, ingestion, injection, and absorption.

7.4.1 Inhalation

Inhalation of chemicals occurs via the respiratory tract. Chemicals that have entered the respiratory tract can subsequently be absorbed into the bloodstream and distributed throughout the body. Chemicals can be inhaled in the form of vapors, fumes, mists, aerosols and fine dusts.

Symptoms of chemical exposure 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 or use of dust masks and respirators when approved. Avoid bench top use of hazardous chemicals, ensure chemical containers are kept tightly capped, and make sure all chemical spills are promptly cleaned up.

7.4.2 Ingestion

Chemical exposure through ingestion occurs by absorption through the digestive tract. Ingestion of chemicals can occur directly and indirectly. Direct ingestion can occur when a chemical is accidently eaten or drunk. Proper housekeeping and labeling diminishes this hazard. Indirect ingestion occurs when food or drink is brought into a chemical laboratory and absorbs chemical contaminants (vapors or dusts) present in the air. When contaminated food or drink is consumed chemical exposure can result. Indirect ingestion can also result from contamination of food or drink stored with chemicals, such as in a refrigerator. A laboratory worker who handles chemicals and fails to wear gloves or practice good personal hygiene, such as frequent hand washing, and then leaves the laboratory to eat, drink, or smoke also risks ingesting chemicals.

Symptoms of chemical exposure due to 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. It is important to note the effects of chronic exposure may not manifest themselves until years later.

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.

Laboratory workers can protect themselves from an injection hazard by following safety procedures. Wear proper PPE including safety glasses/goggles, face shields, and gloves. Inspect all glassware for chips and cracks before use, and immediately discard any glassware or plastic-ware that is damaged. To help protect coworkers, all broken glass should be disposed of in a puncture resistant container that is clearly labeled. This can be a commercially purchased "broken glass" container or a cardboard box or other puncture resistant container with "Broken Glass" written on the outside. When cleaning up broken glass or other sharp items, always use a broom, scoop, dustpan, or pliers. If you must use your hands, wear leather gloves.

Never leave any item(s) out or unattended that can cause cuts or puncture wounds, such as needles and razor blades. 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 thoroughly
3. Administer first aid
4. Seek medical attention if necessary
5. Complete an Injury/Illness Report

7.4.4 Eye and Skin Absorption

Some chemicals can be absorbed through eyes and skin resulting in exposure. This type of exposure most often occurs when a chemical spills or splashes resulting in contact with unprotected eyes or exposed skin. Immediate effects are possible and, once absorbed, the chemical can quickly find its way into the bloodstream causing additional damage.

Symptoms of eye exposure can include itchy or burning sensations, blurred vision, discomfort, and blindness. The best way to protect your eyes from chemical splashes is to always wear appropriate safety glasses whenever eye hazards exist (chemicals, glassware, LASERs, etc.). If you are pouring chemicals, splash goggles are more appropriate than safety glasses. Whenever a severe splash hazard may exist, a face shield, in combination with splash goggles is the best choice for eye protection.

If chemicals get in your eyes, immediately find the nearest 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. Afterflushing for at least 15 minutes, seek medical attention immediately and complete an Injury/Illness Report.

Symptomsofskin exposureto chemicals includedry, whitened skin, redness, swelling, rashes, blisters, itching, chemical burns, cuts, and defatting. Please note that some chemicals can be readily absorbed by the skin. If skin is already physically damaged or sunburnt the rate of absorption may be impacted. Laboratory workers can protect their skin from chemical exposure by wearing the proper gloves, wearing a lab coat and employing other personal protective equipment (such as protectivesleeves,faceshieldsandaprons). Shortsorsandalsarenotadvisableinlaboratories.

For small chemical splashes, remove contaminated gloves, laboratory 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.

Forlargechemicalsplashes,itisimportanttogettoanemergencyshowerimmediatelyandstart flushing for at least 15 minutes. Once under the shower, and after the shower has been activated, remove any contaminated clothing. Failure to remove contaminated clothing can result inthe chemicalbeingheldagainsttheskinandcausingfurtherchemicalexposureanddamage. After flushing for a minimum of 15 minutes, seek medical attention immediately and complete an Injury/Illness Report.

NOTE: Some chemicalsrequire use ofa specialantidote and specialemergency procedures. Be sure to read SDSs for any chemical you work with to determine if a special antidote is needed before chemical exposure occurs.

7.5 Chemical Exposure Limits

The Laboratory Standardrequiresthatemployee exposureto OSHA Regulated Substancesdoesnot exceed Permissible Exposure Limits (PELs) as specified in 29 CFR Part 1010, Subpart Z. PELs 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 which are legally enforceable.

AnothermeasureofexposurelimitsareThresholdLimitValues(TLV)whicharerecommended occupational exposure limits published by the American Conference of Governmental Industrial Hygienists(ACGIH). Similarto PELs, TLVs aretheaverage concentration of a chemicalthata worker canbe exposed to over an 8-hour workday, 5 days per week, over a lifetime without observing ill effects. TLVsalsohaveCeiling(C)limits,whicharethemaximumconcentrationaworkercanbe exposed to at any given time. The ACGIH has established TLVs for over 800 chemicals. TLVs are advisory guidelines only and not legally enforceable. Both PELs and TLVs can be found on SDSs. Another good resource for information is the National Institute for Occupational Health and Safety (NIOSH). If laboratory personnel 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 laboratory practices—the potential for exceeding exposure limits is significantly reduced.

7.6 Chemical Exposure Monitoring

Safe use of materials depends heavily on following proper 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 EHS Office can help evaluate the effectiveness of your controls by monitoring exposures. Exposure monitoring determines 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 the selection of PPE.

If you think you have been 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 EHS Office.

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
- Ethylene oxide

Other substances that have exposure monitoring requirements include

- Lead
- Cadmium
- 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

- Quantity and concentration of the chemical
- Length of time and the frequency of exposure
- Route of exposure
- If mixtures of chemicals are involved.
- Sex, age, and lifestyle of the person exposed to the chemical.

7.7.1 Toxic Effects

Toxic effects are generally classified as either 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 from acute exposures, with long term chronic effects. An example of chronic toxicity is cigarette smoking and lung cancer.

7.7.2 Evaluating Toxicity Data

SDSs, and other related resources, generally refer to the toxicity of a chemical numerically using the term Lethal Dose 50 (LD50). The LD50 is determined by toxicity test study and reflects the amount of a chemical that when ingested or absorbed by skin results in death for 50% of test animals. Another common term is Lethal Concentration 50 (LC50), which describes the amount of chemical inhaled by test animals that causes death in 50% of those 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. The lower the LD50 or LC50 number, the more toxic the chemical. Remember, there are other factors (e.g., concentration of the chemical and frequency of exposure) that contribute to toxicity, 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 toxicity, particularly relative to another chemical. For example, when deciding what chemical to use in an experiment, a chemical with a high LD50 or LC50 would be safer to work with, assuming the chemical did not possess multiple hazards and no additional variable exist.

Prudent Practices in the Laboratory[46] 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

[46]https://www.nap.edu/catalog/12654/prudent-practices-in-the-laboratory-handling-and-management-of-chemical

In addition to having a toxic effect on the body, some chemicals can be carcinogenic, mutagenic, teratogenic, and acutely toxic. See 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 informs people of potential hazards, prevents the generation of unknowns, allows for correct waste disposal, and facilitates emergency response. Most new chemical containers have 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, any chemical labels that appear damaged or are difficult to read should be relabeled. All personnel working in the laboratory must be fully trained on how to label chemicals.

7.8.1 Labeling Non-Original Containers for Content

The full chemical name must be written on a label. If this is not possible, then abbreviations are acceptable only if a full list of chemical abbreviations, a key, is posted in the laboratory. The key must be in a readily visible location, preferably close to the chemicals and/or by the door. The key must contain the abbreviations used and the full name of the chemical. The P.I. must have an additional copy of the key.

7.8.2 Labeling Non-Original Containers for Hazards

Non-original containers (secondary use containers) can include wash bottles, squirt bottles, temporary storage containers, beakers, flasks, bottles and vials- any container that a chemical is transferred into from its original. Non-original containers must be properly labeled with the hazard characteristics (ignitibility, corrosivity, reactivity, and toxicity) of that chemical in order to satisfy federal and state regulations.[47] If the material has any of the following characteristics then the label must indicate the specific hazard.

- Flammable (flash point under 141 degrees Fahrenheit)
- Oxidizer
- Reacts with water or air
- Spontaneously combusts or polymerizes
- A pH less than 2 or greater than 12

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[47] 6 NYCRR §372.2(a)(2); 40 CFR §262.11 https://govt.westlaw.com/nycrr/Document/I4eacc401cd1711dda432a117e6e0f345?viewType=FullText&originationContext=documenttoc&transitionType=CategoryPageItem&contextData=%28sc.Default%29&bhcp=1 AND https://www.ecfr.gov/cgibin/retrieveECFR?gp=&SID=c532e6054beede33caee46c48783d99f&mc=true&r=PART&n=pt40.28.262#se40.28.262_111

- Explosive
- Contains heavy metals

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.

For small containers, such as vials and Eppendorf tubes, laboratory personnel can group them by class into a larger vessel and label the outside of that vessel, making sure to list all hazards present. This system is not recommended for hazardous chemicals and would be more appropriate for non-hazardous compounds such as agar and buffer solutions.

Here are examples of other similar systems.

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

- Store vials in a test tube rack and label the rack with the chemical name. Each vial in the rack should be labeled with an abbreviation, number, letter, or color code[48] that corresponds to the label on the test tube rack

- Preserved specimens should be labeled with the preservative (e.g., ethanol or formaldehyde). A large number of labels can be generated using mailing labels.

7.9 Chemical Storage

Chemical storage areas 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 promotes safer working conditions, extends the useful life of chemicals, and can help prevent contamination.

Chemicals that are stored improperly can result in a number of circumstances.

- Degraded containers that release hazardous vapors can be detrimental to health
- Degraded containers allow chemicals to become contaminated may impact experiments
- Degraded containers that release vapors can impact the integrity of nearby containers.
- Degraded labels can result in the generation of unknowns.
- Chemicals can become unstable and/or potentially explosive.
- Improper storage can result in citations and/or fines from federal, state, and local regulatory agencies.

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[48] Some laboratory workers may be color-blind. This fact must be taken into consideration BEFORE a color-coding system is used.

7.9.1 General Storage Guidelines

It is recommended that laboratories adhere to the following guidelines regarding the safe storage of chemicals. Proper storage of chemicals improves safety and increases efficiency.

- All chemical containers must be labeled. Labels should include any hazards present and the full name of the chemical constituent(s). Check chemical containers regularly. Replace labels that are deteriorating, falling off or are at risk of becoming an unknown.
- Keep all containers 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 benchtops should be kept to a minimum to help prevent clutter, avoid spills, and allow for adequate working space.
- Chemical storage in fume hoods should be kept to a minimum and limited to the experiment being conducted or risk interference with airflow, reduces working space, and increased risk of spills, fire, or explosions.
- For chemical storage cabinets, larger chemical bottles should be stored towards the back and smaller bottles up front where they are visible. Labels should facing out so they can be easily read.
- EPA and FDNY regulations prohibit chemical storage on the floor.
- For multiple containers of the same chemical, older containers should be stored in front of newer chemicals. This reduces excess inventory.
- 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, only order stock needed for a specific experiment or the quantity necessary for a maximum of 2 semesters.
- Liquid chemical containers should be stored in secondary containment to minimize potential for bottle breakage and spills.
- Always segregate and store chemicals according to compatibility and hazard classes.
- Chemical containers should be dated when they arrive, checked regularly and disposed of upon expiration.
- Peroxide forming chemicals must be tested in accordance with the timetable found in Appendix J. Test dates must be recorded on the container label as well as the date received and opened.
- Flammable liquids in excess of limits for a specific flammability class must be stored in approved flammable liquid storage cabinets and refrigerators or freezers.
- Do not store acids in flammable liquid storage cabinets. This can result in serious degradation of the storage cabinet and any 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.
- In general, no chemicals should be stored above eye level.

- FDNY prohibits any type of storage within 18 inches (457 mm) of sprinkler head deflectors in building areas protected by a sprinkler system and within 24 inches(610mm) of the ceiling in areas not protected by a sprinkler system (see Fire Code §315.1[49]).
- 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 9.0).
- Be aware of any special antidotes or medical treatment that may be required for 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 have been properly trained.
- 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).[50] See Appendix L for details.

7.10 Transporting Chemicals

When transporting chemicals between laboratories within the same building or contiguous buildings, the following guidelines are recommended. Adherence helps protect people and the environment and minimize the potential for spills. You should have proper PPE accessible in the event of a spill.

- When ever transporting chemicals by hand, always use a secondary container such as a rubber acid carrying bucket, plastic bucket, or 5-gallon pail. A small amount of chemical-compatible packing material (shipping peanuts, vermiculite, or cardboard inserts) can be used to prevent bottles from tipping over or breaking during transport.

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

[49] 315.2.1 Ceiling clearance. Storage shall be maintained 2 feet (610mm) or more below the ceiling in non sprinkle red areas of buildings or a minimum of 18 inches (457 mm) below sprinkler head deflectors in sprinkle red areas of buildings.

[50] http://www.nyc.gov/html/fdny/pdf/firecode/2009/fire_code_ll26_2008_amended_ll37_41_64_2009_final_complete.pdf; http://www.nyc.gov/html/fdny/pdf/rules/rules_compilation_4th.pdf#4827-01

- Only freight elevators should be used to transport chemicals. If it is necessary to employ a passenger elevator, transport should be restricted to low-use times. If this is not possible, warn passengers or prohibit others from riding with you.

- When transporting compressed gas cylinders, always use a proper gas cylinder hand truck with the cylinders strapped to the cart keeping 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, use a buddy system. Have one person send the properly secured dewars or cylinders on the elevator while the other person waits at point where it will arrive.

Please contact the EHS Office if chemicals are to be transported between laboratories in non-contiguous buildings. NOTE: If chemicals are being transported off the main campus, there are specific procedures, training and legal requirements that must be followed. For more information, refer to the Hazardous Material Shipping section.

8.0 CHEMICAL HAZARDS

Chemicals can be broken down into hazard classes. Chemicals can exhibit more than one hazard or combinations of hazards. Several factors can influence how a chemical will behave, the hazards presented, and the required response.

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

The following sections describe general information and safety precautions about specific hazard classes. The chemical hazards listed are based on the Department of Transportation (DOT) hazard class system.[51] A general description of the hazards of various chemical functional groups can be found in Appendix I. The following sections are general guidelines. Laboratory personnel should always review SDSs 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

[51] https://www.fmcsa.dot.gov/regulations/enforcement/nine-classes-hazardous-materials-yellow-visor-card

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. Exposure to air, water, or other materials such as metals can cause a chemical to become unstable or potentially explosive. This is also a concern when certain chemicals dry out.

If you ever come across any chemical that you suspect may be shock, heat, and friction sensitive, do not attempt to move them. Instead, contact your EHS Office immediately!

Explosions can damage surrounding materials, generate toxic gases, and cause fires. If you plan to conduct an experiment where the potential for an explosion exists, first determine if another non-explosive prone chemical could be substituted. If you must use a chemical or compound that is potentially explosive, even low powered explosives, you must first obtain prior approval from the P.I. before starting any work. After obtaining approval, thoroughly read the SDSs and any other chemical resources related to the potentially explosive compound (s) to minimize hazards.

Whenever setting up experiments using potentially explosive compounds the following guidelines should be applied.

- 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 chemicals and equipment (particularly highly toxic and flammable) from the immediate work area.
- Notify the laboratory about the experiment, potential hazards and time line.
- 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 in place to help minimize any potential incidents.
- Always wear appropriate PPE, including the correct gloves, a lab coat or apron, safety goggles used in conjunction with a face shield, and explosion-proof shields.
- 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 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 signs of contamination. Specifically, note any deterioration of the outside of the container, crystalline growth in or outside the container and or discoloration of the chemical. If you discover a potentially explosive compound that exhibits any of these signs of contamination, contact your EHSO for assistance.

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: This classification is different than the criteria used by the DOT. This distinction is important because allowable container sizes and storage amounts are based on the particular OSHA Class of the flammable liquid.

Summary Table of Flammable Liquids

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

Summary Table of Combustible Liquids

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 EHS Office for 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 also 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 flammable storage cabinets are determined by the classification of the flammable liquids, quantities kept on hand, building construction (fire wall ratings), and building floor intended for storage. 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 EHS Office 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 by the DOT 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-butyllithium under hexanes and white phosphorus.

In addition to the hazard of the spontaneously combustible chemical itself, many of these chemicals are also stored under flammable liquids. In the event of an accident, such as a bottle being knocked off a shelf, the chemical can spontaneously ignite and a fire can occur. Extra care must be taken when handling spontaneously combustible chemicals.

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 working 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.”[52] 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.”[53]

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 tetrahedron, in order to have a fire, you need the following:

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[52] https://www.osha.gov/dte/grant_materials/fy07/sh-16625-07/hazcomglossary.pdf
[53] ibid

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

Oxidizers can supply the oxygen needed for the fire, whereas organic peroxides supply both the oxygen and the fuel source. Both oxidizers and organic peroxides may become shock sensitive when they dry out, are stored in sunlight, or 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 SDSs 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 overheating.

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

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 be avoided and plastic/polyethylene lined bottles and caps 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 present, explosions are more likely when concentrating, evaporating, or distilling these compounds.

When these compounds are improperly handled and stored, a serious fire and explosion hazard exists. A list of common peroxide forming chemicals can be found in Appendix J This list is not exhaustive, as there are numerous chemicals that can form peroxides. Be sure to read chemical container labels, SDSs and other chemical references.

The following guidelines should be adhered to when using peroxide forming chemicals:

- Each peroxide-forming chemical container MUST be dated when received and opened.
- Each peroxide forming chemical container must be tested for peroxides 6 months after opening. If safe for use, the test date must be marked on the outside of the container.
- After testing, if a laboratory deems the chemical safe for continued use, they may retain the chemical for an additional 6 month period, but never to exceed the expiration date.
- If a laboratory determines that a chemical is no longer safe for continued use, or the chemical reaches its expiration date, or 6 months passes from the test date, it must be disposed of as a hazardous waste.
- New and unopened containers of peroxide forming chemicals that have a pre-printed manufacturer's expiration date must be disposed of if that date has passed.
- Because of sunlight's ability to promote formation of peroxides, all peroxidizable compounds should be stored away from heat and sunlight.
- Peroxide forming chemicals should not be refrigerated at or below freezing or precipitating temperatures as these forms of peroxides are especially sensitive to shock and heat. Refrigeration does not prevent peroxide formation.
- 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.
- 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.
- A number of peroxide forming chemicals can be purchased with inhibitors added. Unless absolutely necessary for research, never purchase uninhibited peroxide formers.
- Before distilling any peroxide forming chemicals, 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.

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 [54] and the American Chemical Society booklet Safety in Academic Chemistry Laboratories[55] outline ways to test for peroxides. If the test 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 must be disposed of or deactivated. Test older test strips for efficacy with a dilute solution of hydrogen peroxide. Please Note: Compounds 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 laboratory 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"[56] as a chemical falling within any of the following categories:

- 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

- 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

- 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.[57] 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 and good personal hygiene should be followed. When working with known poisons, it is very important to have thought an experiment through, addressing health and safety issues before beginning work. Safety Data Sheets (SDSs) and

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[54] https://www.nap.edu/catalog/12654/prudent-practices-in-the-laboratory-handling-and-management-of-chemical
[55] https://www.acs.org/content/dam/acsorg/about/governance/committees/chemicalsafety/publications/safety-in-academic-chemistry-laboratories-students.pdf
[56] https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=10371
[57] ibid

other chemical references should be consulted before beginning the experiment. Ask the following questions before working with poisonous chemicals:

- 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 PPE is 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 in advance. Additional information can be found in the Exposure Monitoring and Routes of Chemical Entry sections of this manual.

If you think you may have been exposed to a poisonous substance, seek medical attention immediately. Alert Public Safety. Call Poison Control Center at 1(800) 222-1222. If possible, bring a copy of the SDS 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."[58] 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. 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.

[58] ibid

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.

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 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 SDSs for any chemical(s) you work with to determine if a special antidote is needed.

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 laboratory 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, the toxicity of HF is the main concern.

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

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

- Before anyone uses HF they MUST have prior approval from the P.I.
- All users of HF must receive Hydrofluoric Acid Safety training from both their EHS Office and supervisor.
- A Standard Operating Procedure (SOP) should be written for the process. This SOP should be posted or readily available near the designated area where HF use will occur.
- HF should be used in a designated fume hood labeled with a “HF Designated Area” sign.
- HF can etch the glass sash on a hood making it hard to see through. If this occurs, please contact EHS about installing a polycarbonate sash.
- An appropriate first aid kit must be available. A HF first aid kit includes 2.5% calcium gluconate gel and must be labeled with a “Hydrofluoric Acid First Aid Kit” sign posted in a prominent place.
- 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.
- Laboratory personnel involved should be able to answer the following in the affirmative:
    - Read the SDS for HF
    - Read the HF Use SOP developed by the lab
    - Read the Hydrofluoric acid section in this Laboratory Safety Manual
    - 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 occurs
  - 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 for working with HF:

- Never work alone when using HF. Always have a buddy system in place.
- Use a plastic tray for containment in case of a spill.
- Wash gloves off with water before removing them.
- Keep containers of HF closed.
- A Safety Data Sheet (SDS) for HF must be available.
- All containers of HF must be clearly labeled.
- Any stock of HF should be stored in plastic secondary containment and the cabinet labeled.
- HF should be stored in lower cabinets near the floor.

8.9.2 Perchloric Acid

Perchloric acid is a strong oxidizing acid that can react violently with organic materials and can also explode if concentrated above 72%. Perchloric acid should be used and stored away from combustible materials, and wooden furniture. Like all acids, secondary containment should be used for storage. Use alternate techniques that do not involve Perchloric acid if possible. If you must use Perchloric acid in your experiments, purchase the smallest size container necessary.

Any work involving heated Perchloric acid (such as in Perchloric acid digestions) 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. Also, remove all organic materials, such as solvents, from the immediate work area.

Because Perchloric acid is so reactive, keep it stored separate from other chemicals, particularly organic solvents, organic acids, and oxidizers. Inspect regularly for container integrity and for discoloration of contents. Discolored Perchloric acid should be discarded as hazardous waste.

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. [59] These

[59] See https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=10106

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 SDSs 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. This could mean an entire room out of a suite of rooms or one particular fume hood within a laboratory. One area known to everyone working in the laboratory designated for the use of particularly hazardous substances. A sign should be posted indicating the area is designated for use with particularly hazardous substances. The designated location and any special precautions should be included in 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 laboratory should be properly trained.

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 SDSs 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 comprehensive 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 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 any necessary chemical and waste containers.
- Before work, 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.
- 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.
- Purchase premade solutions to avoid handling powders. If you have to use powders, 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. 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 coworkers have left and thoroughly clean up and decontaminate working surfaces. Inform anyone remaining of your activities.
- Use secondary containment to conduct your experiment in, if possible, 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 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 laboratory workers have received proper training regarding hazards of particularly hazardous substances and that safety considerations have been taken into account BEFORE a new experiment begins. While your EHS Office can provide assistance, 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 keep written documentation on file, such as "Prior Approval" forms that are completed, signed by the laboratory worker as well as signed by the P.I. or laboratory supervisor.

Examples where P.I.s and laboratory supervisors should consider requiring laboratory workers to obtain prior approval include the following:

- Experiments that require the use of particularly hazardous substances. These include but are not limited to "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.

- A significant change in the quantity of chemicals to be used for a routine experiment, such as an increase of 10% or greater than the quantity normally used.

- New equipment brought into the laboratory requires additional special training.

- A laboratory worker is alone and running 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 Laboratory Standard defines a “select carcinogen”[60] as any substance which meets one of the following criteria:

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

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

[60] https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=10371
[61] https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_id=24730&p_table=INTERPRETATIONS

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 this is supplemental information to OSHA, NTP, and IARC chemical lists and not legally mandated by New York State.

9.7 Reproductive Toxins

The OSHA Laboratory Standard defines a reproductive toxin as a chemical "which affects the reproductive capabilities including chromosomal damage (mutations) and effects on fetuses (teratogenesis)." [62]

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. 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."[63] Please note that this list is supplemental 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 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.

[62] https://sp.ehs.cornell.edu/lab-research-safety/laboratory-safety-manual/pages/ch9.aspx
[63] https://oehha.ca.gov/proposition-65/proposition-65-list

- 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.

- 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 about whether a chemical meets one of these definitions can be found in SDSs and other chemical references.

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

- Store 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 glove selection 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.[64]

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 the following:

- The Federal Resource Conservation and Recovery Act (RCRA).[65] 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.

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[64] https://www.osha.gov/SLTC/hazardoustoxicsubstances/

[65] https://www.epa.gov/rcra

- The New York State Environmental Conservation Law. [66] 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.

- 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. [67]

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

11.0 SHIPPING HAZARDOUS MATERIAL

CUNY must 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 compliance with applicable regulations, the following guidelines must be adhered to for 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 shipment (including land, air, and water) of 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 the following:

- Laboratory chemicals, cryogenic materials, and samples containing flammable, toxic, explosive, radioactive, oxidizer, and/or corrosive materials

- Biological materials including, for example, infectious substances (known to contain pathogens such as viruses, bacteria, fungi), HHS/USDA Select Agents, animal and human

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[66] http://codes.findlaw.com/ny/environmental-conservation-law/

[67] 15 RCNY 19-03 http://library.amlegal.com/nxt/gateway.dll/New%20York/rules/therulesofthecityofnewyork?f=templates$fn=default.htm$3.0$vid=amlegal:newyork_ny Official DEP rules pdf: http://www.nyc.gov/html/dep/pdf/recrules/regulations.pdf

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.), or ammunition

- Equipmentcontaininghazardousmaterials, suchasmercury, compressedgases, orwet, lithium, or dry batteries containing sodium, potassium hydroxide

11.2 Hazardous Materials TransportationRequirements

Ifhazardous materials ordangerous goods must be shipped, contact the EHS Office for guidance. If yourdepartment will ship hazardousmaterials ordangerousgoodson afrequentbasis, the EHS Office can provide the appropriate training to any additional designated personnel required. 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. Retraining is required every 3 years.

11.3 Dry Ice Requirements

The DOTand IATAclassifydryiceasamiscellaneoushazard(Class 9). Thefollowingthreereasons are why dry ice is considered hazardous during transportation:

Contact: When skin contact is made with dry ice (cryogenic material) severe frostbite can develop.

Explosion: Carbon dioxide gas is released by dry ice in a large volume as it sublimates. It will explode if it is stored in a container that does not allow for release of the gas.

Suffocation: An oxygen deficient atmosphere is created from the large volume of carbon dioxide gas emitted in a confined space.

11.3.1 Packaging Dry Ice

Dry ice needs to be packaged properly to minimize risks. The package itself must be designed to vent gaseous carbon dioxide eliminating the potential for an explosion hazard. Packages must be labeled properly to alert those who come in contact with it of the contents.

When shipping dry ice, please consider the following issues:

- Gasventing: Donotsealdryiceinacontainerwithanairtightsealsuchasa plasticcooleror a jar with a threaded lid. All packages must allow for release of carbon dioxide gas.

- Package integrity: The package must be strong enough to withstand the loading and unloading normally encountered during transport. The package must also be closed and constructed to prevent the loss of contents that could cause vibration or changes in temperature, humidity, or altitude.
- Package materials: Use commercially available packaging to ship dry ice, and do not use plastics that can be rendered brittle or permeable by the temperature of dry ice.
- Airbill: For FedEX purposes, the term airbill (also known as air waybill) should include the following words"Dry ice, 9, UN1845, number of packages X net weight in kilograms." A check box is present on the airbill for FedEx that complies with this requirement.
- Labeling: The net weight of dry ice in kilograms and the words "Hazard Class 9 label, UN1845" should be labeled on the outermost container. The label must be placed on the vertical side of the box, not on the top or on the bottom. 200 kg is the maximum allowable net quantity of dry ice allowed per package.

Other requirements for dry ice shipping include the following items:

- Only the air bill and the dry ice label are necessary references for compliance with "hazmat" regulations related to air shipment of dry ice. Additional labels or markings may be added at the request of the EHS Office for specific items that are "regulated."

- If reusing a dry ice box, please inspect the box thoroughly for contamination or residue. Ensure all unnecessary marking such as-addresses, labels, courier labels (e.g. FedEx), and barcodes are removed. If any cuts, stains or cracks are apparent in the box or in the insulation it should not be reused.

- Wedge your samples in place with cardboard or Styrofoam to prevent movement within the insulated box. If fragile containers such as vials or glass tubes are being used, wrap them up with cushioning material.

- Minimal air space exposure slows the process of sublimation. Fill your package with peanuts or other material to minimize the volume of air space.

- Shipments should contain 5-10lbs. (2.27-4.54kg) of dry ice per 24 hours. Always refer to your package manufacturer's recommendations, and make arrangements to ensure your package will be received on its intended delivery date. Delays may occur, take into account local holidays, closings and business hours.

- Dry ice shipments can be made with FedEx, while couriers such as UPS and USPS have exceptionally restrictive policies pertaining to shipments of hazardous materials. ONLY ship dry ice with FedEx.

See your EHS Office for additional information and Appendix W.

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

- 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.

- Small 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 chemicals, use of laboratory quantity pesticides is regulated by the Laboratory Standard and other applicable rules and regulations.

- Testing of materials for pesticide efficacy, toxicity, or other properties may also be exempt. For clarification, refer to 40 CFR part 172.3. [68]

[68] https://www.gpo.gov/fdsys/granule/CFR-1996-title40-vol11/CFR-1996-title40-vol11-sec172-3/content-detail.html

- 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 here. 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 bio safety 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 Bio safety in Microbiological and Biomedical Laboratories (BMBL). Now in its 5th edition, the BMBL has become the code of practice for bio safety. Each director and/or P.I. is strongly encouraged to use the BMBLas a reference for addressing the safe handling and containment of infectious microorganisms and hazardous biological materials. As with all other areas of laboratory safety, all federal, state, and local regulations regarding bio hazards 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 one of the following: 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 DNA molecules that result from the replication of those just described.

13.1.2 Infectious and Pathogenic Agents

Biological agents are classified into safety risk groups from numbered from 1 to 4. Those agents classified as risk group 1 typically pose no threat to humans. Risk groups 2, 3 and 4 build in severity with agents in group 2 posing a risk that is rarely serious and where prevention and intervention are possible. Risk group 4 identifies agents that pose potentially lethal outcomes and where prevention and intervention are not usually available. Biological agents classified by this system include bacterial, fungal, parasitic, viral, rickettsial, chlamydial, and prion. See the National Institutes of Health (NIH), Centers for Disease Control and Prevention (CDC) and American Biological Safety Association (ABSA) for information regarding the classification of infectious agents.

13.1.3 Bloodborne Pathogens

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. [69]

13.1.3.1 COLLABORATIVE INSTITUTIONAL TRANING INITIATIVE (CITI)

CITI OSHA Bloodborne Pathogens Standard[70] contains initial training for researchers, employees, and students who have been in contact with or handle human blood, body fluids, tissues, or other potentially infectious materials. It can be used to retrain employees and to fulfill retraining requirements for OSHA. It covers Labels & Engineering Controls, Emergency Response Procedures, Universal Precautions & Work Practices, and Hepatitis B Virus Vaccination. The standard requires employers to perform an employee exposure evaluation. This may trigger requirements such as developing an Exposure Control Plan, offering training sessions, and providing the HBV vaccine.

The Exposure Control Plan includes engineering controls, work practices, proceduresfor housekeeping, medical evaluations, hazard communication, and recordkeeping.

Training must be provided to employees at the time of initial assignment to a job with occupational exposure. It should be provided during working hours and at no cost to the employee. Employees must be retrained annually. Additional training should be offered any time 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.

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[69] https://www.osha.gov/SLTC/bloodbornepathogens/bloodborne_quickref.html

[70] https://about.citiprogram.org/en/course/osha-bloodborne-pathogens/

Although no vaccine exists for 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, at a reasonable time and place, and 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, received information about hazards in the laboratory they may encounter, and been informed about ways they can protect themselves.

13.1.4 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 Federal Select Agent Registry[71] 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. It is also a federal violation to maintain animals after the 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 personnel seeking to perform research on animals, and the college's IACUC must ensure that personnel are qualified to perform anyoutlined the procedures. All CUNY-affiliated college IACUCsnow require that researchers and other key personnel involved in animal research complete a prescribed 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.

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[71] https://www.selectagents.gov/index.html

13.2.1 CITI (Animal Biosafety)[72]

The module for Animal Biosafety provides initial awareness training for researchers and animal handlers who are working with conventional or small animal used in biohazard experiments. This specific module can also be used as a periodic refresher training and additional content for animal biosafety can be found in Animal Care and Use.

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 UI-IRB (University Integrated Institutional Review Board) 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 RFCUNY staff. It is also responsible 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

[72] https://about.citiprogram.org/en/course/animal-biosafety/

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 the following:

- 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 are reasonably believed to contain infectious substances, they 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.

13.4.2 Permits for the Import and Export of Biological Materials

The import of disease causing agents for humans, animals, vectors, plant pests, and animal and plant products requires permits issued by federal agencies such as the US Department of Agriculture (USDA) or the Centers for Disease Control and Prevention (CDC).The export of certain microorganisms and toxins is also regulated by the Department of Commerce.

13.4.1.1 *Agents Regulated for Import*

<u>Center for Disease Control and Prevention (CDC)</u>

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

- 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 less than 4 inches in shell length and all non-human primates requires a permit from 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 or stage of life (adult, egg, larvae, pupae, and nymph) and any other living insect or arthropod, infected or suspected of being infected with any disease transmissible to humans
- Any snail species capable of transmitting a human pathogen.

For more information, visit the CDC's Etiologic Agent Import Permit Program. [73]

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.

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

- Live horses, birds, dogs, sheep, cattle, and fish as well as semen, and embryos.
- Foreign import or interstate transfer of infectious agents (bacteria, viruses, protozoa, and fungi), 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

[73] https://www.cdc.gov/phpr/ipp/faq.htm

- 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 (except 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.[74]

[74] https://www.bis.doc.gov/

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. NOTE: As a general rule, BSCs are not suitable for work with hazardous materials. Work with hazardous materials should be conducted under a fume hood.

13.5.1 Biological Safety Cabinet Certifications

All biological safety cabinets must be certified to ensure proper operation. Certification is required at all the following points:

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

Certification must be performed by a trained contractor (National Sanitation Foundation (NSF) Standard No. 49[75]). This is not your EHS Officer. 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 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:

- Install the BSC "deep" in the laboratory away from air currents produced by ventilation inlets, opening/closing of laboratory door(s), and away from areas of heavy traffic. If possible, close laboratory doors, limiting 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 impact performance. Cabinets should not be located directly opposite of each other or opposite a chemical fume hood, as laminar airflow will be hindered.

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[75] http://www.nsf.org/services/by-industry/pharma-biotech/biosafety-cabinetry/nsf-ansi-49-biosafety-cabinetry-certification

- 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. Have a checklist of materials needed and place those materials in the BSC before commencing work. This reduces the number of disruptions of the cabinet's air barrier preserving its protective envelope. Slow movements in and out of the cabinet will reduce the risk of potential contamination.

13.5.3 BSC Operational Procedures

Work in a biological safety cabinet should follow this order of operations

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 items required to perform the procedures. Arrange the items so that work "flows" from the least to the most contaminated item. Avoid a layout that might require reaching for supplies or discarding items outside of the cabinet. Place pipette discard trays (containing disinfectant), biohazard bags and sharps containers inside the BSC to the most contaminated side.

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. This may cause air to enter the workspace instead of flowing through the front grille 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.

7. Avoid using open flames inside the cabinet. This can create turbulence, disrupt the air pattern, compromise safety and risk product contamination. Flames can also damage the interior of the cabinet, HEPA filters, and, in certain circumstances, cause explosions. Reevaluate your procedures to determine if sterilization is required. Use devices such as electric furnaces to sterilize 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 inside the cabinet. Do not use the interior of the BSC as a storage area. 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 for 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 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/cm2 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 doesnot 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

- 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 do not protect your materials from contaminants introduced by the environment or the operator.

- 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.

- In Class IIA1 cabinets, 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 cabinets have 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 cabinets have 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 cabinets 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.

- 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." [76] 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 those in a department. Please consult with your administrative manager, department chair, or EHS Office.

- The P.I. or supervisor should designate a responsible person 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.

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[76] https://www.nysenate.gov/legislation/laws/PBH/1389-AA

- Follow the regulatory guidelines for waste segregation and disposal.

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 review each proposed operation to ensure safety and compliance with federal, state, and local regulations. Your EHS Office or Radiation Safety Officer can provide training and other services to help ensure safety. This may include routine inspections of all use areas, identifying safety violations and help with corrections. 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 the radiation safety program. Any radiation safety program should be reviewed continuously.

The Radiation Safety Committee should meet a minimum of twice a year to update policies, resolve compliance issues, and monitor radiation exposure for 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[77] applies to all radiation equipment and radioactive material within the jurisdiction of the DOHMH and 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 serves as a framework for coordination of radiation control activities for the U.S. Atomic Energy Commission, the U.S. Food and Drug Administration, the NYS Departmentof Labor, the NYS Departmentof Health, the NYS Atomic Energy Council, the NYS Departmentof Environmental Conservation, and other federal, state and city agencies.

If you have questions or concerns about the use of ionizing radiation speak with your P.I. or laboratory supervisor. 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 people 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.

[77] https://www1.nyc.gov/assets/doh/downloads/pdf/about/healthcode/health-code-article175.pdf

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 never operate equipment that produces ionizing radiation and 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 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 pick up and contact your EHSO.

15.0 LASER HAZARDS

LASER is an acronym which stands for Light Amplification by Stimulated Emission of Radiation. LASER light is a form of non-ionizing radiation. Because LASERs produces an intense, highly directional beam of light, they can pose more of a hazard than ordinary light. There are two types of LASER hazards: the LASER beam hazards and the non-beam hazards. LASER beam hazards include eye and skin burns which are due to LASER beam shining on a person's body. Non-beam hazards are associated with the LASER equipment, the hazardous substances released from the LASER equipment, or fumes emitted from materials exposed to LASER beams.

LASER products are classified by wave length and maximum out put in to four classes and subclasses. The classifications also categorize LASERS according to their ability to produce damage in exposed people, from Class 1 (no hazard during normal use) to Class 4 (severe hazard for eyes and skin).

- Class 1 LASERs- include LASER printers and compact disc players. Class 1 LASER is safe under all conditions of normal use. Some Class 1 LASER products may contain LASER systems of a higher class but there are usually adequate engineering control measures to ensure that access to the beam is not reasonably likely. Anyone who dismantles a Class 1 LASER product that contains a higher class LASER system is potentially at risk of exposure to a hazardous LASER beam.

- Class 1M LASERs- include LASERs used for fiber-optic communication systems, are safe for all conditions of use except when the beam is viewed using magnifying optical instruments. Class1M LASERs products produce either a highly divergent beam or a large diameter beam. Only a small part of the whole LASER beam can enter the eye.

- Class 2 LASERs - considered safe because the blink reflex will limit the exposure. Repeated, deliberate exposure to the LASER beam may not be safe. Some LASER pointers and barcode scanners are Class 2 LASER products.

- Class 2M LASERs - safe because of the blink reflex if not viewed through optical instruments. Like Class 1M LASERs, Class 2M LASER products produce either a highly divergent beam or a large diameter beam. Therefore, only a small part of the whole LASER beam can enter the eye. However, these products can be harmful to the eye if the beam is viewed using magnifying optical instruments or for long periods of time. Some LASERs used for civil engineering applications, such as level and orientation instruments are Class 2M LASER products.

- Class 3R LASERs - higher powered devices than Class 1 and Class 2. A Class 3R LASER is considered safe if handled carefully, with restricted beam viewing. The LASER beams from Class 3R products exceed the maximum permissible exposure for accidental viewing and can potentially cause eye injuries, but the actual risk of injury following a short, accidental exposure, is still small.

- Class 3B LASERs - have sufficient power to cause an eye injury, both from the direct beam and from reflections. However, the extent and severity of any eye injury arising from an exposure to the LASER beam of a Class 3B LASER will depend upon the radiant power entering the eye and the duration of the exposure. Examples of Class 3B products include LASERs used for physiotherapy treatments and many research lasers. The use of eye protection when operating lasers of Classes 3B and 4 in a manner that may result in eye exposure in excess of the maximum permissible exposure is required in the workplace by OSHA.

- Class 4 LASERs- have an output power greater than 500 mW (half a watt). There is no upper restriction on output power. Class 4 LASERs are the highest and most dangerous class of LASERs and are capable of causing injury to both the eye and skin. They will also present a fire hazard if sufficiently high output powers are used. LASERs used for many LASER displays, laser surgery and cutting metals may be Class 4 products. The use of eye protection when operating lasers of classes 3B and 4 in a manner that may result in eye exposure in excess of the maximum permissible exposure is required in the workplace by OSHA.

It is the responsibility of the P.I. or laboratory supervisor to ensure that all Class 3B or 4 LASERs are registered with the EHS Office and employees using these LASERs have received the appropriate training.

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.[78] ANSI Z136.1-2007 requires that all Class 3B and 4 LASER users must attend LASER safety training. Your EHS Office

[78] https://www.lia.org/store/product/ansi-z1361-2014-safe-use-lasers-electronic-version; https://labor.ny.gov/formsdocs/wp/CR50.pdf

should offer training to meet this requirement, which includes topics such as LASER hazards, LASER classifications, signage/labeling, medical monitoring, safety guidelines, eye protection, registration of equipment and what to do in case of an exposure incident. For additional information regarding LASER safety, please contact your EHS Office or see the OSHA Safety and Health Topics webpage for LASER hazards.[79]

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, or thermal contact burns. 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 a ground and then comes in contact with any of the following:

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

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

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

[79] https://www.osha.gov/SLTC/laserhazards/hazards.html

given amperage, the table below 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 911 immediately and alert Public Safety. If an individual must be physically removed from an electrical source, eliminate the power source first (i.e., switch off the circuit breaker). If circumstances prevent 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 to prevent electrical hazards include the following:

- 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.

- 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. The use of power strips is generally preferred over extension cords.

- Power strips must have a built-in overload or surge protection (circuit breaker) and must not 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.

- 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).[80]

- 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.

- Flickering lights, warm switches or receptacles, burning odors, sparking sounds when cords are moved, loose connections and frayed, cracked, or broken wires indicate a problem. Have a qualified electrician address the issue immediately.

- 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 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.

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[80] https://www.cpsc.gov/Business--Manufacturing/Business-Education/Business-Guidance/Household-Electrical-Products/Extension-Cords

- 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 the following actions:
  - Locate equipment in a room, vault, or similar enclosure accessible only to qualified persons
  - Place permanent, substantial partitions or screens to exclude unqualified persons
  - Locate a suitable balcony, gallery, or platform elevated and arranged to exclude unqualified persons
  - Elevate 8 feet or more above the floor

For additional information, see the following resources

- OSHA Pamphlet 3075
- 29 CFR 1910.303 through 29 CFR 1910.335
- Electrical Safety Foundation International
- National Electric Code 2002
- 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.

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.

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.

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 laboratory 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 Hazard

There are many types of machines and laboratory equipment on campus that are used as part of research. Many of them can be hazardous and cause serious injury if not used safely. All mechanical motion is potentially hazardous. Motion hazards, such as rotating devices, cutting or shearing blades, in running nip points, reciprocating parts, linear moving belts and pulleys, meshing gears, and uncontrolled movement of failing parts, are all examples. Never use a machine or any equipment unless you have been trained on the proper use and the safety requirements of the equipment.

Research laboratories may use equipment such as Bunsen burners, rotary evaporators, autoclaves, hot plates and centrifuges that can be hazardous.

Machine Shops have many tools that can be hazardous, including lathes, milling machines, table saws and drillpresses.

16.2.1 Machine Safety Responsibilities

The following responsibilities are assigned to employees

Management

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

Supervisors

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

Employees

- 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
- What to do if a safeguard is damaged, missing, or cannot 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 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

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

16.2.3 Personal Protective Equipment

Select the proper personal protective equipment (PPE) for the machine shop. It is strongly suggested that you wear safety glasses at all times in the shop. Consider a face shield when you are working up close with grinding and cutting job tasks. Wear comfortable shoes with a non-slip sole and consider toe reinforcement if you work with heavy objects. Earplugs will protect your hearing in a noisy machining environment. Choose gloves depending on your job task. Use proper gloves when you handle materials with sharp edges. And finally, get training in your job task and the machinery that you will be using.
Follow these basic safety tips for appropriate dress in a machine shop:

- While you operate machines, wear close-fitting clothing, tie back long hair, and remove your jewelry. Loose fitting clothing, neckties, rings, bracelets, or other apparel that may become entangled in moving machinery.
- Consider wearing a hair nets or caps to keep long hair away from moving machinery.
- Gloves should not be worn if there is a chance of them being caught in machinery.

The EHS Office should be contacted to assist Supervisors and personnel in determining the personnel protective equipment needed.

16.2.4 Common Machine Hazards

A number of common machine hazards occur. Awareness of the following moving parts can improve safety:

Pinch Points
Pinch points are 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.

Wrap Points

Wrap points can be found in any exposed component that rotates. Examples include rotating shafts, such as a power take off 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.

Shear Points

Shear points can be found anywhere where there are 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.

Crush Points

Crush points 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.

Pull-In Points

Pull-in points occur where objects are pulled into equipment, usually for some type of processing. 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.

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 properly lighted work areas is essential to safety. A number of points about proper lighting are important to remember:

- Lighting should be adequate to illuminate all work areas. For laboratories this means 100-200 lumens.
- 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 lamps ("universal waste"), contact the EHS Office.
- 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.

Possible hazards

- 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. This can lead 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 following steps:

- The contents of any compressed gas cylinder must be clearly identified, 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.

  - o Never transport a cylinder while a regulator is attached.
  - o Always use caution when transporting cylinders – cylinders are heavy!
  - o Avoid riding in elevators with compressed gas cylinders. See the section on transporting chemicals
- 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).[81]

16.4.2 Safe Storage of Compressed Gas Cylinders

The safe storage of compressed gas cylinders include the following standard practices:

- 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)].[82]

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[81] https://www1.nyc.gov/assets/fdny/downloads/pdf/about/Chapter-32.pdf
[82] http://www.nyc.gov/html/dob/downloads/bldgs_code/electrical_code_local_law_39of2011.pdf

16.4.3 Operation of Compressed Gas Cylinders

The cylinder valve handwheel 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 properly forming. 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

- Make sure 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.
- Turn the delivery pressure adjusting screw counterclockwise until it turns freely and then close the flow control valve to prevent a surge of pressure.
- Slowly open the cylinder valve handwheel 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 each cylinder. 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

Inert Gases

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

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.

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.

Flammable Gases

- Examples include methane, propane, hydrogen, and acetylene.
- 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.
- 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

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.

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 laboratory 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 SDS 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

Cold traps require general safety guidelines. The list below outlines these guidelines:

- 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 section 16.12, “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:

- Proper training and 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 include

- Be familiar with the manufacturer's operating procedures
- 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

Centrifuge rotors require care which includes regular cleaning and routine inspections. The following activities should be a part of the care regimen:

- 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 care including:
  - Polishing
  - Lubricating O-rings
  - 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 until 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 a number of categories:

Frostbite - Liquefied gases and solids are extremely cold and can cause severe contact burns as well as frostbite. Associated vapors also can result in cold exposure.

Asphyxiation - Theses liquids can rapidly convert to large quantities of gas. The 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 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 - Fire or explosion may result from the evaporation and subsequent 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 - 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 liquids to high pressures followed by rapid evaporation, and by confinement of cryogenic fluids with subsequent evaporation. If these confined fluids are 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 – The properties of certain materials call for consideration of the effects of low temperatures. Some materials become brittle at low temperatures. Brittle materials fracture easily and can result in almost instantaneous 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

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 operations. 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.

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 laboratory 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.

Safety Practices

A list of guidelines for safety practices follows:

- Cryogenic fluids must be handled and stored only in containers and systems specifically designed for these products. They must be stored 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. An oxygen (O2) 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 not only to contain the liquid nitrogen but also to allow periodic venting preventing overpressurization. Never attempt to seal the caps of liquid nitrogen dewars. Doing so can present a significant hazard of overpressurization that could rupture the container, cause splashes of liquid nitrogen and, depending on the quantity spilled, cause an oxygen deficient atmosphere within a laboratory.

- 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.

First Aid

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

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

- If clothing becomes soaked with liquid, it should be removed as quickly as possible and the affected area should be flooded with 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

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.

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.

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 Practices

A list of safety principles to follow when using liquid hydrogen include the following:

- Isolation of the experiment
- Provision of adequate ventilation

- Exclusion of ignition sources plus system grounding/bonding to prevent static charge build-up
- Containment in helium purged vessels
- Efficient monitoring for hydrogen leakage
- Limiting the amount of hydrogen “cryopumped” in the vacuum system

16.11 Extractions and Distillations

Extractions

- Do not attempt to extract a solution until it is cooler than the boiling point of the extractant. Doing anything other 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 beforeseparation.
- When opening the stopcock, your hand should keep the plug firmly in place.
- The stopcock should be lubricated.
- Vent funnels away from ignition sources and people, preferably into a hood.
- Keep volumes small to reduce the risk of overpressure and, if large volumes are needed, break them up into smaller batches.

Distillations

- Avoid bumping (sudden boiling) 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 and 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 Washing Glassware

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 laboratory 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 subsections include the recommended laboratory techniques for general equipment are from the American Chemical Society's booklet – Safety in Academic Chemistry Laboratories.[83]

16.14.1 Glassware and Plasticware

- Borosilicate glassware (e.g., Pyrex) is recommended for all laboratory 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 laboratory 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.

Preparation of Glass Tubing and Stoppers

Follow these safety precautions when cutting glass tubing:

- Hold the tube against a solid 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 on either side of the score 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 make contact with anyone nearby during scoring 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 it ample time to cool before grasping it.

Follow these guidelines when drilling a stopper:

[83] https://www.acs.org/content/dam/acsorg/about/governance/committees/chemicalsafety/publications/safety-in-academic-chemistry-laboratories-students.pdf (8th Edition)

- Use only a sharp borer, one a size smaller than 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 be softened by rolling and kneading prior to use. 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 at a point not more than 5 cm from the end to be inserted.
- Insert glass using 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 laboratory 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. If a hot plate is used, ensure that the temperatures of all exposed surfaces are below the auto ignition temperature of the chemicals likely to be released and that the temperature control device and the stirring / ventilation motor (if present) do not spark.
- Whenever possible, use controlled electrical heaters or steam instead of gas burners.
- Use appropriate traps, condensers, or scrubbers to minimize release of material to the environment.
- 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 motors, 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.

Appendices

APPENDIX A: CHEMICAL HYGENE 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 andtraining.

(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)Suchinformationshallbeprovidedatthetimeofanemployee'sinitialassignmenttoawork 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) Thepermissibleexposurelimitsfor OSHA regulated substancesorrecommendedexposure limits for other hazardous chemicals where there is no applicable OSHA standard;

(f)(3)(iv) Signsand symptomsassociated with exposurestohazardouschemicalsusedin 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, 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.

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 SafetyOfficer		
Biological SafetyOfficer		
LASER Safety Officer		
EHS Officer		
Public Safety		

APPENDIX C: LABORATORY SAFETY RESPONSIBILITIES

General List of 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 laboratory 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 B&G and copy both EHSO and their supervisors as soon as any malfunctions are discovered. (Section 2.1)

4. P.I.s, laboratory supervisors, departments, and colleges must 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. Eye protection a mandatory requirement for all laboratory personnel, including visitors, working in or entering laboratories under their control for any laboratory were chemicals are used and/or stored. (Section 3.3)

7. In any laboratory where hazardous materials are handled (chemical, biological or radiological) laboratory personnel, students and visitors to the laboratory must wear appropriate clothing for protection. Legs, arms and torsos must be covered and any loose clothing must be pinned back or contained in a laboratory coat. (Section 3.5)

8. The P.I.s and laboratory supervisors must 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 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)

10. 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 laboratory practice good housekeeping. (Section 4.3)

11. 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)

12. 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 4.9)

13. 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 4.10)

14. It is the responsibility of laboratory personnel to activate (flush) emergency eyewash units once a week and test showers annually. (Section 5.4.1)

15. 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)

16. 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)

17. 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 SDSs (and other sources of information) for all hazardous chemicals used in laboratories under their supervision. (Section 7.3)

18. 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)

19. It is the responsibility of P.I.s and laboratory supervisors to notify EHS when new hazardous materials or work is being planned.

20. It is the responsibility of P.I.s and laboratory supervisors to keep current and accurate inventory of all hazardous chemicals in their laboratories.

21. 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)

22. 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)

23. 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)

24. 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)

25. 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. (Section15.0)

Roles and Responsibilities

The following descriptions serve as an overview of the key roles chemical laboratory roles key for implementing the Chemical Hygiene Plan and Laboratory Safety Manual, assisting with safety and compliance and working with the campus EHS Office.

Chemical Hygiene Officer(CHO)

The role of the Chemical Hygiene Officer (CHO) is to facilitate the implementation of the campus Chemical Hygiene Plan as well as this Laboratory Safety Manual across campus labs and facilities. The CHO also serves 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 Chemical Hygiene Officer has a number of major duties

- Work with campus stakeholders to implement, review annually, and make updates as needed to the Chemical Hygiene Plan and Laboratory Safety Manual. Keep senior administration informed.

- Provide technical expertise regarding laboratory health and safety where appropriate.

- Communicate guidelines for particularly hazardous substances, including proper labeling, handling, use, and storage as well as the selection of personal protective equipment and spill-response equipment for laboratories using these substances.

- Assist with review of academic research protocols and standard operating procedures developed by P.I.s and department personnel.

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

- Conduct laboratory safety training for personnel and assist laboratory supervisors with hands-on training sessions for employees.

- Review reports of laboratory incidents, accidents, chemical spills, and near misses, and recommend follow up action where appropriate.

- Be aware of planed renovations or new construction projects and provide information about code compliance and internal standards where appropriate.

Deans, Directors, and Department Chairpersons

The Deans, Directors, and Department Chairpersons are responsible for laboratory safety within their department(s). Specific roles and responsibilities vary from campus to campus but in general involve the following:

- Communicate the requirements of the Laboratory Safety Manual to faculty, staff, temporary employees, visiting scholars, volunteers, and students working in laboratories within their units.
- Assist with implementation of the Chemical Hygiene Plan.
- Ensure that laboratory personnel adhere to proper health and safety protocols.
- Direct individuals to obtain any required training before working with hazardous chemicals, biohazardous agents, radiation, and/or other physical/mechanical hazards.
- Help prioritize safety needs and equipment (e.g., engineering controls, training, protective equipment).
- Ensure instances of noncompliance 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 procedures for emergency response are established, communicated and updated regularly.
- Notify the Chemical Hygiene Officer before a faculty member retires or leaves so that proper laboratory decommissioning occurs.
- Ensure participation in internal reviews of laboratories by campus EHS as a means to regularly check performance against regulatory requirements and identify opportunities for improvement.
- Review Internal Audit reports provided by the Office of EHSRM and support campus efforts to address citations noted to improve compliance outcomes.

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

P.I. s, faculty, and laboratory supervisors are responsible for safety in their research or teaching laboratories. Follow the guidelines identified within this manual (see Appendix C). These duties can be delegated to other qualified personnel within the laboratory but the responsibility remains with the P.I., faculty or laboratory supervisor responsible for the area.

- Implement and communicate all college and university safety practices and programs, including those found within the Laboratory Safety Manual.
- Communicate roles and responsibilities of individuals within the laboratory.
- Conduct hazard evaluations for laboratory procedures and maintain a file of standard operating procedures documenting those hazards.
- Ensure that specific operating procedures for handling and disposing of hazardous substances are written, communicated, current, and followed, and that laboratory personnel have been trained in these operating procedures and use proper control measures.
- Attend required health and safety training and require all staff and students under their direction obtain and maintain required health and safety training.
- Conduct and participate in inspections and Internal Audits with their laboratory employees.
- Correct instances of noncompliance identified all items identified during inspections in a timely manner.
- Verify all appropriate engineering controls, including chemical fume hoods and safety equipment, are available and in good working order. Notify EHS when significant changes in chemical use may require a re-evaluation of the laboratory ventilation.
- Establish and communicate procedures to identify the potential for and the appropriate response to accidents and emergency situations.
- Report all incidents and near misses to their Director or Department Chairperson, and file a written Injury/Illness Report with EHS for each injured person as soon as is possible.
- Ensure that laboratory personnel under your supervision know and follow the guidelines and requirements contained within the Laboratory Safety Manual.
- Keep the Department Chairperson and the Chemical Hygiene Officer informed of plans for renovations or new laboratory construction projects.

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. All laboratory employees have safety duties:

- Comply with all University health and safety practices and programs by maintaining safe class, work, and laboratory areas that are free from hazards.
- Follow the standard operating procedures for the laboratory/laboratories in which you work and incorporate the requirements outlined in this Laboratory Safety Manual into everyday practice.
- Know the location of the Chemical Hygiene Plan
- Know how to access Safety Data Sheets (SDS) and ensure SDSs are present for all new chemicals you purchase. (The SDS either should have been sent with the original shipment or be available online.)
- Review the SDSs for all chemicals you work with and check with your laboratory supervisor or P.I. if you ever have any questions.
- Attend required health and safety training as designated by your supervisor.
- Inform your supervisor or instructor of any safety hazards and report any unsafe working conditions, faulty fume hoods, or other faulty emergency safety equipment.
- Conduct hazard evaluations with your supervisor for all procedures in the laboratory and maintain a file of standard operating procedures documenting those hazards.
- Know what to do in the event of an emergency situation.
- Participate in laboratory self-inspections and EHS research area inspections.

Facilities Management

Facilities Management[84] serves as an important partner in laboratory operation and safety as well as a conduit for information with regard to building-wide issues. This includes coordinating routine

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

maintenance issues, scheduling building shutdowns, communicating building-wide maintenance and repairs, and informing occupants of building system shutdowns.

Facilities Management departments have a number of laboratory safety responsibilities:

- Comply with all university health and safety practices and programs by maintaining common building areas as well as shops and workspaces 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.
- 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 related to building-wide laboratory safety issues from the EHS Office are addressed.
- Maintain awareness of building issues that could impact the health and safety of laboratory personnel and contact the EHS Office whenever health and safety issues occur in laboratories.
- Know procedures in the event of an emergency situation.
- Assist emergency responders by serving as a resource for control of building control systems (ventilation, turning off water main, etc.).

APPENDIX D: STANDARD OPERATING PROCEDURES (SOPs) - RESOURCES

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 accuracy. These links are being provided only as examples. Each laboratory should write an SOP that is specific to their processes and procedures and compliant with CUNY guidelines.

- 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 and including a blank form)
- Example of a chemical specific information sheet type SOP (generic – not laboratory 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 laboratory specific) University of Pennsylvania

Standard Operating Procedures Fact Sheet

The OSHA Laboratory Standard requires that Chemical Hygiene Plans include specific elements and measures to ensure employee protection in the laboratory. One such requirement is Standard Operating Procedures (SOPs) "relevant to safety and health considerations to be followed when laboratory work involves the use of hazardous chemicals". This is especially the case if your laboratory operations include the routine use of "select carcinogens,' reproductive toxins and substances which have a high degree of acute toxicity".

Standard Operating Procedures can be stand-alone documents or supplemental information included as part of research notebooks, experiment documentation, or research proposals. The key idea with laboratories having standard operating procedures is to ensure a process is in place, so that an experiment is well thought out and includes and addresses relevant health and safety issues.

At a minimum, SOPs should include details such as:

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

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

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

Standard Operating Procedures do not need to be lengthy dissertations and it is perfectly acceptable to point laboratory personnel to other sources of information. An Example to include as part of the SOPs can be:

> "*To use this piece of equipment, see page 4 in the operator's manual (located in file cabinet #4).*"

EH&S can assist laboratories in developing general and specific SOPs for chemical use in laboratories. Due to the large variety of research and the number of laboratories, it is the responsibility of each laboratory P.I., and department, to ensure that SOPs are developed and the practices and procedures are adequate to protect their laboratory workers who use hazardous chemicals.

Standard Operating Procedure Template

Read the Standard Operating Procedures Fact Sheet before filling out this form. Print out the completed form and keep a readily accessible hard copy in the laboratory and submit an electronic copy to the EHS Office. Keeping an electronic copy also is highly recommended.

Cover Page – Identity

College Name andLogo	
Date:	
SOP Title:	
Principal Investigator:	
Department:	
Room and Building:	
PrimaryPhoneNumber:	

Section 1 – Process or Experiment Description

Provide a brief description of your process or experiment, including its purpose. Do not provide a detailed sequential description as this will be covered in section #15 of this template.

Section 2 – Hazardous Substances

List substances used. Include substance name (in full), common name and abbreviation.

Substance Name	Common Name	Abbreviation	Comments

Section 3 – Potential Hazards

List substances used. Include substance name (in full), common name and abbreviation.

Describe the potential hazards associated with the substances or the procedure.) Examples include:

1. Substance hazards such as carcinogenic, irritant, corrosive, acutely toxic
2. Reproductive hazards such as teratogens or mutagens
3. Allergies or substance sensitivities that may be associated with the substance
4. Physical hazards such as reactive, unstable, pyrophoric, implosion, exothermic, use of high energy equipment.
5. Exposure to infectious agents

Section 4 – Routes of Exposure

As applicable, describe the potential routes of exposure associated with the procedure such as inhalation, injection and skin/eye contact.

<u>Section 5</u> – **Approval**

Use will be limited to the following personnel (check all that apply):

	Yes	No
Principal Investigator	○	◉
Graduate students	◉	○
Technical staff	○	◉
Post-doctoral employees	◉	○
Undergraduates	○	◉
Other (describe) ____________________	○	◉

<u>Section 6</u> – Training

Training requirements: The user should demonstrate competency and familiarity regarding the safe handling and use of this material prior to purchase.

Training should include the following:

- Review of currentSDS
- Review of the OSHA Laboratory Standard
- Review of the Chemical Hygiene Plan
- Review CUNY Laboratory Manual
- Laboratory safety training (EH&S)
- Special training provided by the department/supervisor
- Review of the departmental safety manual
- Safety meetings and seminars
- Review of user manuals for equipment related to SOPs

<u>Section 7</u> – Personal Protective Equipment

All personnel are required to wear the following personal protective equipment whenever handling this material or equipment (check all that apply):

Safety glasses	☐
Chemical safety goggles	☐
Face shield	☐
Gloves (*type*)	☐
Laboratory coat	☑
Rubber coat	☐
Other (describe)______________________	☐

<u>Section 8</u> – Designated Area

Designated work area(s) - Required whenever carcinogens, highly acutely toxic materials, or reproductive toxins are used to minimize possible sources of exposure to these materials.

Materials used in this process or operation are restricted to the following designated areas in the laboratory.

Check all that apply:

Demarcated area in lab	☐	*(describe)*
Fume hood	☐	*(identify)*
Glove box	☐	*(identify)*
Other	☐	*(describe)*

Section 9 –Storage Requirements

Materials will be stored according to compatibility and label recommendations in a designated area.

Describe storage requirements for all hazardous materials, especially for highly toxic, highly reactive/unstable materials, highly flammable materials, and corrosives.

Section 10 – Special Handling Procedures

Describe special handling requirements for hazardous materials used in your procedure, especially for highly toxic, highly reactive or unstable, highly flammable, and corrosives materials.

Section 11 – Engineering Controls

Guidance on Engineering and Ventilation Controls – Consult SDS and review safety literature and peer-reviewed journal articles to determine appropriate engineering and ventilation controls for your process or experiment. Guidance is available from the EHS Office.

As applicable, describe the engineering controls used for the procedure.

Examples include:

1. Use of fume hoods or glove boxes
2. Special ventilation
3. HEPA filtered vacuum lines
4. Non-reactive containers
5. Temperature control
6. Bench paper, pads, plastic-backed paper
7. Special signage
8. Safe sharp devices
9. Other safety devices used

Section 12 – **Decontamination**

For hazardous material spills or releases which have impacted the environment (via the storm drain, soil, or air outside the building) or for a spill or release that cannot be cleaned up by local personnel take these two steps.

(Insert contact numbers below and keep current.)

1. Notify the following

   a. Public Safety________________________

   b. EHS Office________________________

   c. EHSRM (646) 664-2854

2. Provide local notifications: Identify the area management staff that must be contacted and include their work and home numbers. This must include the principal investigator and may include the laboratory safety coordinator. *[DELETE PRECEDING GUIDANCE TEXT WHEN COMPLETE]*

Small Spills Cleanup:

Intheevent ofaminorspillorreleasethatcanbecleanedupbytrainedlocalpersonnelusingreadily availableequipmentthefollowingstepsmayapply.Additionalinformationspecifictothecampus should be added below.

- Notify personnel in the area and restrict access.
- Review the SDS for the spilled material, or use your knowledge of the hazards of the material to determine the appropriate level of protection.
- Wearing appropriate personal protective equipment, clean up spill.
- Collect in a compatible container, properly labeled, and ensure container is securely closed.
- Manage spill cleanup debris as hazardous waste.

Clean up work area and laboratory equipment.

Describe specific cleanup procedures for work areas and laboratory equipment that must be performed after completion of your process or experiment. For carcinogens and reproductive toxins, designated areas must be immediately wiped down following each use.

Section 13 – **Exposure: Emergency procedures to be followed (from SDS):**

Skin/eye contact--**Symptoms:**

First Aid:Flush eyes with plenty of water for at least 15 minutes, occasionally lifting the upper and lower lids. Get medical aid. Flush skin with plenty of soap and water for at least 15 minutes while removing contaminated clothing and shoes. Get medical aid if irritation develops or persists. Eyewash stations should not be used following injury with a known metal or similarly rigid solid fragment. In this event, seek immediate medical attention.

Inhalation--**Symptoms:**

First Aid: Remove from exposure to fresh air immediately. If not breathing give artificial respiration. If breathing is difficult, give oxygen. Get medical aid.

Section 14 – Waste Disposal

Collect the hazardous waste in a container that is compatible with the waste. Tightly cap and label the container. Use preprinted hazardous waste labels to label all hazardous waste containers. Keep hazardous waste containers in secondary containment trays in the satellite accumulation area.

Chemical Waste Generated

Chemical Name	State			Non-Hazardous	Hazardous	If hazardous what is/are the hazard/s?	How is the waste managed?
	Solid	Liquid	Slurry				
			☐	☐	☐		
			☐	☐	☐		
			☐	☐	☐		

Section 15 – **Process Steps**

For each step's description, include any step-specific hazard, personal protective equipment, engineering controls, and designated work areas in the left hand column.	
Process Steps	**Safety Measures**
1.	
2.	
3.	
4.	
5.	
6.	
7.	
8.	
9.	
10.	

Training Documentation

Type of training____

Name (Printed)	Signature	Date

Prepared by:________________________________ Date:_____________

Reviewed/Revised: _______________

A copy of the completed SOP must be filed with your EHS

Office

APPENDIX E: LABORATORY 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 with multiple stakeholders, especially if hazardous materials are involved. However, the steps outlined below can help to ensure a safe and smooth transition. Preparation prior to the move is key. 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 and 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, identify and contact the new EHSO about the move.

- When cleaning up your old lab, please be considerate of the next occupants as well as custodial staff, maintenance workers, and any remaining laboratory staff. Ensure that all items are removed from the laboratory (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, laboratory supplies and other materials that have not been used in a long time (and will not be used in the foreseeable future). Check with your EHSO regarding any surplus equipment or furniture you plan to discard. They may be needed elsewhere or require special disposal.

- Before the actual move occurs, visit the new facility and identify where equipment from the old facility can be placed. Check electrical, water, gas, ventilation and space requirements for your equipment, including any new items, and processes. Conducting this type of preplanning will greatly facilitate the moving process.

- When moving equipment and materials to a 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. At no time may dangerous materials, those presenting chemical, biological, radiological or physical hazards, be left in the hallways unattended.

- Identify the location of emergency eyewashes and safety showers, fire extinguishers, and other safety equipment (spill kit etc.) 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 appropriate fire extinguishers are not present in the new facility or have not been regularly inspected, 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 with safety equipment, access to fume hoods must not be blocked at any time during the move.

- 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 Department, Public Safety, locksmith or other responsible party and provide them with your contact information at your new facility in case questions arise after your move.

CHEMICALS

- Before preparing to move chemicals to your new lab, inventory all of your chemicals or update your current chemical inventory.

- Move only those chemicals needed for your research at the new facility or those chemicals you expect to use in the near future. All other chemicals that cannot or will not be used in the new facility should be disposed of properly. Allocate enough time to manage this task. For chemicals that are not being moved and are in good condition, i.e. properly labeled, with intact caps and containers, contact your EHSO. Someone in your department may be able to use the chemicals or the chemicals could be included in a campus chemical recycling/surplus program.

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

- Only trained laboratory workers may move chemicals. Any highly toxic or hazardous chemicals should be moved only 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 securely closed. 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 being packed and in a manner to prevent bottle breakage during transport. Only place compatible chemicals in the same container and do not overload containers. It is best to use DOT approved shipping containers when transporting chemicals. Any off-campus shipment must be performed through EHS Office to ensure proper labeling and storage in shipment requirements.

- When transporting chemicals, it is best to use carts with lips or trays to prevent containers from being knocked or sliding 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), laboratory 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 laboratory, ensure that all spills have been cleaned up. All potentially contaminated surfaces should be cleaned thoroughly with water and detergent. 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. Remember to clean out refrigerators and freezers thoroughly and defrost freezers. Please keep in mind the next immediate occupants of your old laboratory will be custodians and maintenance workers. Please be considerate of their health and safety and thoroughly clean 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 are empty or will no longer be used. Contact your EHSO if you need assistance.

- Before moving any compressed gas cylinders, remove the regulator and replace the safety cap over the cylinder valve. 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.

- Once a compressed gas cylinders has been moved secure them with a chain (preferred) or strap immediately. 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 if it is in use or a cap if it is being stored.

BIOHAZARDOUS MATERIALS

- All biohazardous materials must be properly packaged and moved only 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/college personnel, 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 prior approval is required.

- If you are having a Biosafety Cabinet (BSC) moved to your new location, thoroughly decontaminate both the inside and outside of the cabinet before the move. You will also need to have the BSC recertified by a third party once it has be reinstalled at the new location. 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 or Radiation Safety Officer (RSO) and advance notification of your planned move is required.

- No space may be occupied for the use of radioisotopes until the area has been setup by the RSO. Please contact your EHS office for more information.

- Any equipment to be handled by movers must be certified as contamination free before being moved.

- Only properly trained staff may move radioactive materials or 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 laboratory 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 space. General 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 use of decontamination technologies when applicable, and to maximize recycling/recovery of materials

- 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 but not limited to floor tiles, insulation, fireproofing, and fume hood panels
- Chemical and biological contamination and/or spills
- Fluorescent light bulbs
- Fume hood surfaces
- 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
- Vacuum pumps
- Electronic equipment such as CRT monitors, computers, UPS etc.

SPECIFIC ROLES AND RESPONSIBILITIES FOR DECOMMISSIONING ACTIVITIES

EHS roles/responsibilities

- Initial EHS assessment
- Technical guidance and advice
- Advise on decontamination and hazardous chemical and biohazardous waste disposal
- Ensure compliance with applicable 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
- Review appropriate risk assessment

Research staff members' roles/responsibilities

- Contribute to EHS understanding of needs, concerns, and issues regarding laboratory decommissioning
- Provide EHS with historical information regarding 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 with 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 contamination
- Identify biologically/chemically 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, 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 laboratory 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 laboratory in the condition you want your new laboratory to be in when you arrive

APPENDIX F: GLOVE SELECTION FOR SPECIFIC CHEMICALS

General guidelines for different glove materials

Material	General Resistance
Natural Rubber Latex*** **(See note below)**	Resistant to ketones, alcohols, caustics, and organic acids.
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.

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] If you are allergic to natural rubber products, you may double glove with 8 mil Nitrile gloves

Chemical	Incidental Contact	Extended Contact
Dithiothreitol	Nitrile	
1,4-Dioxane	Nitrile (8 mil), double glove, or 15 mil or heavier	Butyl rubber
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 (Methylalcohol)	Nitrile	
Methylene chloride	Nitrile (8 mil), double glove	Polyvinyl acetate, Viton
Methylphosphonic acid	Nitrile (4 mil), double glove	8 mil or heavier Nitrile

Chemical	Incidental Contact	Extended Contact
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	heavyweight, 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	
P.I.cloram (4-amino-3,5,6-trichloroP.I.colinic acid)	Nitrile	
Polychlorinated Biphenyls (PCB's)	Nitrile (8 mil) glove over a Neoprene glove	Neoprene (20 mil)

Chemical	Incidental Contact	Extended Contact
Polyoxyethylene-sorbital-n-monolaurate (Tween 20)	Nitrile	
Potassium ferricyanide	Nitrile	
Potassium ferrocyanide	Nitrile	
Potassium permanganate	Nitrile	
Propanol	Nitrile	
ProP.I.onic 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	

Chemical	Incidental Contact	Extended Contact
Uranium salts	Nitrile	
Valeric acid	Nitrile	Nitrile, double gloves, or Neoprene or Butyl rubber
Xylene	Nitrile	Polyvinyl acetate (PVA), Viton

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. Contact the glove manufacturer for additional information.

All Safety Products, Inc. – Glove Selection Chart
https://www.allsafetyproducts.com/asp-glove-selection-chart-chemical-break-through-times.html

Ansell Protective Products – See SpecWare Online Chemical Hand Protection
https://www.ansellpro.com/download/Ansell_8thEditionChemicalResistanceGuide.pdf

SHOWA ChemRest - Comprehensive Guide to Chemical Resistant Best Gloves
https://www.showagroup.com/innovation/chemical-resistance

Cole Parmer – Safety Glove Chemical Compatibility Database
https://www.coleparmer.com/safety-glove-chemical-compatibility

Mapa Professional – Hand Protection Selection Guide
http://www.mapa-pro.com/nc/our-gloves/protections/chemical-protection/

Microflex – Chemical Resistance Guide
http://www.microflex.com/Products/~/media/Files/Literature/Domestic%20Reference%20Materials/DOM_Reference_Chemical%20Resistance.ashx

North Safety - Chemical Resistance Guide
https://www.honeywellsafety.com/Supplementary/Documents_and.../1033.aspx
http://207.20.33.136/CEGlovesMain.aspx

Argonne National Laboratory – Glove Selection Guideline
https://www.aps.anl.gov/Safety-and-Training/Safety/Reference-Material/Safety-Glove-Selection-Guide

APPENDIX G: LABORATORY SELF-INSPECTION CHECKLIST

Department: …………………...………………...
Room: ....
Principal Investigator: ....
Telephone No.............................
Today's Date: ....
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 hydrostatic test 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 (Laboratory 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

Laboratory doors are kept closed

Hood interior is clean and uncluttered

Airflow indicator is used

VIII. Personal Protective Equipment

Safety goggles are available and worn

Face shields & safety shields available

Appropriate gloves are available and used

Laboratory 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

Containers and their closures are in good condition

Highly reactive substances are disposed of before expiration date, or when no longer needed (THF, Ether ...) or six months after stability test six months after opening.

All chemical containers are properly labeled (chemical name, hazardous properties, date, name of owner)

X. Waste Management

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 laboratory (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 • • •

XI. Spill Cleanup

Laboratory workers know where spill cleanup procedures & materials are available • • •

XII. Hazards Intrinsic to Our Work

Y N N/A

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APPENDIX H: HOW TO UNDERSTAND AN SDS

(From OSHA, https://www.osha.gov/Publications/OSHA3514.html, accessed 6/2018)

Chemical manufacturers are required by law to supply "Safety Data Sheets" (OSHA Form 174 or its equivalent) upon request by their customers. These sheets have 16 sections giving a variety of information about the chemical. Sections 1 through 8 contain general information about the chemical, identification, hazards, composition, safe handling practices, and emergency control measures (e.g., fire fighting). Sections 9 through 11 and 16 contain other technical and scientific information, such as physical and chemical properties, stability and reactivity information, toxicological information, exposure control information, and other information including the date of preparation or last revision. Additionally, sections 12-16 are not mandatory and may not be present in all SDSs. The following is a section-by-section reproduction and explanation of a Safety Data Sheets (SDS).

U.S. DEPARTMENT OF LABOR
Occupational Safety and Health Administration
SAFETY DATASHEETS
Required For compliance with OSHA Act of 1970
Public Law 91-596 (CFR 1910)

SECTION I: Identification	
Product Name	
Chemical Name	
Manufacturer	
Address	
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: This refers to the generic or standard names for the chemical.

Recommended use: i.e. as a solvent, laboratory chemical, cleaning product etc.

SECTION II - HAZARD IDENTIFICATION

This section identifies the hazards of the chemical presented on the SDS and the appropriate warning information associated with those hazards. The required information consists of:

The hazard classification of the chemical in accordance with GHS and 29 CFR 1910 (e.g., flammable liquid, category).

Signal word.

Hazard statement(s).

Pictograms (the pictograms or hazard symbols may be presented as graphical reproductions of the symbols in black and white or be a description of the name of the symbol (e.g., skull and crossbones, flame).

Precautionary statement(s).

Description of any hazards not otherwise classified.

SECTION III - COMPOSITION/INFORMATION ON INGREDIENTS

This section indicates the components of the product listed on the SDS including additives, and impurities.

The information would include: chemical name including common name or synonyms, CAS number and any stabilizing additives which are present in the product.

Mixtures would have exact percentages or an estimate whenever percentages may vary due to variation in batches.

SECTION IV - FIRST AID MEASURES

This section is intended as a generic guide for untrained responders in case of an individual`s exposure. First aid measures for skin, mouth and eye contact exposures are described in this section while contacting a physician is always emphasized as the next step.

SECTION V - FIREFIGHTING MEASURES

This section lists recommendations for fighting a fire involving the chemical. Recommendations include the type of appropriate extinguishing equipment and what equipment should not be used. Specific hazards resulting from fire involving the chemical are also indicated and advice on specific type of protective equipment is also given.

SECTION VI - ACCIDENTAL RELEASE MEASURES

This section provides recommendations on the appropriate response to spills, leaks, or releases, including containment and cleanup practices to prevent or minimize exposure to people, properties, or the environment. The information may consist of recommendations for:

- Use of personal precautions (such as removal of ignition sources or providing sufficient ventilation) and protective equipment to prevent the contamination of skin, eyes, and clothing.
- Emergency procedures, including instructions for evacuations, consulting experts when needed, and appropriate protective clothing.
- Methods and materials used for containment (e.g., covering the drains and capping procedures).
- Cleanup procedures (e.g., appropriate techniques for neutralization, decontamination, cleaning or vacuuming; adsorbent materials; and/or equipment required for containment/clean up)

SECTION VII - HANDLING AND STORAGE

This section indicatesnecessary precautionswhen handling the chemicaland storage conditions, including any incompatibilities.

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.

SECTION VIII - EXPOSURE CONTROL/PERSONAL PROTECTION

Thissectiongivesinformationregardingregulatorypermissibleexposurelimits(OSHAPEL) and industry exposure limits (ACGIH Threshold Limit Values and Biological Exposure Indices). Appropriate engineering controls and personal protective equipment are indicated to minimize the risk of exposure.

SECTION IX - PHYSICAL AND CHEMICAL PROPERTIES

This section gives information about the physical and chemical 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 betaken. Manufacturers and suppliers are required to provide the following information if it is available:

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

SECTION X – STABILITY AND REACTIVITY

This section describes the reactivity hazards of the chemical and the chemical stability information. This section is broken into three parts: reactivity, chemical stability, and other. Reactivity section may indicate if any specific testing was performed on the chemicalto identify anticipated hazards of the chemical(s). Stability refers to behavior of the chemical under ambient temperature in storage conditions. Conditions that should be avoided and incompatible material are also listed as well as hazardous decomposition products which may develop due to a fire.

SECTION XI – TOXICOLOGICAL INFORMATION

This section may list possible routes of exposure to the chemical along with immediate and chronic effects of such exposure.

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 SDS should be followed.

The toxicological information section often contains data on the toxicity of the substance. The data most often presented are the results of animal experiments. For example, "LD50 (mouse) =250mg/kg."Theusualmeasureoftoxicityisdoselevelexpressedasweightofchemicalper unit body weight of the animal-usually milligrams of chemical per kilogram of body weight (mg/kg). The LD50describestheamountofchemicalingestedorabsorbedbytheskin intest animals that causes deathin 50% oftest animals used during atoxicitytest study. Another commontermis LC50, which describes the amount of chemical inhaledbytest 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.

Asageneral ruleofthumb, the <u>lower</u>the LD50or LC50number, themoretoxicthe chemical. Note there are other factors (concentration of the chemical, frequency of exposure, etc.) that contributetothe toxicityofa chemical, includingother hazardsthe 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 generallyirreversible. Chronictoxicitycan alsoresultin acuteexposures, withlongterm chronic effects

Other important information such as carcinogenicity potential of the chemical and whether it is listed in National Toxicology Program (NTP), IARCor OSHAPossible carcinogen list.

SECTION XII – ECOLOGICAL INFORMATION

This section provides information to evaluate the environmental impact of the chemical(s) if it were released to the environment. The information may include:

- Data from toxicity tests performed on aquatic and/or terrestrial organisms, where available
- Persistence in the environment, biodegradation and bioaccumulation potential
- The potential for a substance to move from the soil to the groundwater (indicate results from adsorption studies or leaching studies).
- Other adverse effects (e.g., environmental fate, ozone layer depletion potential, photochemical ozone creation potential, endocrine disrupting potential, and/or global warming potential).

SECTION XIII – DISPOSAL CONSIDERATIONS

This section provides guidance on proper disposal practices, recycling or reclamation of the chemical(s) or its container, and safe handling practices. The information may include:

- Description of appropriate disposal containers to use.
- Recommendations of appropriate disposal methods to employ.
- Description of the physical and chemical properties that may affect disposal activities.
- Language discouraging sewage disposal.
- Any special precautions for landfills or incineration activities

As a rule, manufacturers/suppliers will indicate that all local, state and federal regulations must be followed when disposing of the chemicals(s) and its container. Contact EHS for any questions related to the disposal of a chemical(s)

SECTION XIV – TRANSPORT INFORMATION

This section provides guidance on classification information for shipping and transporting of hazardous chemical(s) by road, air, rail, or sea. The information may include:

- UN number (i.e., four-figure identification number of the substance).
- UN proper shipping name.
- Transport hazard class(es).
- Packing group number, if applicable, based on the degree of hazard.
- Environmental hazards (e.g., identify if it is a marine pollutant according to the International Maritime Dangerous Goods Code (IMDG Code)).

SECTION XV – REGULATORY INFORMATION

This section identifies the safety, health, and environmental regulations specific for the product that is not indicated anywhere else on the SDS. The information may include:

- Any national and/or regional regulatory information of the chemical or mixtures (including any OSHA, Department of Transportation, Environmental Protection Agency, or Consumer Product Safety Commission regulations)

SECTION XVI – OTHER INFORMATION

This section indicates when the SDS was prepared or when the last known revision was made. The SDS may also state where the changes have been made to the previous version.

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 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 Appendix L: Chemical 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.
- Allofthesecompoundshaveastrongtomildodorofammoniaandtheirvapors 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 reactive to water and/or air.
- 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 ontissues.
- 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 than 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 arecarcinogens.
- 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 chroniceffects.
- 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

EPOXY COMPOUNDS

- Epoxides, also called oxiranes and 1,2-epoxides.
- Exposure to epoxides can cause irritation of the skin, eyes, and respiratory tract.
- Low molecular weight epoxides are strong irritants and more toxic than higher ones.

- Inhalation can produce pulmonary edema and affect the lungs, central nervous system and liver.
- Many epoxy compounds have been found to cause cancer in animals.
- Lower epoxides are highly flammable.
- They also polymerize readily in the presence of strong acids and active catalysts, this reaction generates heat and pressure that may rupture closed containers.
- Therefore contact with anhydrous metal halides, strong bases, and readily oxidizable substances should be avoided.

Examples:

Butylene oxide	Glycidaldehyde
Epichlorohydrin	Glycidol
Ethylene oxide	Isopropyl glycidylether

ESTERS

- Lower aliphatic esters have a pleasant fruity odor.
- The acute toxicity of esters is generally of low order, they are narcotic at high concentrations.
- Vapors are an irritant to the eyes and mucous membranes.
- Toxicity increases with an increase in the alkyl chain length.
- Lower aliphatic esters are flammable liquids, some have low flash points and may cause flashback to an open container.
- The vapors form explosive mixtures with air.
- The flash point increases with increase in the alkyl chain length.
- The reactivity of esters is low.
- Aromatic esters are similar in effects as aliphatic esters.

Examples:

Ethyl acetate	Methyl formate

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	Methyl propyl ether
Ethyl ether	Vinyl ether
Isopropyl 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

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

- Thetoxiceffectsofmostofthesolventsareofloworder,chronicexposuresorlarge 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 peroxides 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
Cyanamidecyanogen	Sodium cyanide

KETONES

- Similar to aldehydes.
- Ingeneral, thetoxicityismuch lowerthanthat ofotherfunctionalgroups,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 EthylKetone
Ketene	

MINERAL ACIDS

- Acid strengths varywidely.
- 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
Hydrofluoricacid	Nitric acid
Hydroiodicacid	Sulfuric acid

ORGANIC CYANIDES (NITRILES)

- These are organic derivatives of Hydrocyanic acid or the cyano-substituted organic compounds.
- Nitrilesarehighlyreactive,theCNgroupreactswithalargenumberofreactantstoform 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 downwith 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-B utylisocyanate	Methyl isocyanate
Hexamethylenediisocyanate	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

- Includes certain classes of inorganic compounds thatare strong oxidizing agents, evolving oxygen ondecomposition.
- 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	Inorganicperoxides
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 is 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, P. *A Comprehensive Guide to the Hazardous Properties of Chemical Substances*; Van Nostrand Reinhold: New York, 2007.

APPENDIX J: PEROXIDE FORMING CHEMICALS

Peroxide forming chemicals are usually flammable and have the ability to form shock-sensitive explosive peroxide crystals under normal storage conditions. It is extremely important that all safety procedures be followed regarding the identification, handling, storage, and disposal of peroxide-forming chemicals. These materials must bestoredaway from light and heat with tightly secured caps and labeled with dates of receipt and opening. Organic peroxides shall be stored in their original DOT shipping containers. Organic peroxides shall be stored in amanner to prevent contamination. Order only what you need. They have a short shelf life.

All peroxide-forming solvents should be checked for the presence of any peroxides prior to distillation or evaporation. Do not open a liquid organic peroxide or peroxide-forming chemical if there are visible crystals, visible precipitate or an oily viscous layer present in the material. These are visual indicators ofdangerous high peroxide levels, immediately contact EH&S department, to manage this hazardous situation and to dispose of this material.

Periodic testing to detect peroxides should be performed and recorded on previously opened material. A variety of methods are available to test for the presence of peroxides in organic solvents. Peroxide test sticks and Potassium Iodide Indicator can be used for the determination of peracetic acid and other organic and inorganic hydroperoxides.

SAFE STORAGE PERIODS FOR PEROXIDE FORMERS	
Unopened chemicals from manufacturer→	Label with Date Received Test upon opening or discard after manufacturer's expiration date
Opened containers:	Test for Peroxide formation or discard after:
Chemicals in Table A→	3 months
Chemicals in Tables B and D→	6 months
Uninhibited chemicals in Table C→	6 **hours**
Inhibited chemicals in Table C→ (Do not store under an inert atmosphere)	6 months

A. Severe Peroxide Hazard - Spontaneously decompose and become explosive with exposure to air without concentration.		
Butadiene[a]	Isopropyl ether	Sodium amide (sodamide)
Chloroprene[a]	Potassium metal	Tetrafluoroethylene[a]
Divinyl acetylene	Potassium amide	Vinylidene chloride
B. Chemicals that form explosive levels of peroxides on concentration (Require external energy for spontaneous decomposition. Form explosive peroxides when distilled, evaporated or otherwise concentrated.)		
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. Shock and Heat Sensitive - Highly reactive and can auto-polymerize as a result of internal peroxide accumulation. The peroxides formed in these reactions are extremely shock- and heat-sensitive.		
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 oxime	Triethylene glycol diacetate
2-Chlorobutadiene	2-Ethylbutanol	Triethylene glycol diprop-ionate
1-(2-Chloroethoxy)-2-	Ethyl B-ethoxypropionate	1,3,3-Trimethoxypropene[d]

phen-oxyethane		
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.

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 Safety Data Sheets. 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, Perchloricacid, peroxides and permanganates
Acetone	Concentrated Nitric and Sulfuric acid mixtures
Acetylene	Copper,Silver, Mercuryandhalogens,Fluorine, Chlorine, Bromine
Aluminum alkyls	Halogenated hydrocarbons, water

Ammonia (anhydrous)	Silver, Mercury, Chlorine, Calcium hypochlorite, Iodine,Bromine,Hydrogenfluoride,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, andotherpetroleum gases, Hydrogen, Sodium carbide, Turpentine, Benzene andfinely divided metals, Methane
Chlorine dioxide	Ammonia, Methane, Phosphineand 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 ormineral
Cyanides	Acids
Ethylene oxide	Acids, bases, Copper, Magnesium perchlorate

Flammable liquids	Ammonium nitrate, Chromic acid, Hydrogen peroxide, Nitricacid, Sodium peroxide, halogens
Fluorine	Reducing agents, Combustible and Organic materials, Metals, Alkalis and Moisture
Hydrocyanic acid	Nitric acid, alkalis
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(anhydrousoraqueous), 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, Oxalicacid, Tartaricacid, Fulminicacid, 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,glacialAceticacid,Aceticanhydride, Benzaldehyde, Carbon disulfide, Glycerine, Ethylene glycol, Ethyl acetate, Methyl acetate and Furfural
Sulfides	Acids
Sulfuric acid	Chlorates, perchlorates, permanganates, organic peroxides, Potassium chlorate, Potassium perchlorate, Potassium permanganate (similar compounds of light metals, such as Sodium, Lithium)
Tellurides	Reducing agents
UDMH (1,1-Dimethylhydrazine)	Oxidizing agents such as Hydrogen peroxide and fuming Nitric acid
Zirconium	Prohibit water, Carbon tetrachloride, foam and dry chemical on zirconium fires

APPENDIX L: CHEMICAL SEGRATION SCHEME AND LIMITS

Unstable/Reactive	Check manufacturer's Safety Data Sheet (SDS) for information on incompatibles and proper storage.
Nitric Acid	Always by itself away from incompatible materials in appropriate secondary containment.
Hydrofluoric Acid	Always by itself away from incompatible materials in an appropriate secondary container.
Perchloric Acid	Always by itself away from incompatible materials in an appropriate secondary container.
Oxidizers	Stored as a group, separated from all other chemical groups, place on shelving compatible with oxidizing materials (not unprotected 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 cabinet approved for flammable materials.
Organic Acids	Store with flammables unless contraindicated by SDS.
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 must be small enough (lecture bottles) to fit inside of fume hoods. Larger cylinders must be in kept in ventilated gas cabinets. Flammable and oxidizing gases must be separated by at least 20-feet or a fire-rated partition.
Radioactive Materials	Stored separately from other materials behind appropriate shielding and in chemically compatible containers.
Other Materials	Stored away from the above materials on secure shelving. Chemicals should not be stored on the floor or above eye level.

Summary Table Chemical Storage Limits

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

APPENDIX M: SAMPLE PRIOR APPROVAL FORM

Prior Approval for Chemical Use/Highly Hazardous Operations

Laboratory personnel listed below must have permission from the laboratory supervisor, Principal Investigator, or the P.I.'s delegate to use the chemicals or conduct the detailed operation in the laboratory listed.

P.I. or supervisor:______________________ Location:___________________________

Name of chemical(s) or operation: ____

Participants should print names legibly below, initial and date to indicate they meet the following requirements:

- Awareness of the hazards the chemical(s) or operation(s) pose
- Read and understood 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
- Completed specific training needed above the standard Laboratory Safety and Chemical Waste Disposal training
- Possesses a valid Certificate of Fitness (C-14)

Name	Initials	Date
_____________________________________	_______	__________
_____________________________________	_______	__________
_____________________________________	_______	__________
_____________________________________	_______	__________
_____________________________________	_______	__________
_____________________________________	_______	__________
_____________________________________	_______	__________
_____________________________________	_______	__________

The P.I., laboratory supervisor, or P.I. delegate listed above must sign below and indicate the date range for which the prior approval extends in order for approval to be valid.

Above Signature:______________________ Date(s) Applicable:_______________________

APPENDIX N: WASTE DETERMINATION/LABELING GUIDE

Waste Name:

Point of Generation:

Answer all the following questions and take all actions indicated.

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 (STP), 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.
NO, no action required.

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, no action required.

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.
NO, no action required.

4. Does the material have a toxic component (See Table 1)?

YES, this waste must be labeled toxic. Include chemical(s) from Table 1 present in the material.
NO, no action required.

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.
NO, no action required.

6. Is this unused material or an off-spec chemical for disposal?

YES, give this material to your EHS officer.
NO, label this material as non-hazardous waste.

Waste determination is complete.

TABLE 1: Maximum Concentration of Contaminants for the Toxicity Characteristic

HW No.	Contaminant	CAS No.	Regulatory 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

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.

APPENDIX O: FUME HOODS

Engineering controls, the first line of defense against workplace hazards, include local exhaust ventilation (i.e., chemical fume hoods) to prevent exposure to gases, chemical vapors and aerosols. There are two basic categories of laboratory hoods: chemical fume hoods and biological safety cabinets. This section addresses the design face velocity requirements and test procedures for chemical fume hoods (CFH). Biological safety cabinets are tested and certified by an independent contractor.

SAFE WORK PRACTICES

Laboratory personnel must employ work practices that minimize/eliminate their exposures when working with hazardous materials in fume hoods.

- All fume hoods are inspected annually. 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.
- Before using a fume hood, ensure that the fume hood is working by checking both the telltale (green crepe paper hanging from hood sash) and air monitoring device if the hood is equipped with one.
- Keep laboratory windows and doors closed and minimize traffic in front of the hood while working. Minimize rapid movements, including opening and closing the sash. 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.
- If the EHSO or Facilities Management has posted an out of service notice on a hood, DO NOT use the fume hood for any reason. Always report any malfunctioning fume hoods to Facilities Management and request repair. Let others in the laboratory know by posting a "Do Not Use" sign on the hood.
- Minimize materials stored in hoods. Excess and unnecessary storage or clutter results in decreased hood performance and increases the chances of an accident or spill.
- Hoods should not be used for permanent storage including of hazardous materials.
- Laboratory personnel should not place their upper body inside the fume hood except during initial setup of equipment and before any hazardous materials have been placed inside the hood.
- Equipment placed inside the hood should not block airflow through slots in the baffle.
- Hazardous materials and any equipment that could be sources of emission should be placed more than 6-inches inside the hood for proper containment of chemical vapors.
- Keep any laboratory equipment elevated at least one inch off the work surface 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.

- The hood sash or panels should be lowered to the lowest (comfortable) working height, usually 12 to 18-inches. Fully opening the sash lowers the face velocity to the point of ineffectiveness.
- The hood sash or panels shall not be removed except for initial experiment setup before hazardous chemicals are placed in the hood.
- Filters to remove contaminants, though rarely used for specific operations, such as volatile radioactive materials, shall be maintained as recommended by the manufacturer.
- 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.
- 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, cleaning up all spills immediately.
- Keepthefumehood sashclosedallofthewaywheneverthefumehoodisnotbeing 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.
- Using fume hoods to evaporate hazardous waste is illegal.

FLOW MONTIORING DEVICES

New and reconditioned hoods should be equipped with an airflow-monitoring device that provides an audible and visible warning should the fume hood face velocity fall below a safe level. For uniformity the selection must be reviewed by EHS. The device should be checked and recalibrated annually at the time of recertification. Any damaged devices should be repaired or replaced.

PERFORMANCE TESTING

Fume hoods must be certified annually using ASHRAE-110 guidelines [85] to test performance.

Performance tests for hoods require one of the following

- Exhaust rate measured by a calibrated meter
- Linear air velocity measured in the plane of the fume hood face (face velocity)
- Smoke tests at different fume hood sash positions

[85] ANSI/AIHA Z9.5-2003, American National Standard for Laboratory

Documenting the performance of a fume hood may be performed by the EHS Office or a competent and designated person. The EHS Office should ensure that this work is conducted annually. If additional problems are suspected with a particular hood, all three performance tests may be performed and/or maintenance required.

Face Velocity

Face Velocity is the linear average air velocity into the exhaust system (i.e., fume hood) measured at the opening into the hood. The measurement of hood face velocity is important for quantitatively determining the effectiveness of a chemical fume hood in capturing and removing materials emitted within it. The average face velocity is the volumetric flow rate of the hood divided by the area of the hood face. For combination or horizontal sashes, the face velocity is measured at the midpoint of the plane of the hood face.

Adequate face velocity generally ranges from 80-120 linear fpm. Minimum face velocity is the minimum acceptable velocity at any point on the operating opening, for example 80 fpm. This should not be less than 95 percent of the as-designed average face velocity. Maximum face velocity is the maximum acceptable velocity at any point of the operating opening. Maximum face velocity should not be greater than 120 fpm to prevent creation of turbulent air currents within the fume hood.

Average face velocity is determined in the following manner:

- Divide the horizontal and vertical planes of the face into equal grids no greater than one foot square. Dimensions of the face opening shall include the space between the air foil and the work surface.
- Velocity readings shall be taken with a calibrated anemometer fixed at the center of each grid cell. The anemometer is held in the plane of the hood perpendicular to the opening.
- The hood face velocity is the average velocity of these measurements.
- The tester will place a certification sticker on the front of the hood, recording the test date, face velocity at a 12 to 18-inches sash height, and tester's initials. The sash height at which the average face velocity is 100 fpm may also be indicated.
- Fume hood testing information should be recorded in a database maintained at the EHS Office. Information should include Principal Investigator (P.I.), department, building, room number, hood ID number, date, velocity (fpm) and tester initials.
- A fume hood that does not maintain an adequate average face velocity has failed the test, cannot be used and is tagged with a sign indicating it is not working.

SCHEDULED MAINTENANCE

Regular checks of fume hood and ductwork is a part of preventive maintenance. Advance notification of the planned interruption of fume hood service should be provided to relevant P.I. s, laboratory personnel and the EHS office. Affected fume hoods should be labeled with "DO NOT USE" signs if not already posted. During this time, no procedures shall be conducted inside the affected fume hoods. If procedures cannot be interrupted or relocated to another fume hood during this time, the P.I./laboratory personnel shall inform those responsible of this conflict and schedule a mutually convenient time for preventive maintenance to be conducted.

Fume hood service interruption notices shall include:

- Date/time of shutdown
- Fan motor number shutdown (if relevant include the site)
- Date/time of reactivation
- Number to call for further information

Once scheduled, the P.I. and laboratory personnel shall make necessary arrangements to conduct procedures requiring local exhaust ventilation elsewhere, or suspend these activities until service is restored. Designated person or persons shall lockout and tagout affected hoods so that they cannot be used during this time. All hazardous materials inside the hoods must be in closed containers or removed. Once maintenance is complete, the lockout device(s) and tag shall be removed and EHS notified. The EHS Office reevaluates the affected hoods and gives clearance for use when maintenance is complete.

REMOVING HOODS FROM SERVICE

When a chemical fume hood is to be removed from service, the P.I. must ensure that all hazardous materials have been removed and the hood has been properly decontaminated. If radioactive materials have been used in the hood, the Radiation Safety Officer must survey the fume hood for radioactive contamination. After decontamination and final survey, clearance for removal is given by EHS Office.

FUME HOOD FAILURE RESPONSABILITIES

If the audible alarm sounds, this indicates that the face velocity has fallen below 80fpm and the fume hood should not be used. If it is suspected that a fume hood is not working properly regardless of the status of the alarm, work inside the hood should stop immediately and the problem should be reported to the Principal Investigator or Laboratory Manager and Facilities. Everyone working in the laboratory has responsibilities related to fume hood operations.

P.I. / Laboratory Personnel

- Inform all laboratory personnel if hood is not working.
- Close or cover any open or exposed containers or radioactive materials.
- Place a "DO NOT USE" sticker or sign on the hood if it is not working properly.
- Remove chemicals and equipment and relocate procedures.
- Contact Facilities or appropriate department.

Facilities or Appropriate Department

- Lockout and tagout of individual hoods before investigation.
- Notify P.I., laboratory manager and research personnel.
- Post "DO NOT USE" signs (if not already posted).
- Repair and adjust adequate flow rate.
- Provide adequate preventive maintenance, including a review of entire system.
- Ensure personnel safety when doing repairs.
- Ensure any contractors follow lockout/tagout procedures.
- Contact EHS to do re-certification after repair or adjustment.

EHS

- Assist with communications between Departments and personnel.
- Arrange for annualcertifications.
- Issue clearance beforerepairs.
- Inform P.I. and Facilities Office if a hood fails certification.
- Re-certify after repairs or adjustment.

ROOF WORK

The fumehood exhaust fans are designed such that the exhaust is ejected high above the building. Working near these outlets could potentially expose workers to hazardous chemicals, albeit in extremely dilute concentrations. If maintenance/repair work must be done on the roof of any building containing hood exhaust(s), the EHS Office must be informed so that workers can be provided with information regarding chemicals used in relevant fumehoods and for clearance to work in the vicinity.

DUCTLESS FUME HOODS

The NYC Fire Code does not allow the use of ductless fume hoods in NYC; therefore ductless fume hoods are not to be installed in CUNY establishments.

REFERENCES

- ANSI/AIHA Z9.5-2003, American National Standard for Laboratory
- NFPA 45 Standard on Fire Protection for Laboratories Using Chemicals.
- ACGIH's Industrial Ventilation: A Manual for Recommended Practice.
- ANSI/ASHRAE 110-1995 Method of Testing Performance of Laboratory Fume Hoods.

APPENDIX P: FIRE EXTINGUISHERS TESTING AND INSPECTIONS

Annual

All fire extinguishers must be inspected monthly and serviced annually. Annual maintenance is a complete and thorough examination of each extinguisher including examining all its parts, cleaning and replacing any defective parts and reassembling, recharging and where appropriate, pressurizing the extinguisher. This is done by a person or vendor who has a Certificate of Fitness in Extinguisher Maintenance. Maintenance should be performed at least once every year, after each use, or when monthly inspection indicates a need for maintenance.

Monthly

Laboratory personnel should perform regular visual checks (at least on a monthly basis) to ensure that fire extinguishers are present in their labs and will operate. The point of these inspections is to give reasonable assurance that the extinguishers are fully charged, completely visible, fully accessible, and operable. The extinguisher should be in its designated place, not been actuated and show no signs of damage that would interfere with operation. After the inspection is complete the monthly inspection tag shall be initialed and dated. For those fire extinguishers with a dial, the inspector 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.

Hydrostatic Testing

Fire extinguishers that are subject to internal pressures are required to undergo hydrostatic testing to prevent unexpected, in-service failure. Undetected internal corrosion caused by moisture in the extinguisher, external corrosion caused by atmospheric humidity or corrosive vapors, rough handling, repeated pressurizations, manufacturing flaws, improper assembly of valves or safety relief discs, or exposure to abnormal heat, as during a fire, may cause damage.

The frequency of hydrostatic testing is determined by the National Fire Protection Association Standard for Portable Fire Extinguishers (NFPA 10). NFPA 10 provides the following hydrostatic test frequency based on the different types of portable fire extinguishers.

Type	Test Interval
Pressure Water	5 years
CO2	5 years
Dry Chemical	5 years
Stainless Steel shell	
Dry Chemical	12 years
Halon	12 years
Water Mist	5 years

APPENDIX Q: MACHINE SHOP GUIDANCE

GENERAL STANDARD OPERATING PROCEDURES FOR COMMON TOOL AND MACHINE SHOP EQUIPMENT

Machine shop tools and equipment place users at risk of injury due to moving machine parts which can cause crushed fingers or hands, amputations, burns, or blindness. The basic procedures listed below minimize the risk from these preventable injuries and apply to all equipment that contains pinch points, wrap points, shear points, crush points, pull-in points, or the potential to throw fragments.

General Safety Tips

- Before using equipment, read the instruction manual and obtain training from a supervisor. Ask for help if you do not feel confident using the equipment. Inspect equipment before use to confirm it is in good working order.
- Maintain tools in accordance with manufacturer requirements.
- Do not install or repair equipment unless you are qualified.
- Do not use defective machinery, equipment or hand tools. Take it out of service and report it to the supervisor.
- Do not tamper with or remove any part of the equipment or safety devices.
- Do not use a tool with a damaged or frayed electrical cord.
- Keep electric cords clean and free from kinks.
- Work Area must be clean, dry and well-lit.
- Stand where you have good footing and good balance when using any tools.
- Use the right tools the correct way. Use hand tools and machine shop equipment for their designed purposes only. Never use a dull blade or cutting edge.
- Do not work alone in a machine shop.
- Concentrate – do not take your eyes off your work or talk to anyone as you use tools.
- Know the location of start, stop switches or buttons.
- Do not wear loose clothing, loose neckwear or exposed jewelry while operating machinery.
- Roll up long shirtsleeves above the elbows.
- Pull back and secure long hair.
- Do not wear thin fabric shoes, sandals, open-toed shoes, and high-heeled shoes.
- Arrange the work and use portable tools so that the tool will move away from your hands and body if it slips.
- Wear safety glasses with side shields at all times.
- Use hearing protection and respiratory protection when required.

- Always keep hands and other body parts a safe distance away from moving machine parts, work pieces, and cutters. The drill should be bolted to the floor or work surface
- Use all guards and safety devices (i.e. three-prong plugs, double-insulated tools, safety switches, and guards) that are part of the equipment.
- Turn off and unplug equipment before making adjustments or changes.

Drill Press.

- Keep the drill press table free of tools and other materials.
- Use only properly sharpened drill bits, sockets and chucks in good condition. Remove dull drill bits, battered tangs, or sockets from service.
- Do not remove by hand metal or wood chips from the table or stock. Use brushes or other tools to remove chips.
- All belts and pulleys must have guards; if the belts or pulleys are frayed, the drill press must be taken out of service and the belts or pulleys replaced.
- Secure stock with a vise or clamps prior to a machining process.
- Use the correct speed and drill for the type of stock being machined.
- Use the appropriate bit for the stock being machined. Do not use bits with feed screw or extremely long bits.
- The drill bit should be mounted the full depth and in the center of the chuck.
- Never attempt to remove a broken drill with a center punch or hammer.
- When an operator has finished working on the drill press, and before leaving the drill press for any reason, the power must be shut off and the machine must come to a complete stop.
- The drill itself as well as the material being drilled, must be clamped or secured firmly.

Bench or Pedestal Grinder

- Do not use a grinder with chipped or cracked wheels.
- When starting motor, stand to one side of the wheel until the wheel reaches operating speed. This prevents injury if a defective wheel breaks apart.

- Prior to starting the grinder, ensure guards enclosing the outside of grinding wheel are in place.
- Prior to adjusting the work rest or tang, unplug the power to the grinder from the wall receptacle. If the grinder is hardwired into a box, follow Lockout/Tag Out Policy

Hand Tools

- Do not use a screwdriver as a chisel as it may cause the tip of the screwdriver to break and fly, hitting the user or other employees.
- Do not use a wooden handle on a tool such as a hammer or an axe is loose, splintered, or cracked, the head of the tool may fly off and strike the user or another worker.
- Do not use a wrench if its jaws are sprung, it might slip.
- Impact tools such as chisels, wedges, or drift pins are unsafe if they have mushroomed heads. The heads might shatter on impact, sending sharp fragments flying.
- Keep floors clean and dry to prevent accidental slips with or around dangerous hand tools.
- Around flammable substances, sparks produced by iron and steel hand tools can be a dangerous ignition source. Where this hazard exists, spark-resistant tools made from brass, plastic, aluminum, or wood will provide for safety.

Power Tools

- Never carry a tool by the cord or hose.
- Never yank the cord or the hose to disconnect it from the receptacle.
- Keep cords and hoses away from heat, oil, and sharp edges.
- Disconnect tools when not in use, before servicing, and when changing accessories such as blades, bits and cutters.
- Secure work with clamps or a vise, freeing both hands to operate the tool.

- Avoidaccidentalstarting.Theworkershouldnotholdafingerontheswitchbutton while carrying a plugged-in tool.
- Tools should be maintained with care. They should be kept sharp and clean for the best performance. Follow instructions in the user's manual for lubricating and changing accessories.
- All portable electric tools that are damaged shall be removed from use and tagged "Do Not Use."

Pneumatic Tools

- Eye protection is required and face protection is recommended for employees working with pneumatic tools.
- Noise is another hazard. Working with noisy tools such as jackhammers requires proper, effective use of hearing protection.
- When using pneumatic tools, employees must check to see that they are fastened securely to the hose to prevent them from becoming disconnected.Ashortwireorpositivelockingdeviceattachingtheairhosetothetool will serve as an added safeguard.
- A safety clip or retainer must be installed to prevent attachments, such as chisels on a chipP.I.ng hammer, from being unintentionally shot from the barrel.
- Screens must be set up to protect nearby workers from being struck by flying fragments around chippers, riveting guns, staplers, or air drills.
- Compressed air guns should never be pointed toward anyone.

Table Saw

- Always inspect the table saw before beginning a shift.
- Always wear eye and ear protection while using the saw and a dust mask is recommended.
- Tie back hair, remove all jewelry, and wear snug fitting clothing while using this machine.
- Never wear gloves while using this machine.

- Keep the table and surrounding area free of debris and excessive dust that may cause tripping or slipping.
- Eliminate potential distractions and ignore anyone who tries to converse with you while operating the saw.
- Ensure that all guides are properly locked before using the saw and that the appropriate guards are in place.
- Check each piece of wood for metal and loose knots and remove either before cutting.
- The power must be disconnected at the service panel before changing a blade.
- The blade must be adjusted to protrude no more that approximately 1/4" through the stock that is being cut.
- A "kickback" is the most dangerous hazard when running a table saw. It occurs when material being cut is thrown back at the operator. To prevent it:
  1) Do not use a dull blade. Replace it with new.
  2) Use the splitter guard.
  3) Do not drop wood on the saw.
  4) Do not cut freehand or rip warped wood.
- Use push sticks, feather boards and other holding or pushing jigs and devices to keep hands away from the blade.
- Pay attention to the direction you are applying force to the stock so that your hands slip, they will not go toward the blade.
- Use a stick to clear scraps, not your hands.
- Always maintain control over any stock captured between the blade and the fence of the saw.
- The blade must be completely stopped before making adjustments.
- Never reach over the saw to push stock.
- Stand slightly to the side of the saw, never in line with the saw.

APPENDIX R: LABORATORY SPECIFIC WORKING ALONE PROTOCOL APPROVAL*

EHSRM has always recommended that no one work alone with hazardous materials in the lab, but we also recognize that there are circumstances where this may be necessary. As a result, a program has been developed where working alone must be authorized by the responsible Principal Investigator (P.I.) of the lab. The form requires the P.I. to confirm the status of the applicant's C-14 Certificate and evaluate activities that would help mitigate or prevent an accident or injury to the person working alone.

If you have solo work with hazardous materials being performed in a lab,please complete the form and submit to campus EHS Office with a copy of the applicants C-14 Certificate of Fitness. **Working alone will not be approved for individuals without a C-14 Certificate of Fitness.**

Section I: APPLICANT

Name		**Date**	/ /
Phone Number		**Emergency Phone Number**	
Name of Principal Investigator			
Proposed date(s) of task/activity			
Duration of authority			
Place of Work			
Areas to be accessed			
Brief of task / activity to be undertaken alone or in isolation			

SECTION II: PRINCIPAL INVESTIGATOR APPROVAL

Identify hazardous substances/processes associated with the task/activity to be undertaken alone or on isolation.

Low Hazard

☐ The worker is not involved in any highly hazardous materials or processes. "Working alone" is allowed.

Chemical Hazards - Working with any materials in these hazard classes requires a **valid certificate of <u>fitness</u>** and the use of the "buddy system."

☐ **Pyrophoric Chemicals**
(ex: Lithium Reagents: RLi (R = alkyls, aryls, vinyls); Metal carbonyls: Lithium carbonyl, Nickel tetracarbonyl; Metal hydrides: Potassium Hydride, Sodium hydride, Lithium Aluminum Hydride; Nonmetal hydrides: Arsine, Boranes, Diethylarsine, diethylphosphine, Germane, Phosphine, phenylphosphine, Silane; Elements: Phosphorus, Cesium, Lithium, Potassium, Sodium, Sodium Potassium Alloy (NaK)), or listed as OSHA Hazard Class Pyrophoric

☐ **Water Reactive Chemicals**
(ex:AluminumCarbide,Calcium,CalciumCarbide,LithiumaluminumHydridePotassium,sodium),or listed as OSHA Hazard Class" substances which, in contact with water, emit flammable gases."

☐ **Potentially Explosive Chemicals**
(ex: Azide Metal (M-N3), Nitrate (-ONO2), Nitro (-NO2), Nitrite (-ONO), Peroxide (-O-O-), Ammonium nitrate, Ammonium perchlorate, Benzoyl peroxide, Dinitrophenol,Nitrocellulose, Picric acid (trinitrophenol), Ureanitrate), or listed as OSHA Hazard Class Explosive or Self-reactive

☐ **Explosive Salts**
(ex: Perchlorate salts (ClO4-)), or listed as OSHA Hazard Class Explosive or Self-reactive

☐ **Acutely Toxic Chemicals**
(ex: Carbon Monoxide, Cyanide salts, Digoxin,2,4-Dinitrophenol, Methyl mercaptan, Nitric oxide, Phosgene, Potassium cyanide,Sodium Azide,Sodium cyanide, any chemical with LD50 (oral)< 50 mg/kg) or listed as OSHA Hazard Class Acutely Toxic Category 1 or 2

☐ **Peroxide Forming Chemicals**
(ex: Isopropyl Ether, Methyl Isobutyl Ketone, Tetrahydrofuran, Acrylonitrile, Methyl Methacrylate,Styrene), or listed as OSHA Hazard Class Peroxide

☐ **Strong corrosives**
(ex:Hydrochloricacid,Hydrofluoricacid,Nitricacid,Perchloricacid,Phenol,Sulfuricacid,Potassium hydroxide,Sodium hydroxide), or listed as OSHA Hazard Class Corrosive

☐ **Strong Oxidizing Agent**
(ex: Ammonium perchlorate, Ammonium permanganate, Bromine, Calcium chlorate, Calcium hypochlorite, Chromic acid, Hydrogen peroxide,Oxygen), or listed as OSHA Hazard Class Oxidizer

☐ **Strong Reducing Agent**
(ex: Lithium, Lithium aluminum hydride, Magnesium, Potassium, Sodium, Sodium borohydride)

☐ **Regulated Carcinogens**
(ex: Acrylonitrile, Benzene, Formaldehyde, Gallium Arsenide, Inorganic Arsenic, Paraformaldehyde), or listed as OSHA Hazard Class Carcinogen

☐ **Other**:

Biological Hazards: Working with any materials in this hazard class requires a "buddy system."

☐ **Select Agents**
(ex: Botulinum neurotoxin, Tetrodotoxin, Yersenia pestis)
http://www.slectagensts.govSlect%20Agents%20and%20Toxins%20List.html

☐ **Others:**

Process Hazards: Specify with any materials in this hazard class requires a "buddy system"

☐ **Use of machine shop or lathes {identify specific equipment}**

☐ **Procedures involving high pressure equipment {identify specific equipment}**

☐ **Transferring large quantities {e.g. 10 liters or more} hazardous**
☐ **Handing animals that could cause serious injury**
☐ **High voltage, high current**
☐ **Other:**

Health and Safety

☐ **Inability for self-rescue:** Can the person rescue themselves in case of emergency?

Additional Requirements:

Identify the "Buddy" and confirm they are available before beginning work:

The laboratory Emergency Plan is posted near the laboratory phone. The names and phone numbers for the laboratory and building contacts are up to date.

Yes ☐ No ☐

Principal investigator Approval

I have reviewed the Hazard Assessment for this procedure, the tasks and hazards involved in the work, the consequences resulting from a worst-case scenario, the possibility of an accident or incident that would prevent the laboratory personnel from calling for help, the laboratory personnel's training and experience and the time the work is to be conducted (during normal business hours versus at night or on weekends/holidays). This laboratory worker has permission to work alone on this procedure.

P.I. Signature:_________________________________Date:_____________

P.I. Phone Number_________________P.I. Emergency phone number:_____________________

**This is a recommended form for labs to use when approving "Working Alone." The P.I. can change these recommended hazards that would require the Buddy System, unless required by another policy. The P.I. can use this form to document their approval for someone to work alone in the lab.*

APPENDIX S: OVERVIEW OF HAZARDOUS WASTE DISPOSAL PROCEDURE

[Insert School Logo]

Environmental Health and Safety

[Insert College name] College faculty, staff, students, contractors, and other parties that handle or generate hazardous wastes are required to properly handle, store and label hazardous wastes and to comply with applicable federal, state and local regulations. Please check off each topic as discussed.

1. The **[Insert College name]** College Hazardous Waste Program
    - Do not dispose of hazardous waste down sink drains.
    - Do not dispose of hazardous waste in the normal trash.
    - Do not dispose of hazardous waste by evaporation in fume hood.
    - Do not dispose of hazardous waste in broken glass container.
    - HW must be collected in a compatible container which is in good condition.
    - All containers of HW MUST be labeled with the word “Hazardous Waste” and with other words identifying contents and hazards present.
    - All HW containers must be kept tightly capped except when adding or removing waste.
    - Do not mix incompatible chemicals together in the same waste container.
    - Do not store waste containers next to other bottles holding incompatible chemicals. Separate incompatible chemicals into separate secondary containment trays.
    - Store HW containers at or near point of generation and under the control of generator.
    - Inspect HW containers weekly for leaks or signs of deterioration.
    - HW containers must be marked with the date the container becomes full and taken to the Main Accumulation Area (**[Insert room number]**) for disposal
2. Review Safety Data Sheets prior to working with chemicals.
3. Use appropriate personal protective equipment when working with chemicals.
4. Report any accident to P.I., Supervisors and Safety Officers.
5. Report any emergency to Public Safety (Ext. **[Insert extension number]**).

APPENDIX T: FIRE SAFETY IN LABS

[Insert School Logo]

Environmental Health and Safety

Do you know what the fire hazards are in your laboratory?

- Type of materials and how they should be used?
- Reaction and hazard potential?
- Proper storage methods?
- Emergency response procedures?
- Special considerations when working with material?

If the answer is "no" to any of these questions, you should

Ask your supervisor and/or consult the Safety Data Sheets (SDS)! You need to know the characteristics of the chemicals you are working with and are stored in your lab. The SDS can be obtained through ChemWatch.

Do you know the location of the safety equipment in and around your laboratory?

- Fire extinguisher
- Emergency eyewash and emergency shower
- Spill clean-up material
- Alarm pull box

- Fire retardant or flame resistant laboratory coats help reduce the risk o clothing fires.
- Never use a fire extinguisher on someone who is on fire. Use the emergency shower.

Common causes of fires include:

- Improper storage, including improper use and storage of flammable liquids (keep no more than the permitted amount of flammable liquids i the laboratory at any time and no container larger than 5 gallons).
- Keeping chemicals past the expiration dates (e.g. ethyl ether is 6 mont from when first opened).
- Not using the least hazardous materials.
- Purchasing non-anhydrous chemicals and drying out in the fume hood.
- Spontaneous combustion (ex.: some solvents on towels will self-ignite the trash).
- Water reactivity (ex.: sodium).
- Faulty electrical wiring & equipment (frayed wires, too close to combustibles, overheating wires, lack of over current protection).
- Poor housekeeping.

APPENDIX U: GUIDELINES FOR CHEMICAL STORAGE

Guidelines for Safe Chemical Storage

Safe chemical handling requires routine inspections of chemical storage areas and maintenance of stringent inventory control.

Proper storage information can usually be obtained from the Safety Data Sheets (SDS), label, or other chemical reference material. SDSs are available through ChemWatch website at http://jr.chemwatch.net/chemgold3/?X. The username is **[INSERT USERNAME]** and the password is **[INSERT PASSWORD]**.

Keys for safe chemical storage:

•	All chemicals are properly labeled with the identity of the hazardous chemical(s) and appropriate hazard warnings. • Maintain Labels on Incoming Containers • Replace Torn or Defaced Labels
•	Incompatible chemicals are segregated by hazard class (see segregation chart).
•	Chemicals are not stored alphabetically except within a grouP.I.ng of compatible chemicals.
•	Flammable materials are stored in flammable materials storage cabinet. Cabinet doors are kept closed.
•	Hazardous chemicals are not stored higher than eye level.
•	Shelves are not overcrowded.
•	Chemicals are not stored on the floor (even temporarily)
•	Liquids are stored in secondary containers, or the storage cabinet that have the capacity to hold the contents if the container breaks.
•	Acids are stored in a dedicated acid cabinet. Nitric acid is isolated from all other acids.
•	Highly toxic or controlled materials are stored in a locked, dedicated poison cabinet.
•	Volatile or highly odorous chemical are stored in a ventilated cabinet.
•	Chemical fume hoods are not used for storage as containers impede airflow in the hood and reduce available workspace.
•	No chemical storage under, over or near a sink.
•	Peroxide forming chemicals such as ethers, dioxane, acetal, and tetrahydrofuran are dated upon receipt and on opening. (At the end of 6 months, these chemicals must be tested for peroxide formation for continued safe use and can be re-dated and retained for an additional 6-month period after it is found to be safe).
•	Refrigerators and freezers for storing flammable liquids must are designed, constructed, approved, and labeled for that purpose.
•	Refrigerators used for storing chemicals, samples or media are labeled with words to the effect as follows: "Caution—Do Not Store Food or Beverages in This Refrigerator."
•	Only compressed gas cylinders that are in use and secured in place are kept in the laboratory.
•	Emergency phone numbers, eyewash, emergency shower, fire extinguishers, spill cleanup supplies and personal protective equipment are readily available and personnel trained in their use.
•	Look for unusual conditions in chemical storage areas, such as: • Improper storage of chemicals • Leaking or deteriorating containers • Spilled chemicals • Temperature extremes (too hot or cold in storage area) • Lack of or low lighting levels • Blocked exits or aisles • Doors blocked open, lack of security • Trash accumulation • Open lights or matches • Fire equipment on the floor, blocked, broken or missing Lack of information or warning signs ("Flammable liquids", "Acids", "Corrosives", "Poisons", etc.)

APPENDIX V: LABORATORY HAZARD ASSESSMENT TOOL

This toolis adaptedfromUCLAEHS.Theform must be completed by the P.I., Laboratory Supervisor, or their designee to conduct a laboratory hazard assessment specific to activities in their laboratories. The laboratoryhazard assessment identifies hazards to employees and specifies personal protective equipment (PPE) to protect employees during work activities. The P.I. assessment must verify that it is complete and that training has been conducted. EH&S personnel are available to assist with this form.

This assessment consists of four sections and serves as a step in satisfying PPE requirements.

Section 1: Laboratory Information

Section 2: Laboratory Hazard Assessment

Section 3: PPE Training

Section 4: Verification of PPE Training

Section 1: Laboratory Information

Department	
Laboratory location(s) with building & room number(s)	
Principal Investigator	
Laboratory Safety Coordinator	
Name & title of person conducting assessment	
Phone number	
Email address	
Date assessment completed	
Signature	

Section 2: Laboratory Hazard Assessment

In this section, you will:

- Conduct a hazard assessment of the laboratory to identify activities when PPE is needed to protect the laboratory staff from exposure to hazards.
- Certify the hazard assessment for the laboratory by signing Section 1.

The following checklists are an overview of common laboratory activities and associated potential hazards and applicable PPE. Check each box that describes activities performed by laboratory personnel.

Chemical Hazards				
Are the following activities performed in the lab?				
Yes	**No**	**Activity**	**Potential Hazard**	**Applicable PPE**
◯	◯	Working with small volumes (<4 liters) of corrosive liquids.	Eye or skin damage.	Safety glasses or goggles. Light chemical-resistant gloves. Laboratory coat.

Chemical Hazards				
Are the following activities performed in the lab?				
Yes	**No**	**Activity**	**Potential Hazard**	**Applicable PPE**
◉	◯	Working with large volumes (>4 liters) of corrosive liquids, small to large volumes of acutely toxic corrosives, or work which creates a splash hazard.[1]	Poisoning; increased potential for eye and skin damage.	Safety goggles. Heavy chemical-resistant gloves. Laboratory coat and chemical-resistant apron.
◉	◯	Working with small volumes (<4 liters) of organic solvents or flammable organic compounds.	Skin or eye damage, potential poisoning through skin contact.	Safety glasses or goggles. Light chemical-resistant gloves. Laboratory coat.
◉	◯	Working with large volumes (>4 liters) of organic solvents, small to large volumes of very dangerous solvents, or work which creates a splash hazard.[1]	Major skin or eye damage, potential poisoning through skin contact. Fire.	Safety goggles. Heavy chemical-resistant gloves. Flame-resistant laboratory coat (e.g. Nomex).
◯	◯	Working with toxic or hazardous chemicals (solid, liquid, or gas).[1,2]	Skin or eye damage, potential poisoning through skin contact and/or inhalation.	Safety glasses (goggles for large quantities). Light chemical-resistant gloves. Laboratory coat.
◉	◯	Working with acutely toxic or hazardous chemicals (solid, liquid, or gas).[1, 2, 3]	Increased potential for eye or skin damage; increased potential poisoning through skin contact and/or inhalation	Safety goggles. Heavy chemical- resistant gloves. Laboratory coat.

◉	○	Working with an apparatus with contents under pressure or vacuu	Eye or skin damage.	Safety glasses or goggles; face shield for high risk activities. Chemical-resistant gloves. Laboratory coat, chemical-resistant apron for high risk activities.
◉	○	Working with air or water reactive chemicals.	Severe skin and eye damage. Fire.	Work in inert atmosphere, when possible. Safety glasses or goggles. Chemical- resistant gloves. Laboratory coat, flame resistant laboratory coat for high risk activities (e.g. Nomex). Chemical-resistant apron for high risk activities.
◉	○	Working with potentially explosive chemicals.	Splash, detonation, flying debris, skin and eye damage. Fire.	Safety glasses face shield, and blast shield. Heavy gloves. Flame-resistant laboratory coat (e.g. Nomex).
◉	○	Working with low and high temperatures.	Burns. Splashes. Fire.	Safety glasses. Laboratory coat. Thermal insulated gloves, when needed.
◉	○	Minor chemical spill cleanup.	Skin or eye damage, respiratory damage.	Safety glasses or goggles. Chemical- resistant gloves. Laboratory coat. Chemical- resistant apron and boot/shoe covers for high risk activities. Respirator as needed. Consider keeping Silver Shield gloves in the laboratory spill kit.
◉	○	Reactive Materials		

Biological Hazards

Are the following activities performed in the lab?

Yes	No	Activity	Potential Hazard	Applicable PPE
◉	○	Working with human blood, body fluids, tissues, or blood borne pathogens (BBP). [5]	Exposure to infectious material.	Safety goggles with face shield or facemask plus goggles, latex or nitrile gloves, laboratory coat or gown.

Biological Hazards

Are the following activities performed in the lab?

Yes	No	Activity	Potential Hazard	Applicable PPE
○	○	Working with preserved animal and/or human specimens.	Exposure to infectious material or preservatives.	Safety glasses or goggles, protective gloves such as light latex or nitrile for unpreserved specimens (select protective glove for preserved specimens according to preservative used), laboratory coat or gown.
○	○	Working with radioactive human blood, body fluids, or blood borne pathogens (BBP).	Cell damage, potential spread of radioactive contaminants, or potential BBP exposure.	Safety glasses (goggles for splash hazard), light latex or nitrile gloves, laboratory coat or gown.

○	○	Working with agents or recombinant DNA classified as Biosafety Level 1 (BSL-1).	Eye or skin irritation.	Safety glasses or goggles for protection from splash or other eye hazard, light latex or nitrile gloves for broken skin or skin rash, laboratory coat or gown.
◉	○	Manipulation of cell lines, viruses, bacteria, or other organisms classified as Biosafety Level 2 (BSL-2). [5]	Exposure to infectious material, particularly through broken skin or mucous membranes.	Safety glasses or goggles for protection from splash or other eye hazard, light latex or nitrile gloves, laboratory coat or gown.
◉	○	Manipulation of infectious materials classified as Biosafety Level 2 facility with BSL-3 practices (BSL-2+). [5]	Exposure to infectious materials with high risk of exposure by contact or mucous membranes.	Safety glasses or goggles for protection from splash or other eye hazard, light latex or nitrile gloves (double), laboratory coat or disposable gown (preferred), surgical mask.
◉	○	Manipulation of infectious materials classified as Biosafety Level 3 (BLS-3).	Exposure to infectious materials with high risk of exposure, particularly through inhalation.	Safety glasses or goggles for protection from splash or other eye hazard, light latex or nitrile gloves (double), full disposable gown or Tyvek suite (preferred), respirator, shoe cover or dedicated shoe.
◉	○	Working with live animals (Animal Biosafety Level 1, ABL-1).	Animal bites, allergies.	Safety glasses or goggles for protection from splash or other eye hazard, light latex, nitrile or vinyl gloves for broken skin or skin rash, laboratory coat or gown. Consider need for wire mesh glove.
◉	○	Working with live animals (Animal Biosafety Level 2, ABL-2). [5]	Animal bites, exposure to infectious material, allergies.	Safety glasses or goggles for protection from splash or other eye hazard, light latex, nitrile or vinyl gloves, laboratory gown, hair cover, shoe covers, surgical mask. Consider need for wire mesh glove.

Radiological Hazards				
Are the following activities performed in the lab?				
Yes	**No**	**Activity**	**Potential Hazard**	**Applicable PPE**
◉	○	Working with solid radioactive materials or waste.	Cell damage, potential spread of radioactive materials.	Safety glasses, impermeable gloves, laboratory coat.
◉	○	Working with radioactive materials in hazardous chemicals (corrosives, flammables, liquids, powders, etc.).	Cell damage or spread of contamination plus hazards for the specific chemical.	Safety glasses (or goggles for splash hazard), light chemical-resistant gloves, laboratory coat. Note: Select glove for the applicable chemical hazards above.

Radiological Hazards

Are the following activities performed in the lab?				
Yes	**No**	**Activity**	**Potential Hazard**	**Applicable PPE**
◉	○	Working with ultraviolet radiation.	Conjunctivitis, corneal damage, skin redness.	
◉	○	Working with infrared emitting equipment (e.g. glass blowing).	Cataracts, burns to cornea.	UV face shield and goggles, laboratory coat.
◉	○	Working with X-Rays		Appropriate shaded goggles, laboratory coat.

Laser Hazards

Are the following activities performed in the lab?				
Yes	**No**	**Activity**	**Potential Hazard**	**Applicable PPE**
		Open Beam		
◉	○	Performing alignment, trouble-shooting or maintenance that requires working with an open beam and/or defeating the interlock(s) on any Class 3 or Class 4 laser system.	Eye damage.	Appropriately shaded goggles/glasses with optical density based on individual beam parameters.
◉	○	Viewing a Class 3R laser beam with magnifying optics (including eyeglasses).	Eye damage.	Appropriately shaded goggles/glasses with optical density based on individual beam parameters.
◉	○	Working with a Class 3B laser open beam system with the potential for producing direct or specular reflections.	Eye damage, skin damage.	Appropriately shaded goggles/glasses with optical density based on individual beam parameters, appropriate skin protection.
◉	○	Working with a Class 4 laser open beam system with the potential for producing direct, specular, or diffuse reflections.	Eye damage, skin damage.	Appropriately shaded goggles/glasses with optical density based on individual beam parameters, appropriate skin protection.
		Non Beam		
◉	○	Handling dye laser materials, such as powdered dyes, chemicals, and solvents.	Cancer, explosion, fire.	Gloves, safety glasses, flame resistant laboratory coat or coveralls.
◉	○	Maintaining and repairing power sources for large Class 3B and Class 4 laser systems.	Electrocution, explosion, fire.	Electrical isolation mat, flame- resistant laboratory coat or coveralls.

Physical Hazards

Are the following activities performed in the lab?

Yes	No	Activity	Potential Hazard	Applicable PPE
◉	○	Working with cryogenic liquids.	Major skin, tissue, or eye damage.	Safety glasses or goggles for large volumes, impermeable insulated gloves, laboratory coat.
◉	○	Removing freezer vials from liquid nitrogen	Vials may explode upon rapid warming. Cuts to face/neck and frostbite to hands.	Face shield, impermeable insulated gloves, laboratory coat.

Physical Hazards

Are the following activities performed in the lab?

Yes	No	Activity	Potential Hazard	Applicable PPE
◉	○	Working with very cold equipment or dry ice.	Frostbite, hypothermia.	Safety glasses, insulated gloves (possibly warm clothing), laboratory coat.
◉	○	Working with hot liquids, equipment, open flames (autoclave, Bunsen burner, water bath, oil bath).	Burns resulting in skin or eye damage.	Safety glasses or goggles for large volumes, insulated gloves (impermeable insulated gloves for liquids, steam), laboratory coat.
◉	○	Glassware washing.	Lacerations.	Cut or puncture resistant rubber gloves, laboratory coat.
◉	○	Working with loud equipment, noises, sounds, alarms, etc.	Potential ear damage and hearing loss.	Earplugs or ear muffs as necessary.
◉	○	Working with a centrifuge.	Imbalanced rotor can lead to broken vials, cuts, exposure.	Safety glasses or goggles, lab coat, latex, vinyl, or nitrile gloves.
◉	○	Working with a sonicator.	Ear damage, exposure.	Safety glasses or goggles, lab coat, latex, vinyl, or nitrile gloves. Ear plugs or ear muffs.
◉	○	Working with sharps.	Cuts, exposure.	Safety glasses or goggles, lab coat, cut or puncture resistant gloves.

Nanomaterial Hazard				
Is the following activity performed in the lab?				
Yes	No	Activity	Potential Hazard	Applicable PPE
◉	○	Working with engineered nanomaterials. [8]	Inhalation, exposure, dermal exposure.	Goggles, gloves, laboratory coat.

1. Use a chemical fume hood or other engineering control whenever possible. In addition to engineering controls and PPE, consider personal clothing that provides adequate skin coverage.
2. Consult SDS.
3. Chemical-resistant gloves are to be selected based on the specific chemical(s) used.
4. Use a Biosafety cabinet to minimize exposure
5. Appropriate skin protection can include laboratory coat, gloves, sun block, or barrier cream.
6. Working with dry engineered nanomaterials (e.g. synthesizing, storage) should be separately evaluated for respiratory protection.

Section 3: Conduct PPE Training

PPE training is conducted by the laboratory P.I. It may be supplemented by online resources approved by the EHS office. Documentation of training must be kept (see the following page).

Step 1

The P.I. or laboratory supervisor identifies those requiring PPE training, informs them of the requirements and outlines how they can meet the obligations.

Step 2

1. The P.I., laboratory manager, or their designee reviews the **completed** *Hazard Assessment Tool* (this document) with the employee. It describes the tasks in the laboratory when employees need PPE to protect themselves from exposure to hazards. In this step, the hazard assessment is used as a trainingtool.

2. While discussing laboratory activities and the associated hazards with laboratory staff, the supervisor will address how their laboratory obtains PPE, what types of PPE are used in the laboratory and for which tasks, where and how the PPE is stored and maintained, how to properly use the PPE, and discuss any limitations of the PPE. The supervisor should also discuss general PPE safety practices, including not wearing PPE outside of laboratory hazard areas (e.g. hallways and eating areas).

Step 3

When the supervisor believes the employees have demonstrated understanding, the employees and the P.I. then sign the following *Verification of PPE Training* form (next page) to document that PPE training has been conducted. A copy of this signed form is to be maintained in the Laboratory Safety Manual.

Step 4

Repeat or conduct a refresher training whenever the hazard assessment is updated (at least annually).

Section 4: Verification of PPE Training

The following employees of____(laboratory) have received the following training:

1. When PPE is necessary.
2. What PPE is required in a given circumstance
3. How to properly don, doff, adjust, and wear PPE.
4. The limitations of PPE.
5. The proper care, maintenance, useful life, and disposal of PPE.

Employee Name	**FNDY COF Number**	**Employee Signature**

As a part of this training, employees were informed of the personal protective equipment selected by this facility for their use. By my signature and those of the employees listed above, we certify that each employee has demonstrated his/her understanding of this training.

_______________________________ _______________________________

(Signature of Principal Investigator) (Date)

APPENDIX W: DRY ICE SHIPPING PROTOCOL

Federal regulations require that anyone involved in shipping a hazardous material (including dry ice) must first receive training. If you are going to package dry ice for shipment or sign any type of shipping documentation (such as a FedEx Airbill) for a dry ice shipment, it is necessary to renew your certification every three years.

Example: FedEx Airbill containing proper documentation for 1 box containing 6 kg of dry ice.

- Package Dry Ice properly using approved dry ice shipping containers. Below are some Manufacturers of Dry Ice Shipping Containers:

  a) DG supplies, Inc.
  5 Boxal Drive
  Cranbury, NJ 08512
  (800) 347-7879
  http://www.dgsupplies.com

b) HAZMATPAC, Inc.
5301 Polk St., Bldg. 18
Houston, TX 77023
(800) 923-9123
http://www.hazmatpac.com

c) United City Ice Cube Company
503 W 45thSt
New York, NY 10036
212-563-0819
https://www.unitedcityicecube.com

- Make sure to mark and label container properly.

Dry Ice Shipping Label (Class 9 Hazard: Miscellaneous)

IATA Acceptance Checklist for Dry Ice

From: http://www.iata.org/whatwedo/cargo/dgr/Documents/EN_Form_DryIce_59.pdf

2018

ACCEPTANCE CHECKLIST FOR DRY ICE (Carbon Dioxide, solid)

(For use when a Shipper's Declaration for Dangerous Goods is not required)

A checklist is required for all shipments of dangerous goods (9.1.4) to enable proper acceptance checks to be made. The following example checklist is provided to assist shippers and carriers with the acceptance of dry ice when packaged on its own or with non-dangerous goods.

Is the following information correct for each entry?

DOCUMENTATION

	YES	NO*	N/A
The Air Waybill contains the following information in the “Nature and Quantity of Goods” box (8.2.3)			
1. The UN Number “1845”, preceded by the prefix “UN”..	☐	☐	☐
2. The words “Carbon dioxide, solid” or “Dry Ice”	☐	☐	☐
3. The number of packages of dry ice (may be in the Pieces field of the AWB when they are the only packages in the consignment)...	☐	☐	☐
4. The net quantity of dry ice in kilograms...	☐	☐	☐

Note: The packing instruction “954” is optional.

Quantity

	YES	NO*	N/A
5. The quantity of dry ice per package is 200 kg or less [4.2]	☐	☐	☐

PACKAGES AND OVERPACKS

	YES	NO*	N/A
6. The number of packages containing dry ice delivered as shown on the Air Waybill...........	☐	☐	☐
7. Packages are free from damage and in a proper condition for carriage	☐	☐	☐
8a. Packaging conforms with Packing Instruction 954...	☐	☐	☐

8b. The package is vented to permit the release of gas.. ☐ ☐ ☐

Marks & Labels

9. The UN number "1845" preceded by prefix "UN" [7.1.4.1(a)].. ☐ ☐ ☐

10. The words "Carbon dioxide, solid" or "Dry ice" [7.1.4.1(a)].. ☐ ☐ ☐

11. Full name and address of the shipper and consignee [7.1.4.1(b)] .... ☐ ☐ ☐

12. The net quantity of dry ice within each package [7.1.4.1(d)] .... ☐ ☐ ☐

13. Class 9 label affixed [7.2.3.9]... ☐ ☐ ☐

14. Irrelevant marks and labels removed or obliterated [7.1.1(b); 7.2.1(a)].......................... ☐ ☐ ☐

Note: The Marking and labelling requirements do not apply to ULDs containing dry ice

For Overpacks

15. Packaging Use marks and hazard and handling labels, as required must be clearly visible or reproduced on the outside of the overpack [7.1.7.1, 7.2.7] .... ☐ ☐ ☐

16. The word "Overpack" marked if marks and labels are not visible [7.1.7.1] .... ☐ ☐ ☐

17. The total net quantity of carbon dioxide, solid (dry ice) in the overpack [7.1.7.1]........... ☐ ☐ ☐

Note: The Marking and labelling requirements do not apply to ULDs containing dry ice

State and Operator Variations

18. State and operator variations complied with [2.8]... ☐ ☐ ☐

Comments:

Checked by:

Place:

Signature:

Date: Time:

*** IF ANY BOX IS CHECKED "NO", DO NOT ACCEPT THE SHIPMENT AND GIVE A DUPLICATE COPY OF THIS COMPLETED FORM TO THE SHIPPER**.

APPENDIX X: LABORATORY SAFETY REFERENCE LIBRARY

Reference materials identified in the OSHA Laboratory Standard

In addition, the following reference materials are recommended:

AHandbookof Radioactive Measurements Procedures, National Councilon Radiation Protection and Measurements,1978.

A Practical Guide to the Determination of Human Exposure to Radiofrequency Fields, National Council on Radiation Protection and Measurements, 1993.

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Biological Effects and Exposure Criteria for Radiofrequency Electromagnetic Fields, National Council on Radiation Protection and Measurements, 1986.

Biological Effects of Ultrasound Mechanism and Clinical Implications, National Council on Radiation Protection and Measurements, 1983.

Biosafety in Microbiological and Biomedical Laboratories, the Centers for Disease Control and Preventionand the National Institutesof Health, U.S. Government Printing Office, 2007.

Biosafetyin the Laboratory: Prudent Practices for the Handling and Disposal of Infectious Materials, National Research Council, National Academy Press, 1989.

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