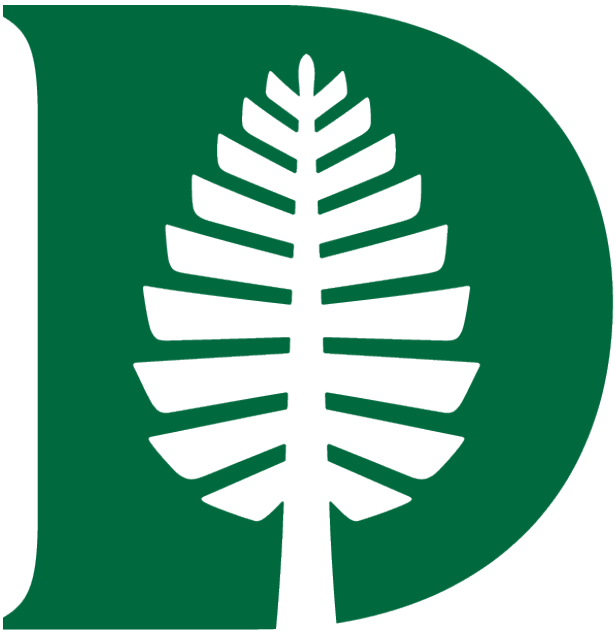
Chemical Hygiene Plan



DARTMOUTH

Commitment to Safety

Dartmouth College and Environmental Health and Safety are committed to maintaining and promoting a safe, healthy, and injury free work environment for all community members. The research safety programs (chemical, biological, radiological) support the educational and research mission of the College by working to protect the College community from injuries and illnesses, promoting accident prevention, fire safety, and the proper management and disposal of hazardous materials. EHS endorses efforts that ensure occupational safety and health quality by emphasizing the control of risks in the working environment.

At its core, Dartmouth works to provide education, research support, and public service year after year. To accomplish this, a wide variety of hazardous materials and processes are used that require specific training and special precautions to protect the health and safety of our faculty, staff, students, and visitors. It is EHS policy to provide a safe workplace, communicate effectively, remain in regulatory compliance, and provide the necessary training to minimize potential hazards to all community members. EHS works to set a high standard for safety and to complement individual laboratory safety policies and activities. Every Principal Investigator is responsible for ensuring that appropriate information and training is provided to their staff, students, and visitors. Likewise, it is the responsibility of those staff, students, and visitors to follow safe working practices and procedures as specified in written protocols and policies. The effectiveness and success of our work depend upon the active support and commitment of all individuals to foster a culture of safety.

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1 EMERGENCY CONTACTS

DO NOT EMAIL IF YOU HAVE AN EMERGENCY

Type	Who to call	Daytime	After hours, holidays or weekends
FIRE MEDICAL POLICE	911 (DHMC 5555)	911 (DHMC 5555)	911 (DHMC 5555)
Hazardous Materials	EHS	603-646-1762	603-646-3333 (DHMC 5555)
Facilities/Building Issue – Hanover Campus	Work Control Geisel Facilities Troubleshooters	Work Control 603-646-2508	603-646-2344
		Geisel Facilities 603-650-5345	
Facilities/Building Issue – DHMC Complex	Geisel Facilities DHMC Facilities	Geisel Facilities 603-650-5345	603-650-7105 and DH Pager #9234
		DHMC Facilities 603-650-7105	

Hazardous Materials Emergencies are spills or releases involving:

- **Chemicals, radioactivity, and biological products affecting human health, property, or the environment require immediate and specific response.**
  - **Examples: chemical spill/exposure, oil spill, gas leak, needle stick, unknown odor, etc.**

NON-EMERGENCIES

	Contact	Daytime	After hours, holidays or weekends
DC Safety and Security Non-Emergency	Safety and Security	603-646-4000	603-646-4000
Hanover Police Non-Emergency	Hanover Police	603-643-2222	603-643-2222
Lebanon Police Non-Emergency	Lebanon Police	603-448-1212	603-448-1212
Facilities/Building Issue	Work Control/ Troubleshooters	603-646-2508	603-646-2344

2 Introduction

This section outlines the focus of this manual, who it pertains to, why it's necessary, the role Environmental Health and Safety (EHS) plays in safety here at the College, and some definitions to get started.

2.1 Purpose and Scope

This manual is a safety reference for laboratory personnel at Dartmouth College. This manual provides basic safety information about hazards you may encounter in the laboratory and methods to help prevent laboratory accidents and minimize exposure to hazardous chemicals. Hazardous chemicals/materials are a vital tool in teaching and research. The risks of exposure, fire/explosion, or injury can be reduced and/or eliminated with training, planning, and the proper equipment. Competency in the lab can be achieved through training, observation, and supervision. This manual explains the safety policies, procedures, and responsibilities to protect all Dartmouth College laboratory personnel and communicate the possible health hazards associated with their roles.

All laboratory personnel who work with or around hazardous chemicals must have access to and be familiar with this manual. Each laboratory worker must be familiar with the contents that pertain to their workplace and the procedures for obtaining additional safety information needed to perform their duties safely.

The most up to date version of our laboratory safety manual can be found on the EHS homepage.

2.2 Regulatory Background

The Occupational Health and Safety Administration (OSHA) Laboratory Standard (29 CFR 1910.1450) requires the development and implementation of a Chemical Hygiene Plan (CHP) (See Appendix A for more details about this plan). Specifically, there must be a written and employee-accessible program that protects employees from health hazards associated with hazardous chemicals used in the laboratory. This Dartmouth College Laboratory Safety Manual functions as the base part of the Chemical Hygiene Plan in conjunction with lab specific safety plans, to form the complete CHP, and applies to laboratory work areas, while the Dartmouth College Hazard Communication Program applies to non-laboratory chemical use on campus.

Although the Laboratory Standard provides some compliance flexibility, the Chemical Hygiene Plan must address specific areas. These areas include:

•Exposure monitoring	•Hazard identification
•Employee information and training	•Use of personal protective equipment
•Medical consultations and examinations	•Recordkeeping

In addition to the Laboratory Standard, there are several other agencies with applicable compliance standards that need to be considered in the laboratory.

- OSHA Hazard Communication, Bloodborne Pathogens, Personal Protective Equipment, Eye/Face/Hand Protection, Control of Hazardous Energy, and others.
- Environmental Protection Agency (EPA) and NH State Hazardous Waste Regulations.
- NH State Radiological Health Section radiation protection rules.
- National Fire Protection Association (NFPA) and any Authorities Having Jurisdiction (AHJ) fire and life safety standards.
- National Institutes of Health (NIH) Guidelines for biological safety.
- Drug Enforcement Agency (DEA).
- Department of Homeland Security (DHS).
- College and hospital policies.
- Consensus standards.

2.3 EHS Scope of Services

The Office of Environmental Health and Safety (EHS) advises and guides the Dartmouth Community on occupational safety, research safety, and environmental protection issues. EHS manages the College's chemical, biological, and radiological use and performs an essential role in emergency preparedness and response.

EHS also conducts inspections, assessments, and training on several topics to ensure compliance with pertinent regulatory requirements and an understanding of current and/or potential workplace hazards.

2.4 Select Definitions

Action Level: indicates the level of a harmful or toxic substance/activity that requires medical surveillance, increased industrial hygiene monitoring, or biological monitoring.

ANSI: The American National Standards Institute is a private nonprofit organization that oversees the development of voluntary consensus standards for products, services, processes, systems, and personnel in the United States.

BioRAFT: the training, laboratory management, and compliance system used by the EHS department and researchers.

CEMS: Chemical Environmental Management System developed by the University of New Hampshire. A chemical inventory management system.

Chemical Hygiene Plan (CHP): a written document that establishes procedures and policies to protect laboratory personnel and other support staff from the potential adverse health effects associated with exposure to hazardous chemicals.

Chemical Hygiene Officer (CHO): a qualified individual who provides technical guidance in developing and implementing a chemical hygiene plan. A specialist focused on a single OSHA standard—the Laboratory Standard, which applies only to chemical exposure in laboratories. At Dartmouth College, the CHO is a member of EHS and reports to the Associate Director for Research. Individual departments or faculty groups should also designate a Lab Safety Liaison for their own specific laboratories.

Designated Area: a pre-determined and labeled area where potentially hazardous chemicals are used and stored. For simplicity, any laboratory at Dartmouth that uses or stores potentially hazardous chemicals is considered a designated area and must be labeled with an EHS-provided door sign.

Extremely Toxic Chemicals: Substances with lethal dose values of 5 mg/kg or lower are considered extremely or super toxic. This is equivalent to as little as 7 drops or even a taste of the pure substance, causing death in a 150-lb person. Lethal dose information can be found on safety data sheets and from online and printed resources. Always reference the lowest published LD or LD_{50} data, regardless of the route of entry or organism tested.

Hazardous Chemical: Any chemical classified as a health hazard or simple asphyxiant per the Hazard Communication Standard (§ 1910.1200).

Laboratory Personnel: any person working in a Dartmouth College teaching or research laboratory who handles/uses potentially hazardous chemicals. At Dartmouth, visiting scientists, guest researchers, special volunteers, support staff, students, and other similar personnel are included in the scope of the chemical hygiene plan.

Laboratory/Laboratory Scale/Laboratory Use: a workplace in which relatively small quantities of hazardous chemicals (usually several) are used in a non-production capacity and in which one person generally manages the tasks performed.

Lethal Dose 50 (LD50): In toxicology, the median lethal dose, LD_{50} (abbreviation for "lethal dose, 50%"), LC_{50} (lethal concentration, 50%), or LCt_{50} is a toxic unit that measures the lethal dose of a toxin, radiation, or pathogen.

NFPA: The National Fire Protection Association is a U.S.-based international nonprofit organization devoted to eliminating death, injury, property, and economic loss due to fire, electrical, and related hazards.

OSHA: The Occupational Safety and Health Administration was created to ensure safe and healthful working conditions for workers by setting and enforcing standards and providing training, outreach, education, and assistance.

Particularly Hazardous Substances: these include "select carcinogens", reproductive toxins, and substances that have a high degree of acute toxicity. A substance is considered "Particularly Hazardous" if it has an LD_{50} $\leq$50 mg/kg (approximately one teaspoon for a 150 lb. person) or carries a "skin" designation.

Permissible Exposure Limit (PELs): OSHA's legally enforceable exposure limit for a hazardous chemical.

Potentially Hazardous Chemical: a substance recognized to have a measurable potential for adverse (acute or chronic) health effects in humans. The Federal Hazard Communication Standard provides additional guidance in determining the extent of the hazard presented by a chemical.

Principal Investigator (PI)/Course Professor: The PI is the person who is ultimately responsible for the implementation and oversight of this policy in his/her laboratory or course. This includes providing students and staff with specific information and training beyond this plan on the unique hazards of their lab work, documenting this activity, and ensuring compliance with EHS waste disposal requirements.

Registered Dartmouth Academic Program: is defined as any Dartmouth course, program, collaboration, or affiliated academic requirement to meet established standards

Reproductive Toxins/Teratogens: chemicals that affect an individual's reproductive system, including chromosomal damage (mutations) and/or have an adverse effect on an embryo/fetus (teratogenesis).

Select Carcinogen: a substance regulated by OSHA designated as having a moderate to high potential for causing cancer in humans or in animal models.

Skin Designation: the American Conference of Governmental Industrial Hygienists (ACGIH) designation for chemicals with potentially significant contributions to exposure via skin contact (including eyes and mucous membranes).

Threshold Limit Values (TLVs): occupational exposure limits established by the American Conference of Governmental Industrial Hygienists (ACGIH). These limits are guidance values but can be used for compliance when OSHA has not established a safe level of its own.

3 Emergencies and Exposures

This section outlines the basic first steps in dealing with different emergency situations. This list is likely not all inclusive for your laboratory. Therefore, your lab should develop specific procedures needed in your lab space.

Emergencies are stressful times. Take the time to become familiar with the following procedures in preparation for an actual event.

Incident	Actions	Call
Fire	1. Pull the fire alarm. 2. Evacuate building. 3. Go to a safe location. 4. Dial 911.	911 (DHMC 5555)
Serious injury or hazardous material exposure	Call 911 If safe to do so, guide the person to fresh air or an emergency shower	911 (DHMC 5555)
Large spill	1. Leave the area. 2. Eliminate ignition sources. 3. Warn others. 4. Secure area.	603-646-1762 603-646-3333 (DHMC 5555)
Migrating spill threatens other areas	1. Leave the area. 2. Eliminate ignition sources. 3. Warn others. 4. Secure area.	603-646-1762 603-646-3333 (DHMC 5555)
Unknown material incident	1. Leave the area. 2. Eliminate ignition sources. 3. Warn others. 4. Secure area.	603-646-1762 603-646-3333 (DHMC 5555)

3.1 When you hear a fire alarm:

- Shut off all open flames.
- If time permits, safely store highly hazardous materials such as pyrophoric materials or chemicals that, if left unattended on a benchtop, can cause a dangerous reaction.
- Leave your work location.
- Shut all doors behind you as you leave.
- Evacuate the building through the nearest exit.
- Do not use elevators.

You must exit your laboratory and the building during all fire alarms. Chemical spills may present insidious hazards you cannot smell or see, so don't rely on your nose – just get out. Failure to do so is illegal and can result in disciplinary action from the police and/or the College.

3.2 Chemical Spills

Chemical spills are likely to happen in teaching and research laboratories. Controlling the extent of a chemical spill requires planning and a prompt response. Using shatter resistant primary and secondary containers and minimizing the amount of chemicals available to students can prevent many chemical spills.

EHS will supply every lab that uses hazardous chemicals with a spill kit (contact EHS ehs@dartmouth.edu to request one). It contains inert absorbent pads that work on all spills, solvents, aqueous materials, or acids/bases. The kits also contain bags and hazardous waste labels for packaging contaminated spill debris.

EHS supplied spill kits are for CHEMICAL spills only. Biological or radioactive spills or contamination require different materials and methods outlined in the Emergency Response and Biohazard Exposure Control Plan and the Radiation Safety Program, respectively.

3.2.1 Small Chemical Spills

- Small spills involving chemicals you are familiar with can be safely handled within the laboratory.
- All spilled material must be collected, labeled, and stored for disposal by EHS.
- Safely store spill related debris in a chemical fume hood and contact EHS to request a waste pick up.
- All spills and near misses should be reported to EHS by emailing ehs@dartmouth.edu and describing the incident.

3.2.2 Large or Uncontrolled Chemical Spill

- Notify everyone in the room (or area) that a spill has occurred.
- Eliminate potential ignition sources, such as lights, motors, or open flames.
- Leave the room (or area) immediately and close the door behind you.
- Secure the area and prevent others from entering.

Call **603-646-1762** to report the spill to Dartmouth College EHS.

On weekends and after hours, call Safety and Security at **(603) 646-4000** (***For Emergencies, call 911 or 603-646-3333)***

During the call:

1. Give the following information:
    a. State your name.
    b. Exact location.
    c. Chemical spilled.
    d. And any special circumstances.
2. Provide the telephone number where you can be reached.
3. Remain nearby if possible until help arrives.

Do not re-enter the area until the appropriate authorities give permission.

3.3 First Aid for Chemical Exposure to the Skin or Eyes

- Go to the nearest eyewash station or safety shower.
- Remove contacts if possible.
- Flush the contaminated area with large volumes of water for at least 15 minutes.
- Have someone call 911.
- While flushing, remove any clothing that may have been contaminated.
- Continue flushing until the fire department arrives.
- Provide the SDS of spilled chemical(s) to EMS/emergency room personnel.

3.4 First Aid for Chemical Exposure Via Inhalation

- Remove the person to fresh air.
    - If the person is responsive, ask them to take slow, deep breaths.
- Call 911.

3.5 Mercury Spills

Dartmouth College has worked to eliminate/reduce mercury on campus for years and continues to try and reduce the volumes further. Mercury is an environmental pollutant and a neurotoxin to humans. The extent of mercury exposure in humans depends on several factors: the form of mercury, the amount of mercury, the age of the person exposed, the length of exposure, how the person was exposed, and their overall health before exposure. In addition, improper disposal and/or unrecognized or unreported releases of mercury are a threat to the community and can lead to significant regulatory consequences for the College. As a generator of hazardous chemical waste, Dartmouth has an obligation under federal and state regulations and to the community to reduce the volume and quantity of mercury waste generated on campus.

Principal Investigators and researchers are responsible for identifying mercury containing devices in their laboratory that should be eliminated (e.g., thermometers, barometers, manometers). Whenever a non-mercury alternative is available, it should be used. EHS has non-mercury replacement thermometers for a common temperature range. EHS can also assist with trying to find non-mercury versions for unique ranges. EHS will dispose of mercury thermometers at no cost. EHS can also assist with the disposal of any other mercury containing device.

Where no acceptable alternative for a mercury containing device is available or viable due to cost, EHS will work with the lab to manage the mercury containing device to reduce the chances of spillage. This could be in the form of secondary containment, shielding, padding, improved storage options, and the like.

If an elemental mercury spill occurs:

1. Notify all occupants in the area.
2. Evacuate the immediate space.
3. Close off access to the area and label it "Do Not Enter."
4. Call EHS for mercury clean-up at 603-646-1762.

Mercury vapor can be created by heating or agitation, but will settle over time. Air monitoring with a mercury vapor analyzer is required before any remedial mercury work.

3.6 Medical Consultation

Medical consultation and evaluation are available to Dartmouth College employees upon request. Contact EHS to discuss potential occupational exposures or to request a consultation with a doctor through the Occupational/Employee Health Program located at Dartmouth-Hitchcock Medical Center (DHMC)

In general, medical follow-up is required:

- Following acute chemical exposure.
- When signs or symptoms develop associated with exposure(s) to chemicals used in the laboratory.
- When chemical exposure monitoring data reveals an exposure at or above the action level for an OSHA regulated substance.

3.7 Special Note on Pregnancy

Personnel who are pregnant or considering becoming pregnant may have special concerns about working with hazardous materials that have potential reproductive hazards. Such concerns can be discussed with their supervisor and EHS. All inquiries are confidential. Pregnancy disclosure is not mandatory, but EHS encourages early consultation (first trimester) with a medical professional.

3.8 Procedures for Power Outages or Service Interruptions

If the power in your lab should be interrupted for any reason:

- Immediately stop all work.
- Seal all chemical containers.
- Shut off or unplug equipment.
- Lower all chemical fume hood sashes.

Local ventilation will not work or may be diminished, so if there is potential for generating toxic airborne contaminants, immediately exit the lab and contact EHS.

The building should have emergency power for a few essential services, but this is not intended to allow continued use of the lab. For your own safety, secure all reactions, containers, and equipment, close the doors, and leave the lab.

Take special care with potentially unstable reactions requiring cooling water and any work involving a glove box, pyrophoric/water reactive, or temperature sensitive chemicals. Contact EHS if you have concerns about potentially long-term power interruptions and the stability of your chemicals or reactions.

4 Requirements and Responsibilities

Understanding each person's role is important to ensure a safe laboratory environment. Your department, principal investigators, lab safety supervisors, laboratory personnel, facilities staff, and EHS all share responsibility for laboratory safety. Each section below will explain the processes to set up a lab and the requirements to keep it running safely.

4.1 Requirements for Laboratory Safety

- The safety of all laboratory workers (including undergraduates, visitors, or others) is ultimately the Principal Investigator's (PI) responsibility.
- The PI or designee must inform all laboratory workers of the hazards of their work and provide appropriate training and personal protective equipment **before** the work begins. This training should be specific to the materials used (review SDS, etc.) and the processes/physical hazards employed (heat, pressure, glassware handling, etc.).
- Document all training with the date, location, trainee signature, and outline of the material covered. Keep these records in the laboratory for audit or review. (See Appendix C)
- All work with hazardous materials or processes must be adequately supervised. Researchers must never work alone or without detailed procedures and instructions.
- In addition to training and supervision provided by the principal investigator, all new researchers must complete appropriate EHS training programs in basic laboratory safety and waste management found here.

- Work with ionizing radiation requires Radiation Safety Committee approval and compliance.
- Work with biological hazards must comply with the Institutional Biosafety Committee requirements and approval.
- Inform facilities personnel, other non-laboratory workers, and any outside contractors of potential lab-related hazards when they are required to work in the laboratory environment. Potential hazards should be identified and minimized to provide a safe environment for repairs and renovations.
- All laboratory personnel must abide by the minimum requirements outlined in the Dartmouth Laboratory Safety Manual, by EHS, and by their school or department.
- Safety begins at the bench. Minimize clutter and put away chemicals and equipment when not in use.
- All laboratory personnel must wear assigned personal protective equipment and follow the waste disposal requirements set forth by EHS.
- Review Safety Data Sheets (SDS) for any chemicals they are not familiar with.
- Promptly report accidents or unsafe conditions to the PI or EHS.
- If you have questions regarding chemical safety, please ask EHS for help.

4.1.1 Additional Requirements for Research Involving Hazardous Materials

There are additional requirements for the use of radioactive materials, biological agents (including recombinant or synthetic nucleic acids), controlled substances, carcinogens, reproductive toxins, and substances with a high degree of acute toxicity. These requirements are set forth by either federal, state, local, College, or departmental policy.

- Minimize the amount of and safely store flammable, pyrophoric, corrosive, and reactive chemicals when not in use. Laboratory personnel should contact EHS to dispose of excess chemicals.
- OSHA regulations include additional requirements for carcinogens, reproductive toxins, and substances with a high degree of acute toxicity. Researchers who use such chemicals must consider special containment devices, decontamination procedures, and restriction of use to designated areas.
- PIs must understand and follow radioactive material ordering, receipt, storage, use, and disposal responsibilities and ensure laboratory members also understand these requirements. Visit the EHS homepage or contact the Radiation Safety Officer for more information.
- PIs who possess or use any biological materials in their research, including recombinant or synthetic nucleic acid molecules, must obtain approval from the Institutional Biosafety Committee (IBC) before ordering materials or beginning work. See the EHS website or contact the Biological Safety Officer (BSO) for more information.
- PIs that wish to use or possess select agents or select agent toxins must first notify EHS and follow additional security requirements. Use and possession of select agents or select agent toxins require prior approval by the IBC. For more information, contact the Biological Safety Officer.
- PIs whose research involves blood and other potentially infectious materials must complete the required training before beginning work.

- PIs whose laboratories work with recombinant DNA must submit protocols to the Institutional Biosafety Committee to ensure compliance with the National Institutes of Health (NIH) Guidelines for such research.
- Faculty, staff, and students who are pregnant, think they may be pregnant, or are planning a family, and may potentially be exposed to chemical reproductive toxins, radioactive material, or other ionizing radiation, may voluntarily contact EHS for counseling, evaluation, and exposure monitoring. For more information, contact EHS.
- The U.S. Department of Transportation (DOT), the Federal Aviation Administration (FAA), and the International Air Transport Association (IATA) require training for employees preparing hazardous materials for shipment. Regulated hazardous materials include radioactive material, infectious substances, fixed tissue, biologicals in alcohol solutions, dry ice, formalin, unknowns, and other chemicals.
- Hazardous materials must have appropriate security to prevent accidental exposure, unauthorized access, and theft. Radioactive materials, select agents, controlled substances, and drug precursors require additional security controls. Keep these substances in locked storage. **Lock laboratories when not occupied**. Laboratory personnel should keep an inventory of these materials to detect unauthorized removal. Notify Safety and Security of theft or the presence of unfamiliar or unauthorized personnel.
- Laboratory personnel can request a chemical or radioactive material waste pickup from the laboratory at no charge by doing the following:
    - Chemical waste – send a note to ehs@dartmouth.edu
    - Radioactive waste – via BioRAFT https://dartmouth.bioraft.com/
    - **Disposal in the normal trash, drain, or sewer is strictly forbidden.**
    - Contact EHS with further questions.

4.2 Responsibilities

4.2.1 Department Chair

- Ensure the department's ongoing compliance with health and safety standards.
- Assist EHS with compliance issues that must be addressed immediately and assist EHS in rectifying repeated compliance issues within specific labs.
- Provide early notification to EHS regarding new arriving faculty for laboratory hazard planning and preparation.
- Provide notification as early as possible to EHS before termination or retirement of faculty who use hazardous materials to expedite laboratory clearance for the next investigator.
- Ensure that faculty are moving or leaving their assigned laboratories and assist with identifying and removing hazards as necessary.

4.2.2 Principal Investigator (PI)/Course Professor

Responsible for the implementation of laboratory requirements:

- Set up a new lab profile in BioRAFT by contacting EHS at ehs@dartmouth.edu.
- Identifying hazardous conditions or operations in the lab.

- Establishing safe standard operating procedures (general and protocol-specific), which may require literature searches for safe practices appropriate for the work.
- Ensure that laboratory personnel meet the training requirements of the Laboratory Standard, including chemical hazard information, safety rules, and good work practices.
- Obtaining prior approval for use of high hazard chemicals or operations in the laboratory from EHS. (See Appendix E)
- Consulting with laboratory personnel on using higher-risk chemicals, such as particularly hazardous substances or highly reactive chemicals, or conducting higher-risk experimental procedures so that special safety precautions may be taken.
- Providing laboratory personnel under their supervision access to the Laboratory Safety Manual and any individual Laboratory Safety Plan.
- Complete a Laboratory Safety Plan for the laboratory (See section 6)
- Training laboratory personnel they supervise to work safely with hazardous chemicals while maintaining records of such training.
- Enforcing personnel protective equipment needs and requirements for staff and visitors.
- Immediately report laboratory accidents and injuries to Risk Management and EHS within 24 hours.
- Making available required medical surveillance, consultation, or examination of laboratory personnel. Students should contact Dick's House, and employees should contact Occupational Health at Dartmouth-Hitchcock Medical Center. (See section 3.5)
- Conduct an "exit interview" with laboratory workers before their departure to ensure that they have properly labeled and prepared hazardous materials for disposal by EHS or use by other workers.
- Notify EHS before vacating laboratory space or when moving the lab, and notify the department chair and EHS of planned departure from Dartmouth or discontinuance of the use of hazardous materials. Decontaminate laboratory surfaces and prepare hazardous materials for disposal by EHS or use by other laboratories.

4.2.3 Laboratory Supervisor

- Ensure that laboratory personnel meet the training requirements of the Laboratory Standard, including chemical hazard information, safety rules, and good work practices.
- Provide initial training to laboratory personnel upon employment on the contents of the Laboratory Safety Manual.
- Ensure that staff and visitors observe safety rules and don proper Personal Protective Equipment (PPE) when working in or visiting the laboratory.
- Ensure that proper safety supplies and equipment, such as gloves, safety glasses and/or goggles, lab coats, etc., are available for all people in the laboratory. *Note: if you believe a respirator may be required, contact EHS for consultation before purchase*
- Obtain safety data sheets or direct laboratory staff on where to find SDS (e.g., CEMS) for hazardous chemicals used in the laboratory and make these available to the laboratory staff.
- Post appropriate hazard information signs within the laboratory.
- Provide information to EHS in a timely manner so that it may post appropriate signage at laboratory entrances.

- Conduct an "exit interview" with laboratory workers before their departure to ensure that they have properly labeled and prepared hazardous materials for disposal by EHS or use by other workers.
- Notify EHS one month prior to vacating laboratory space or when moving the lab, and notify the department chair and EHS of planned departure from Dartmouth or discontinuance of the use of hazardous materials. Decontaminate laboratory surfaces and prepare hazardous materials for EHS disposal. (Refer to EHS Lab Move/Closure Guidelines – Appendix J .)

4.2.4 Laboratory Personnel

- Read the Laboratory Safety Manual for relevant safety information and other information provided by your supervisor.
- Complete applicable required training provided by EHS or assigned by your PI.
- Understand the risks of each hazard you will be working with in the laboratory and how to handle a small spill of hazardous material.
- Follow safety guidelines when handling hazardous materials, including the proper use of personal protective equipment.
- Notify EHS of accidents, spills, or conditions that may warrant further investigation and/or monitoring.
- Review laboratory materials to ensure that you have properly labeled and prepared all hazardous materials for disposal by EHS or use by other workers before you leave the research group.
- Follow all instructions in standard operating procedures or protocols for specific hazards found in the laboratory.
- If you feel you require more training or have any questions, please contact EHS.

4.2.5 Environmental Health & Safety (EHS)

- EHS is responsible for developing, periodically reevaluating, and ensuring the effectiveness of the Dartmouth College Laboratory Safety Manual.
- Provide appropriate and required safety training for laboratory personnel.
- Investigate potential safety and health hazards identified by laboratory employees.
- Monitor personnel for over-exposures to chemical, biological, physical, and radioactive hazards.
- Advise laboratory personnel on proper disposal of waste chemicals and other hazardous materials.
- Consult with faculty, staff, students, and safety committees on safety matters.
- Post appropriate signage at laboratory entrances.
- EHS provides support and technical assistance in safely using, storing, and disposing of hazardous chemicals.
- EHS annually hires a third party to test each chemical fume hood and certify its performance to ensure it works as designed.
- Lab audits will be performed regularly. These audits cover all aspects of laboratory safety and are designed to help the lab follow proper safety precautions and protect the well-being of all who enter the laboratory. (See Appendix B for a Lab Inspection Checklist)
- For more information, please visit the Environmental Health and Safety homepage.

4.2.6 Facilities and Maintenance

- Facilities/Maintenance is responsible for maintaining and repairing building systems, including ventilation, plumbing, electrical, life safety, and structural components.
- Laboratory equipment is not considered part of the building, except for chemical fume hoods and gas cylinder cabinets, which are integrated into the ventilation systems.
- Please note that if facilities personnel are requested to enter a lab space for maintenance or repair of a building system, the laboratory space must be safe to enter. If the personnel do not feel the space is safe, they can refuse to enter until it is made safe.
    - Hanover Campus - Please visit their website for more information or to complete a Service Request Form.
    - Geisel Hanover and Borwell Campus – contact Geisel.facilities@dartmouth.edu or call 603-646-5345.

4.3 (Reserved) The Dartmouth College Chemical Safety Committee

The Chemical Safety Committee comprises faculty and staff representatives from the different schools and departments and is responsible for general oversight of Dartmouth College's chemical safety program. The committee serves as a peer review mechanism for faculty who wish to use high hazard chemicals or procedures and will meet biannually.

For more information on the Chemical Safety Committee, please contact the Chemical Hygiene Officer at 603-646-1762.

5 Laboratory Safety

The laboratory safety section introduces the basic ideas of hazard and risk and how researchers can work to minimize or control their exposure to each. Protecting ourselves from harm follows a process to reduce those risks and hazards. Training is discussed, which plays a central role in our understanding of potential hazards around us and how we can protect those in research from potential harm.

5.1 Basics of Laboratory Safety

With regard to safety, the terms hazard and risk are not interchangeable.

- A *hazard* is the inherent danger in a material or system intrinsic to a substance or operation.
- A *risk* is the probability of an injury occurring when working with a hazardous material or laboratory operation.

Safety management aims to eliminate all hazards that *can* be eliminated, and for those that *cannot* be eliminated, determine the best way to adequately reduce, control, and monitor their risk.

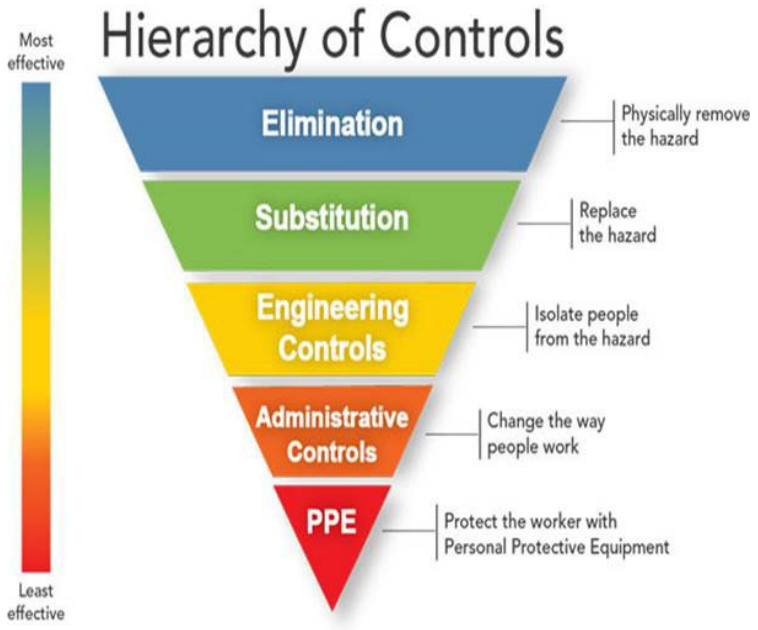
5.1.1 Hazard Assessment

A hazard assessment process is important to determine the hazards in your lab and what precautions must be taken. Some questions to consider are the following:

- Does your lab work primarily with chemicals, biological agents, radioisotopes, or some combination?
- Are the lab workers undergraduates, graduate students, or professional techs?
- Does your lab work involve animal handling?
- Are large quantities of flammable materials (>4 liters) used in a process or experiment?
- Are there water reactive or pyrophoric materials used in the open air (e.g., in a fume hood instead of a glove box)?
- Are there open flames or hot processes along with a significant number of flammables?
- How are hazardous chemicals used, and what engineering controls are available (e.g., a fume hood or glove box)?
- Is there a significant risk of spill, splash, or splatter for the tasks?
- What is the toxicity of chemicals used, and is there concern about inadvertent spread of contamination?

5.2 The Hierarchy of Safety Controls

NIOSH defines five rungs of the Hierarchy of Controls: elimination, substitution, engineering controls, administrative controls, and personal protective equipment. The hierarchy begins with the most effective controls and proceeds to the least effective. PPE is the last line of defense in controlling risk. It is important to understand this hierarchy of safety controls and use them as the basic framework for planning any laboratory work or experiment.



5.2.1 Elimination

Eliminating hazardous substances, processes, activities, or equipment in the laboratory is the safest control method to protect employees. Consider all aspects of your process and determine if any portion of the experiment could be eliminated for a less hazardous operation/chemical.

5.2.2 Substitution

Search all options to find a less hazardous substance that can provide the same results for your experiment. Often, newer materials and methods have replaced the need for more toxic chemicals or radioactive materials. Talk to other researchers or do a literature review to see if other comparable materials can be used. Remember, less hazardous does not necessarily mean hazard free. Investigate the potential hazards or disposal concerns of any substitution material.

5.2.3 Engineering Controls:

- Laboratories, where hazardous, infectious, and/or radioactive materials/sources or physical hazards exist, must have provisions for restricting access by unauthorized persons.
- Hazardous chemicals may only be used in laboratory facilities specifically designed and engineered for such work. They may not be used in areas not intended for such use, including (but not limited to) offices, storage rooms, shared equipment areas, cold rooms, and other areas lacking the appropriate infrastructure and a proper means of ventilation.
- Use a chemical fume hood when opening, pouring, or handling chemicals or substances that would otherwise enter the atmosphere without containment. Confirm the hood is flowing properly before use. Hoods are certified for flow by a third-party contractor annually. Fume hoods should be uncluttered with minimum necessary sash opening, user movements should be slow, and the first six inches inside the sash should be clear. These allow for proper airflow and containment. Sashes should be kept closed when not in use.

- Containment and ventilation should be the primary method to prevent inhalation and control flammable vapors. You are responsible for reporting issues that arise (malfunctions, alarms, or evidence of failure) to facility maintenance personnel.

5.2.4 Administrative Controls:

- Each PI/laboratory supervisor must ensure that all laboratory personnel under their direction possess the requisite knowledge, training, and education to handle hazardous chemicals in the laboratory safely.
- All laboratory personnel are responsible for following appropriate work practices when using hazardous chemicals.
- Avoid working with hazardous chemicals alone or at night when assistance and emergency response capabilities are limited. Use a partner system and work only with the approval of the PI or faculty member directing the research.
- Implement a standard operating procedure (SOP) for work with high hazard chemicals.
- **Food, drinks, cosmetics, and medication for consumption or use are prohibited inside laboratories where hazardous chemicals are used or stored.**
- Keep members of the lab current in BioRAFT; remove access when personnel no longer work in the lab. Access to the Chemical Environmental Management System (CEMS – chemical inventory) is available upon request to EHS.

5.2.5 Personal Protective Equipment:

Personal protective equipment (PPE) is a vital means of worker protection, but it should be used in combination with fume hoods, safety shields, and work enclosures. Respirators (N95, filter cartridge style, or supplied air) are only appropriate as a secondary control, and their use requires medical clearance, training, fit testing, and approval from EHS. Additional guidance on using PPE can be found in OSHA 29 CFR 1910.132, the Dartmouth College Personal Protective Equipment Policy.

Minimum laboratory attire should include, but is not limited to, the following:

1. Lab coat.
2. Safety glasses.
3. Nitrile gloves.
4. Fully covered skin: No exposed skin (e.g., tank top, shorts, etc.)
5. Fully enclosed shoes – no sandals, open-toe or open-heel shoes, etc.

Eye/Face Protection:

- Minimum protection for chemical work is impact-resistant safety glasses. Ordinary prescription eyeglasses do not qualify as safety glasses. (EHS will supply safety glasses at no cost.)
- Splash goggles (seal against the face around the eyes) are required for handling toxic or corrosive liquids in larger quantities or in high-risk systems (pressurized or aerosolized) or where there is a risk of a splash hazard.

- Face shields may be used in conjunction with goggles or glasses for additional impact and splash protection.
- Contact EHS for help with specialty eyewear for UV light, lasers, or welding. Look for the ANSI Z87+ stamp on all protective eyewear.

Note on contact lenses: Contact lenses are allowed but must be worn with the above safety eyewear. In the event of eye exposure, contacts need to be removed as soon as possible for proper flushing.

Hand Protection:

- Chemicals eventually permeate all glove materials. However, gloves are safe for limited periods if one knows the specific use and glove characteristics (thickness, permeation rate, and exposure time).
- Remove gloves before contacting "clean" areas such as food area surfaces or common equipment such as telephones, computer keyboards, and photocopiers. Do not wear gloves outside the laboratory, as you could possibly contaminate surfaces you touch, such as doorknobs, elevator buttons, or restroom fixtures.
- Disposable nitrile gloves (4mm thick) provide the minimum protection for lab-scale chemical work to a wide range of materials. The gloves provide a barrier to exposure and are single-use.
- High-risk work (involving toxic or high probability exposure scenarios) may require impervious reusable gloves; consult permeation guides to select the best glove.
- Specialty gloves (for handling cryogenic material/high heat applications or cut protection) must be used as required.
- Contact EHS if you need assistance selecting the proper type of gloves for the chemicals you handle.

Protective Clothing:

The clothing you wear in the laboratory can affect your safety.

- Do not wear loose, skin revealing (e.g., shorts, skirts) or torn clothing in the laboratory.
- Loose or torn clothing and unrestrained long hair can easily catch fire, dip into chemicals, or become ensnared in apparatus and moving machinery.
- If the possibility of chemical contamination exists, cover any personal clothing you wear home with protective apparel.
- Appropriate apparel can include laboratory coats and aprons, jumpsuits, special boots, shoe covers, and gauntlets, which can be washable or disposable.

Laboratory coats help prevent contact with dirt and minor chemical splashes or spills encountered in laboratory-scale work. The cloth laboratory coat is, however, primarily a protection for clothing and may itself present a hazard (e.g., combustibility) to the wearer. Remove your lab coat immediately upon significant contamination.

Laundry Services - Several area laundry services (e.g., Unifirst) provide routine laundering of reusable lab coats. Local dry cleaners should only be used if the lab coat is soiled from normal

everyday use and is not contaminated with hazardous materials. They generally are not familiar with the proper handling of potentially contaminated items.

Do not take lab coats home or to the laundromat for cleaning because of the potential for contamination of the home environment. Check with your department administrator/office to determine if your department already has an arrangement for laundering lab coats.

- Flame-resistant lab coats for work with solvents (required in the Chemistry department), basic lab coats, chemically resistant aprons, coveralls, and shoe covers are available in various disposable and reusable styles.
- Contact EHS if you need help selecting the proper type, and visit the scientific stockrooms to learn the types they keep in stock. (See Appendix F for lab coat policy)

Foot Protection:

- At all times, wear shoes in laboratories or other chemical use and storage areas.
- Do not wear perforated shoes, sandals, or cloth sneakers in laboratories or mechanical work areas.
- Safety shoes protect the feet against injuries from heavy falling objects, crushing by rolling objects, or lacerations from sharp edges. Safety shoes are required for employees whose job duties require the lifting, carrying, and moving of heavy objects that, if dropped, would likely result in a foot or toe injury.

Open-toe shoes are inappropriate for laboratory environments, as they offer no protection from dropped or spilled chemicals, containers, or apparatus. Wear sturdy closed-toe shoes in the laboratory.

Respiratory Protection:

- Respirators (N95, filter cartridge style, or supplied air) should not be used in the laboratory without prior approval of EHS.
- Laboratory supervisors are not authorized to select or recommend respiratory protection.
- Contact EHS or respirator@dartmouth.edu if you feel that you need respiratory protection. The selection, fitting, and use of respirators is referenced in OSHA standard 29 CFR 1910.134

(See Appendix P – Common Lab PPE Reference Guide [Courtesy of UC Santa Cruz])

(See Appendix Q – Laboratory PPE Hazard Assessment [Courtesy of University of Washington])

5.3 Emergency Eyewashes and Emergency Showers

Emergency eyewash and safety showers must be within a 10-second travel distance and not more than 75 feet from where toxic chemicals are used. These facilities must be on the same level as the chemical area; there can be no stairs or ramps between the hazard and the eyewash and/or safety shower. For ease of use, handheld drench hoses in laboratories need a hands-free lock feature. Units must be plumbed units that meet the ANSI Standard Z358.1.

Field Operations

Some field operations and locations where plumbing connections are unavailable might require a non-plumbed unit (self-contained with a reservoir). Do not use these non-plumbed units in areas where plumbed units can be installed.

Non-plumbed units are more difficult to maintain. Their solutions require frequent changes per the manufacturer's instructions. Because most non-plumbed units do not have a significant reserve capacity, you must refill them after every use or test to ensure they maintain the required minimum flow and duration.

Eyewash Bottles

Personal eye flush squeeze bottles do not meet ANSI requirements because they cannot deliver the required minimum flow rate and duration. EHS discourages the presence of these bottles in your lab because they have a limited shelf life, are prone to contamination, and are ineffective at dual-eye or eye-face irrigation.

Drench Hose

Eyewash

Shower

Lab lities

group is respon g that emergency ies, both
oratory space a common areas, onal and

es at least once onds of eyewash es water

pressure and flushes rust, scale, and other debris out of the system.

3) Perform these checks on all eyewash facilities that your research group might use, even if the facilities are in common areas outside the group's lab room(s).
4) After the weekly check, ensure that water does not remain on the floor to create a slip hazard for personnel. This is an especially important consideration for eyewash facilities in common corridors lacking floor drains. For these facilities, use buckets, secondary containment trays, or other collection devices to prevent water discharge directly onto the floor.

Building Facilities

Facilities are responsible for performing annual testing on safety showers and have the equipment necessary to contain, collect, and clean the large volume of water discharged by a safety shower test. Research groups should NOT flush emergency showers. These are only to be used in an emergency.

In the event of an exposure

Follow these steps in the event of an exposure. Everyone needs to read and understand this process, as you may be a victim or be present and need to assist another person.

Eyewashes:

1. Get to or assist the victim in finding the eyewash. Sight may be impaired. Remove contacts if possible.
2. Activate the unit using the hands-free valve.
3. Hold the eyelids open with your fingers if necessary.
4. Place the eyes in the stream of water.
5. Flush for 15 minutes.
6. Get medical attention. Have someone call 911.
7. Provide the SDS of spilled chemical(s) to EMS/emergency room personnel.

Emergency Showers:

1. Get to or assist the victim to the shower. Sight may be impaired. Remove contacts if possible.
2. Activate the unit using the hands-free valve.
3. Put modesty aside. Remove contaminated clothing first, if possible. (Rinsing contaminated clothing will wash chemicals out of the clothing and onto the skin). If this is not possible, remove contaminated clothing during the flushing process.
4. Flush for 15 minutes.
5. Get medical attention. Have someone call 911.
6. Provide the SDS of spilled chemical(s) to EMS/emergency room personnel.

Test Failures, Malfunctions, and Deficiencies

Corrective actions must be performed when any personnel notes deficiencies at any time. Malfunctions or deficiencies noted during periodic activations, inspections, or normal daily activities must be reported immediately to Facilities or EHS. Inform your supervisor.

If the use of the equipment is not possible, tag the unit "DO NOT USE." The supervisor must notify Facilities or EHS for repair or replacement. Annual test failures must be corrected immediately. Malfunctions will be reported to supervisors and facility managers.

(See Appendix O for the College Emergency Eyewash and Shower Procedure)

5.4 Sharps Safety

Sharps are defined as items capable of causing percutaneous wounds or breaks in the skin. Examples of sharps include hypodermic needles, syringes, surgical needles, Pasteur pipettes, scalpels, capillary pipettes, razor blades, contaminated (with biohazardous materials or chemicals) glass slides, cover slips, and broken glassware.

Understand Risk

Sharps can be contaminated with human materials such as viral vectors, cancer cells, pathogenic agents, or biological toxins. In some applications and uses, they may also be contaminated with hazardous chemicals such as solvents and corrosive materials. It is important to understand how sharps are used to avoid potential injury.

Reduce Risk

- **Substitute** plasticware for glassware whenever possible.
- **Limit the use of sharps** to when no other alternatives are available.
- **Use Luer Lock** – Use Luer lock syringes and needles or units where the needle is integral to the syringe to prevent the needle from slipping off.
- **Use Safety Engineered Sharps** – When possible, use safety engineered sharps. These sharps have built-in safety features like retractable needles or sheaths that cover the needle or scalpel when you're done.

Best Practices

- **Lock them up** – Stocks of needles and syringes, even if stored separately, should be under lock and key when not used.
- **Keep in Full View** - when in use, sharps always need to be kept in full view, and if possible, only one should be handled at a time.
- **Keep Sharps Containers Within Arm's Reach** - Dispose of sharps directly, without manipulation, in an approved sharps disposal container (i.e., do not bend, shear, break, recap, or use hands to remove needles from syringes or blades from scalpels). Maintain sharps disposal containers within arm's reach.
- **Safe transport** – Use secondary containers to transport your sharps from Point A to Point B, particularly in public areas.
- **Understand proper waste streams** – Syringes and needles must be disposed of in designated red sharps containers. These containers can be purchased in the Remsen or Borwell Scientific Stockrooms.
- **Use cork, foam, or a cushion for storage of repeated use sharps** – This will avoid potential recapping injuries and prevent accidental needle sticks.

Things to Avoid

- **Do not recap** –Recapping needles is one of the easiest ways to have a needlestick occur accidentally. However, if recapping must be done:

    - ***Consult with your PI and EHS before using a recapping method.***
    - ***Use one of the following two methods:***

        - 1) One-handed scoop technique or
        - 2) Use forceps or tongs to place the cap on the needles

Place cap on hard flat surface. Slide syringe needle into cap.

Scoop cap up with syringe needle so that cap is sitting on needle.

Using a hard flat surface, press cap onto needle until cap snaps into place.

- **Alternatives to Recapping** - Rather than recapping the needle or leaving a scalpel exposed, place it in a clean conical tube if it needs to be set down.
- **Do not clean up spills or broken glass with your hands** - Handle broken glass or other sharps with a secondary device such as forceps, crucible tongs, pieces of cardboard, or broom and dustpan- not your hands.
- **Do not guess** – Follow the Hazardous Waste Disposal Guide to determine if your sharps waste should be disposed of as a biohazard or a chemical hazard.
- **Do not bag it** – Never place sharp objects in a bag, which can poke through, cause leaks, or poke someone.

5.5 Training

EHS provides online basic laboratory safety and hazardous waste management training covering safe handling and disposal of hazardous materials. This training can be found at https://dartmouth.bioraft.com. Classroom training is provided per request. The PI and/or laboratory supervisor are responsible for providing health and safety information to his or her staff on the specific hazards found in their laboratory on an ongoing basis. Documentation of this activity should be kept in the lab (See Appendix C for a sample training sign-in).

Specific training requirements may need to be met depending on the type of work your lab does. Researchers must take Lab Safety and Hazardous Waste training as the baseline.

Training requirements:

Course	Who	Frequency
Laboratory Safety and Hazardous Waste Training	All researchers.	**Initial & every 3 years**
Biological Safety Training	All researchers working with potential biohazards.	**Initial & Annual**
Biological Materials and Dry Ice Shipping Training	All those needing to ship biological materials.	**Initial & every 2 years**
Laser Equipment Safety Training	All those working with class IIIB and IV lasers.	**Initial & Annual**
Radiation Safety Training	All those working in a radiation use laboratory.	**Initial & Annual**
X-ray Equipment Safety Training	All those working with or around X-ray equipment.	**Initial & Annual**
NMR-MRI Training Course	All those working in an NMR-MRI facility.	**Initial & Annual**
Handling Pyrophoric Materials	All those working with pyrophorics.	**One time**

The hazard communication training module on BioRAFT is designed to provide non-research support staff with training on basic chemical hazards, safety data sheets, selection of personal protective equipment, and emergency response initiation (awareness level training) for work in and around lab facilities. The academic and research community must communicate potential health hazards to any individual working in your area. Facilities supervisors evaluate specific tasks and may require additional training or specialized contract personnel.

5.6 Minors, Volunteers, Visitors, and Undergraduates in Laboratories

Please visit the Office of General Council website for details on interactions with minors.

Enabling minors, volunteers, visitors, and undergraduate students to work in our research laboratories is an important part of research and teaching. It is imperative that these minors, volunteers, visitors, and/or undergraduate students be kept safe and healthy in their work.

Any minors, volunteers, visitors, or undergraduates planning to work in a Dartmouth College laboratory must complete training before starting work in the lab. The Principal Investigator will determine what training is needed with assistance from EHS.

No minor (unless the minor is a Dartmouth student who has received the necessary training) shall be present during any activity with potential exposure to hazardous materials.

Before allowing high school students or minor visitors to tour or observe in a lab, the supervising employee must conduct a basic safety orientation, including both general safety information and any hazards particular to the lab in question.

A minor is anyone meeting all the following criteria:

- Under 18 years of age.
- Not currently enrolled as a full-time student at Dartmouth College.
- Participating in an internship or short-term program with a laboratory component.

5.6.1 Minors under 12

- May not be present in a laboratory unless they are part of a PI-authorized and supervised tour/visit.
- The PI or designated supervisor will be responsible for proper supervision and providing proper personal protective equipment (PPE) for visitors.
- Laboratory tours may only be conducted when all hazardous materials are properly stored and are not being used for experiments.
- Youth participating in tours/visits must always be supervised and may not participate in laboratory activities.

5.6.2 Minors 12-17

- May participate in a registered Dartmouth academic program.
- Must have written consent from a parent/guardian.
- Must receive general lab safety training.
- Must be trained in the specific hazards to which they will be exposed and adhere to laboratory-specific requirements concerning PPE.
- Must be under the direct supervision of a designated qualified adult.

5.6.3 Visitors in Laboratories

Visitors include anyone other than Dartmouth lab staff, students, or faculty, as well as custodial, maintenance, administrative, and Environmental Health and Safety personnel. It also includes family members and visitors from outside the College, including visiting students and researchers. To protect the visitor and Dartmouth, the following guidelines for visitors to laboratories will be followed:

- No person under 18 can visit a laboratory without prior approval and supervision.
- All visitors must always be escorted and supervised by laboratory personnel while the visitor is in the laboratory.
- Visitors to the laboratory are expected to follow the exact same requirements as the laboratory workers regarding personal protective equipment (PPE), proper dress, food and drink, etc.
- A student or other person regularly visiting the lab (e.g., visiting researcher), even if just as a volunteer, must follow all laboratory personnel requirements (See section 4.2.4), including training requirements.

5.6.4 Visitors 12 to 18 years of age

Must be under the direct supervision of a Dartmouth College employee who is knowledgeable and trained in the hazards of the laboratory. Visitors between 12 and 18 may be present as observers only.

5.7 Working Alone

Working alone should be avoided. Working with hazardous materials and equipment always poses risks to researchers' health and safety. Whenever possible, laboratory and instructional shop personnel should avoid working alone when conducting research/work, especially when experiments involve hazardous substances, procedures, or equipment. These risks are heightened when working alone because help is not readily available in the event of an incident.

To reduce the risks of working alone:

- Working alone, especially after hours, should be avoided whenever possible.
- Reduce the amount(s) of hazardous materials used.
- Conduct a Hazard Assessment of the work performed and the risks and emergency requirements for working alone or after hours.
- Have a phone immediately available and be in contact with another person (who knows that he or she is being relied upon) at least every 30 minutes.
- Know the location of, and maintain clear access to, emergency equipment (e.g., safety shower, eye wash, fire extinguisher)
- Check alarm systems (e.g., oxygen sensors) frequently and immediately act upon alarm activation.
- Implement a buddy system. Individuals working in separate laboratories/instructional shops outside of working hours should make arrangements to check on each other periodically.

While Dartmouth acknowledges that working alone is sometimes necessary, specific safety concerns need to be addressed. In Appendix A of OSHA standard 29 CFR 1910.1450, the National Research Council (NRC) recommends the following in terms of working alone in the laboratory:

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

Tasks requiring PI approval before working alone:

Some tasks require PI approval before being performed alone, including:

- Work with certain hazardous materials:
  - Cryogens (e.g., liquid nitrogen, liquid helium).
  - Pyrophoric and explosive materials.
  - Highly reactive materials (e.g., strong oxidizers, acids, bases).
  - Hydrofluoric acid.
- Transferring large quantities of hazardous materials (e.g., >5L)

- Procedures that may create hazardous conditions (e.g., oxygen deficiency), or adverse outcomes if not well-controlled (e.g., exothermic polymerization).
- Work around high voltage.
- Machine shop activities.
- Work involving high-pressure equipment.
- Use of class IIIB and IV lasers.

If you perform an essential lab function that requires one of these tasks, consult with your Principal Investigator or Laboratory Supervisor to implement appropriate controls, including a buddy system.

Responsibilities:

It is the responsibility of P.I.s, laboratory managers/supervisors to ensure that procedures for working alone are developed and followed by personnel working in laboratories and under their supervision. The P.I. shall be aware of all work being performed in the laboratory at all times.

P.I. and Manager Responsibilities:

- Review all workspaces under their control.
- Identify individuals required to work alone.
- Identify hazard(s) and assess risk(s).
- Take any necessary steps to eliminate the hazard(s).
- Eliminate the hazard(s) and minimize the risk(s) from the hazard(s) by using engineering. controls, administrative controls, or a combination of the two controls.
- Develop a site-specific working alone policy and procedure to address the risk(s).
- Communicate the site-specific working alone policy and procedure to all personnel.
- Ensure understanding and compliance with the policy and procedure.
- Annually review the site-specific policy and procedure.
- Maintain documentation of the site-specific working alone policy and procedure.

Buddy System:

A buddy system can reduce the risk of certain tasks by ensuring that another person can seek help if someone is injured or incapacitated during their work. There are several methods to implement a buddy system.

- *In-person buddy*: Another person within the same lab.
- *In-building buddy*: If there are others in your building conducting critical tasks, you may coordinate to serve as each other's buddies. Check in with one another regularly (e.g., every 15-30 minutes).
- *Remote buddy*: Using video conferencing tools or a phone call, a researcher can have a buddy aware of their status live but not present in person. The second option is for the researcher to tell their buddy where they are working, when to expect to check in, and what to do if they do not check in at the appointed time.
    - *Prior to designating a remote buddy, tell them where you are working (building and room number), when you are working, when you will check in, and what to*

do if you do not check in on time. If you do not check in, you may instruct your buddy to call you, call a roommate, or call an appropriate authority, such as your PI.

5.8 Unattended Operations

The operation of laboratory equipment overnight or otherwise unattended is strongly discouraged. The risk and magnitude of fire, flood, or hazardous material release associated with such operations are greatly increased compared to similar operations under regular observation. In an emergency, such operations pose challenges for Public Safety, Facilities, and other responding personnel who may have difficulty reaching responsible laboratory staff.

Experimental procedures involving unattended equipment operation often occur in warm/cold rooms or laboratory support areas that are not regularly occupied and may involve hazardous substances like methanol-containing transfer buffer. Special attention must be paid to unattended operations in areas not normally visited by laboratory personnel; periodic visits to these spaces must be made during unattended operations to ensure that unsafe conditions have not been created. Unattended operations involving highly hazardous materials should be brought to the attention of EHS prior to commencing work.

When unattended operation of equipment is necessary, the researcher shall:

- Post a sign on the exterior laboratory door describing any unattended process that might cause a hazardous condition if experimental equipment or building services fail. The sign must include contact numbers for responsible parties should the equipment or building services fail and cause a hazardous condition while unattended. Please complete and post an Unattended Operation of Equipment Sign on all doors where unattended work and/or equipment is located.
- Ensure that all hose connections are secure, that electrical and other connections pose minimal risk of accident, and that proper drainage for operations requiring running water is provided.
- Operations that involve or have the potential to produce pressure or vacuum need to have a blast shield in place for personnel protection.
- Consult with EHS on potentially hazardous unattended operations before starting.

(See Appendix K for a template Unattended Operations Door Sign)

6 Laboratory Safety Plan

This chapter provides detailed instructions for completing and updating the various sections of a Laboratory Safety Plan. The Laboratory Safety Plan is a required document that outlines specific conditions, hazards, and controls in your laboratory spaces.

Laboratory Safety Plans are a key element of the Chemical Hygiene Plan. The Laboratory Safety Plan (LSP) aims to provide you with safety information specific to the laboratory in which you work. The annual communication of LSP contents to laboratory personnel by the Principal Investigator provides the minimum specific training required by the Laboratory Standard.

This chapter describes the required information to include in an LSP.

Preparing A Plan

Each Principal Investigator is required to prepare a Laboratory Safety Plan to supplement the Laboratory Safety Manual. The LSP needs to cover each building in which you have laboratory space. Laboratory space is any location where you use or store hazardous materials or equipment. This could include common areas that you might share with other research groups.

Instructions for Updating the Laboratory Safety Plan

Each Principal Investigator is required to update the Laboratory Safety Plan at least **annually** or more often if changes occur. Changes include but are not limited to the addition/deletion of personnel, rooms, and research processes.

6.1 Process

6.1.1 Laboratory Project Information

Provide pertinent demographic information about the Principal Investigator, including position title, department, email address, after-hours phone number, the person responsible for safety in the absence of PI, and lab phone number.

The after-hours number can be a home phone number or a cell phone number. First responders (EHS, Safety and Security, Troubleshooters, and Hanover Fire Department) will use it to contact the PI or the Safety Supervisor during an emergency after hours or on weekends.

Employee Information and Training

The OSHA Laboratory Standard requires that supervisors advise employees of chemical hazards at the time of initial assignment and whenever new exposure situations occur. The Laboratory Standard requires communicating the following information to employees:

- Location and availability of the Chemical Hygiene Plan (Laboratory Safety Manual and Laboratory Safety Plan). Printed copies are not required except for the sections of the LSP that are printed and posted.
- Location and availability of known reference material (including safety data sheets) on the hazards, safe handling, storage, and disposal of hazardous chemicals.

- Permissible Exposure Limits (PELs) for OSHA regulated substances and recommended exposure limits for non-regulated substances.
- Physical hazards and health hazards of chemicals in the workplace.
- Signs and symptoms associated with exposures to hazardous chemicals used.
- Documentation that each employee has received training from EHS on the OSHA Laboratory Standard.
- Documented annual review of the Laboratory Safety Plan for each person.

Floor Plans

It is an optional step to prepare a floor plan for each laboratory room covered by the LSP, showing the location of hazardous materials (including wastes), benches, desks, laboratory hoods, fire extinguishers, spill control supplies, compressed gas cylinders, and any other items that could be of concern to emergency response personnel. Identify each building, room, and hazard.

List all locations and indicate all hazards present for the locations. Reference the hazard list below.

- Hazardous Chemicals and Equipment.
- Radioactive Materials.
- X-Ray Equipment.
- Laser Equipment.
- Biological Hazards.
- Recombinant or Synthetic Nucleic Acid Molecules.
- Transgenic Animals or Plants.
- Shipping.

6.1.2 Hazardous Chemicals and Equipment

Each research group must prepare a summary of the types of hazardous materials stored in the laboratory to inform laboratory and emergency response personnel. Indicate the total quantity of each hazard/compatibility class. Consult the chemical inventory system (CEMS) for a list of your chemicals and their SDSs.

Laboratory Safety Procedures

The Laboratory Safety Manual (LSM) provides basic safety protocols. Each Principal Investigator must supplement the LSM with safe handling procedures, research protocols, and other safety procedures specific to his or her research group. Items you are to address include:

- Detailed procedures for handling toxic chemicals and “select carcinogens” used in the laboratory, including designation of the work area and entry restrictions.
- Identify materials and procedures restricted to laboratory hoods and biological safety cabinets.
- Designation of areas where eating or drinking is allowed, if any (also indicate areas on the floor plan)

Hazardous Waste Disposal

Describe the processes that generate hazardous waste in your lab, the waste streams generated, and estimate the amount of hazardous waste that will be generated weekly or monthly. Prepare procedures to ensure proper segregation, containment, and storage of wastes. Give special attention to avoid mixing of incompatible wastes and to ensure proper segregation.

Emergency Procedures

Prepare specific procedures for each laboratory in the event of an emergency arising outside of the laboratory, as well as those that might arise within the laboratory. These procedures should include:

- Action to prevent damage to equipment.
- Actions to prevent loss of experiments in progress.
- Actions to secure hazardous material in use when an emergency occurs.
- Chemical spill response procedures.

Personal Protective Equipment

Identify the personal protective equipment required for laboratory procedures.

- Conduct a walk-through survey of the laboratory to identify hazards for which eye, face, and hand PPE are required. Detail the specific PPE needed to be worn for tasks in the lab.
- Identify specific work areas, materials, or chemicals in the space that represent a hazard.

6.1.3 Radioactive Materials and X-Ray Equipment

To obtain authorization to procure and use radiation sources, a prospective Authorized User must submit a Radioactive Material Use Application. The Radiation Safety Officer will review the application and contact the prospective user to evaluate the facilities available, the training and experience of the applicant and staff for the proposed use, and the details of the proposed research using radioactive materials.

The procedures described in the application, as modified by the Radiation Safety Officer and/or the Radiation Safety Committee, become the conditions under which they authorize a researcher and his/her personnel to use radiation sources. The Radiation Safety Officer must review any subsequent change in procedure regarding the use, storage, or disposal of sources before instituting the change. Please read the Dartmouth College Radiation Safety Manual for more information.

6.1.4 Laser Equipment

Provide information on the laser as requested: location, laser type, manufacturer, beam characteristics, maximum output, frequency, aperture diameter, divergence, focal length, access controls, and emergency switch. List the names of the operators and training requirements. This will be done through a Laser Registration Form.

6.1.5 Biological Hazards Registration

Biological hazard registrations are completed online via BioRAFT. Complete the registration in its entirety for review by the Biological Safety Officer and the Institutional Biosafety Committee (IBC). Work may not begin until approval from the IBC.

6.1.6 Shipping

Indicate if you will ship equipment, chemicals, or biological materials from your lab. List your lab's shipping coordinator, any others who will prepare packages, the items you will send, and the destinations where you will ship.

7 Exposure Control and Environmental Monitoring:

Section 7 covers fume hoods and snorkels that draw contaminants from the work area and away from users. Best practices for the use of this laboratory equipment are presented. Environmental monitors or sensors are covered and used as needed in locations where a potential atmospheric hazard exists. Individual tips for keeping yourself and others safe from the dangers of hazardous materials are given.

7.1 Chemical Fume Hoods

Local exhaust ventilation systems such as chemical fume hoods, engineered enclosures, and glove boxes are the preferred and primary methods for controlling exposure to hazardous chemicals in the laboratory. If fume hoods and other appropriate engineering controls are used properly, the need for routine monitoring of airborne contaminants in the laboratory is likely unnecessary.

- Proper fume hood practices by laboratory personnel are critical for protection from chemical exposures. This includes the following:
    - Keeping the sash at the correct height (typically 18 inches or lower) while in use
    - Keep the hood uncluttered to ensure proper airflow.
- The fume hoods are inspected annually by a third party.
- If you notice that the hood may not be working properly, please contact facilities for repair:
    - **Hanover campus –**
        - Facilities Customer Service Center
        - facilities.center@dartmouth.edu
        - Facilities Customer Service Center 603-646-2508
        - After hours 603-646-2508

- **Geisel School of Medicine (Hanover)**
  - Geisel.Facilities@Dartmouth.edu
  - Geisel Facilities 603-646-5345
  - After hours 603-646-2344
- **Geisel School of Medicine (DHMC campus)**
  - Geisel.Facilities@Dartmouth.edu
  - Geisel Facilities 603-646-5345
  - After hours 603-650-7150, DH Pager 9234
- **DHMC Campus**
  - DHMC Engineering 603-650-7150
  - After hours 603-650-7150, Pager 9234

7.1.1 Fume Hood Best Practices

- Always check the airflow before working in the fume hood by looking at the flow monitor or testing flow with a strip of paper or Kimwipe. **Never** work in a non-functioning fume hood.
- Note if the hood has been certified for airflow within the past year by checking the inspection sticker (Generally located near the hood utility controls on the right or left)
  - If the hood does not have a current certification, contact EHS.
- Work within the hood at a sash height no greater than 18 inches. Hoods have stops at 18 inches; do not raise the sash above this height unless moving equipment in and out of the hood.
- The recommended best practice for a combination sash hood (horizontal sliding panels within a vertical sliding sash) relies on completely closing the vertical sash while working through the horizontal slides.
- Work at least 6 inches inside the hood to ensure proper capture and prevent vapors from spilling out of the hood.
- **NEVER** work with your head inside the plane of the vertical sash. Always keep your head/torso outside the hood. Working inside can expose you to the chemicals you're working with
- Maximize containment by using a hood shelf at the rear of the hood to raise materials out of the airflow path (hood shelves are available from EHS). Reduce the number of items stored in the hood to only those you are working with.
- Use the chemical storage cabinets below for chemical storage, not the hood interior.
- Minimize cross drafts, floor traffic, and excess movement around the hood.
- Remove sources of ignition from the hood when working with flammable materials.
- Lab coats and safety glasses still need to be worn even if working with chemicals inside a fume hood.

7.2 Local Exhaust (Snorkels/Cones)

Snorkels or cones are not substitutes for chemical fume hoods and do not fully surround the reaction at the point of release. Snorkels are far less effective at capturing dust, mist, or fumes and can typically only capture contaminants released within a few inches of the snorkel. Snorkels are extremely susceptible to cross drafts.

Laboratory snorkels are good for removing heat from benchtop-heated processes or as local ventilation for benchtop apparatuses such as gas chromatographs or rotary evaporators. Snorkels are also tested once a year to ensure proper airflow.

7.3 Environmental Monitoring

Atmospheric monitoring

As needed in several locations across campus, specific environmental monitoring is done via installed sensors monitoring atmospheric conditions in a laboratory. Most of the laboratory space does not require the use of environmental monitors. Only those with a recognized hazard that may potentially affect an entire room are targeted. Monitors are in use for potential conditions such as low oxygen or flammable gas/vapors.

Personal Monitoring

Personal monitoring can also be done based on the materials used for specific concerns. Contact EHS with questions about chemical specific monitoring. EHS 603-646-1762 or ehs@dartmouth.edu

7.4 Exposure and Threshold Limits

Various government agencies have determined chemical exposure levels to which an employee can be exposed for 8 hours a day, 5 days a week, without adverse health effects. These chemical limits are called permissible exposure levels or occupational exposure levels. Some chemicals have short-term exposure levels that cannot be exceeded within a 15-minute period.

In a laboratory setting, exposure to a chemical fume or vapor is often minimized with the proper use of a fume hood. The duration of chemical exposure is also limited due to the nature of laboratory work. Safety data sheets accessed through CEMS or within your lab will allow the laboratory worker to see appropriate chemical exposure levels. If there is concern over potential exposure to a laboratory chemical, contact EHS at 603-646-1762 for assistance.

7.5 Personal Controls for Hazardous Chemicals

- Complete all relevant training before handling
- Always select and wear the correct personal protective equipment (PPE) when handling hazardous chemicals.

- Protect your clothes and exposed skin with laboratory coats or gowns. Open-toed shoes, sandals, shorts, and other apparel that leave exposed skin are prohibited when handling hazardous chemicals. Lab coats must not be worn outside research areas--such as lunchrooms, restrooms, public areas, office spaces, and outside of the building.
- Keep all containers tightly closed when not in use. All waste collection containers must also be kept closed. Evaporation of hazardous chemicals is not an approved disposal method.
- Good housekeeping is mandatory in all laboratories using or storing hazardous chemicals. Ensure that all chemical spills are cleaned up promptly and safely. Dispose of old chemicals, mixtures, and solutions routinely (after each term). Keep exit routes, emergency eyewash, and safety shower access clear. Keep clutter to a minimum in fume hoods, workbenches, and on the floor. Ensure trash, recycling, sharps, and chemical wastes are promptly and properly disposed of.
- If you need to ship or transport hazardous chemicals, contact EHS for training and assistance. Never put chemicals in the mail, your personal vehicle, or College vehicles, or allow movers or contractors to handle or move them unless arranged through EHS. Concealing hazardous chemicals in the mail or shipment via air is illegal and may result in federal penalties.
- Hazardous chemicals can be safely transported within and between physically connected buildings using bottle carriers and suitable carts. Avoid riding in an elevator with cryogens, toxic compressed gases, air or water-reactive chemicals, and highly toxic or volatile materials.
- After working with laboratory chemicals, carefully remove your gloves and thoroughly wash your hands and forearms. In all circumstances, wash your hands before leaving the laboratory. Remove gloves before leaving the lab or touching commonly used surfaces like doorknobs, telephones, etc.
- Never dispose of hazardous chemicals down the drain, in the trash, or via evaporation; it is a violation of federal, state, and local regulations.

8 Fire Safety

Flammable substances (solids, liquids, gases) are among laboratories' most common hazardous materials. The main objective of working safely with flammable liquids is to avoid the accumulation of vapors and to control ignition sources. However, the ability of a material to vaporize, ignite, or explode varies with the type or class of substance.

8.1 Liquids

Flammable liquids have a **flash point** below 100°F (37.7°C) and a vapor pressure not exceeding 40 psi (276 kPa). Contrastingly, **combustible liquids** have a flash point at, or above, 100°F (37.7°C).

The ***flash point*** is the lowest temperature, as determined by standard tests, at which a liquid gives off vapor in sufficient concentration to form an ignitable mixture with air near the surface of the liquid within the test vessel. Many common laboratory solvents and chemicals have flash points lower than room temperature.

It's the vapor, not the liquid, that burns. The rate at which different liquids produce flammable vapors depends on their vapor pressure. The degree of fire hazard also depends on the ability to form combustible or explosive mixtures with air.

8.1.1 Bonding and Grounding

Hazard Overview

Flammable liquids can be ignited easily by a flame, a hot surface, or a spark generated by electricity or mechanical work. Highly volatile solvents pose the highest hazard because the vapor can reach ignition sources several feet away. If the vapor is ignited, the fire can quickly reach the bulk liquid. A flammable vapor and air mixture with a specific concentration can explode violently. Vapors are usually heavier than air and accumulate near the floor or bottom of the hood.

The flash point is the minimum temperature at which a liquid emits sufficient vapor to form an ignitable mixture with air near the surface of the liquid. So, a solvent with a flash point below room temperature is highly flammable. Flammable liquids are divided into hazard categories depending on their boiling and flash points.

Most flammable solvents defat the skin and can be harmful or toxic if inhaled.

Safe Handling

- Always wear standard laboratory PPE to avoid skin contact: Closed-toe shoes, clothes that cover the legs, safety glasses, gloves, and a lab coat. The lab coat should be flame-resistant or, at a minimum, 100% cotton. Most synthetic material quickly melts if ignited.
- Keep sources of ignition away when handling flammable liquids. Never heat a flammable solvent with a Bunsen burner or other open flame. Be aware that a laboratory has many ignition sources, such as outlets, electrical equipment, light fixtures, and static electricity build-up.
- Keep all containers of flammable solvents tightly closed when not in use.
- Use flammable solvents only in well-ventilated areas, such as a chemical fume hood, to avoid the build-up of an explosive atmosphere. Never pour large amounts while working on an open bench top, and never let flammable solvents evaporate while placed on an open bench top.

Transferring Large Amounts - Bonding and Grounding

When transferring flammable liquids from large containers (>4 L) to a smaller container, the flow of the fluid can create static electricity, which could result in a spark. Static electricity build-up is possible whether using a pump or pouring liquid. If the bulk container and receiving vessel are both metal, bond the two by firmly attaching a metal bonding strap or wire to both containers. Ground one of the containers by connecting it to a building ground.

If the receiving vessel is made of a non-conductive material such as glass or plastic, use a metal pipe or wire to ground the liquid in the receiving vessel. Also, ground any conductive surfaces in contact with the container, including the bulk vessel. Always transfer the liquid slowly, as splashing and sloshing create more static electricity.

You may safely proceed with transfers without grounding and bonding if you transfer flammable liquids from a 1-gallon (4 L) container or anything smaller. Ideally, this should be performed in a chemical fume hood, and the user must wear appropriate PPE.

When do I need to set up grounding and bonding?

If you plan to transfer flammable liquids ***from*** a medium-sized container larger than 1 gallon (4 L) and up to 5 gallons (20 L), **GROUNDING AND BONDING are REQUIRED.** *This must be performed in a well-ventilated area*, such as a chemical fume hood, and the user must wear appropriate PPE.

Contact EHS if you have questions about how to set up bonding and grounding.

8.2 Solids

The United States Department of Transportation (DOT) defines and classifies flammable solids in one of three categories (source: 49 CFR 173.124):

1. **Flammable Solid**–
   Self-reactive materials that are thermally unstable and can undergo a strongly exothermic decomposition even without the participation of oxygen; desensitized explosives also fall within this category.
2. **Spontaneously Combustible Material**–
   Pyrophoric (air-reactive) or self-heating materials will likely self-heat when in contact with air and without an energy supply.
3. **Dangerous when wet material**–
   Liable to spontaneously combust or emit flammable/toxic gas with water contact.

8.3 Gases

The DOT defines flammable gases in 49 CFR 173.115 as materials that are:

- Gases at 20° C (68° F) or less and 101.3 kPa (14.7 psi) of pressure, and:
  - Are ignitable at 101.3 kPa (14.7 psi) when in a mixture of 13 percent or less by volume with air ***or***
  - Have a flammable range at 101.3 kPa (14.7 psi) with air of at least 12 percent regardless of the lower limit.

8.3.1 Bunsen Burners

Laboratories working with Bunsen burners must adhere to the following guidelines. In case of a fire, as you are evacuating the space, pull the nearest fire alarm, close the doors behind you, and call 911.

NOTE: There are no natural gas (methane) connections for Bunsen burners in Dartmouth laboratories. Always check that the Bunsen burner you want to use is designed to run on propane.

EHS supplies free of charge Bunsen burner tubing meeting this standard:

Flexible Steel Covered with Rubber/Cloth

Prior to Bunsen Burner Use

1. Evaluate whether an alternative method may be used instead of a Bunsen Burner.
2. Wear appropriate personal protective equipment.
    a. Splash goggles or safety glasses.
    b. Lab coat.
    c. Use insulating heat-resistant gloves when handling hot items.
3. NEVER use open flames as a heat source for chemical experiments, distillation, or boiling. Use electric hotplates and heating mantles instead.
4. Read and follow the manufacturer's instructions on how to use the Bunsen burner.
5. Remove combustibles (e.g., paper, notebooks), chemicals, and waste from the area.
6. Tie back long hair, remove dangling jewelry, and secure loose clothing with tape or other means.
7. Inspect the hose for cracks, holes, pinch points, or other defects; replace or trim, if found.
    a. NEVER use Tygon, rubber, or any other non-flame-resistant tubing
8. Ensure the hose is long enough that it sits comfortably on the bench top without strain on the connections.
9. Connect the Bunsen burner to a plumbed propane gas valve.
10. Ensure the hose is securely attached to the gas fitting and the burner.
11. Do not position the burner under shelving, cabinets, or overhanging equipment.

During Use

1. Use a sparker/lighter with an extended nozzle to ignite the burner. Never use a match.
2. Never reach over an exposed flame.
3. Adjust flame to regulate air flow and to produce an appropriate flame for the experiment.
4. **Do not leave open flames unattended. Never leave the laboratory while a Bunsen burner is in use.**
5. Use tongs when holding objects in a flame and place hot objects on trivets or hot pads.
6. Never heat a closed container over a laboratory burner.
7. Never look into a test tube or container being heated. Never point the open end of a test tube being heated towards anyone.

8. Always use a laboratory burner in a fume hood if toxic chemical fumes are produced during the heating process.
9. If you smell a “sulfur” odor, shut off the gas valve.

After Use

1. Turn off the Bunsen burner.
2. Shut off gas to the Bunsen burner. Ensure that the main gas valve is off before leaving the lab.
3. Do not touch the Bunsen burner until it has reached ambient temperature.

8.4 Ignitability

The ***auto-ignition temperature*** of a substance, whether solid, liquid, or gaseous, is the minimum temperature required to initiate self-sustained combustion independent of the heat source. Diethyl ether (ignition temperature 160°C [320°F]) can be ignited by the surface of a hot plate. Silane gas (ignition temperature 21°C [69.8°F]) can spontaneously ignite at or near room temperature.

Spontaneous ignition or combustion occurs when a substance reaches its ignition temperature without applying external heat. Consider the possibility of spontaneous combustion, especially when materials are stored or disposed of. Materials susceptible to spontaneous combustion include oily rags, dust accumulation, organic materials mixed with strong oxidizing agents (such as nitric acid, chlorates, permanganates, peroxides, and persulfates), the alkali metals (lithium, sodium, potassium, rubidium, and cesium), finely divided metal powders, and phosphorus.

8.5 Fire prevention tips

Basic fire prevention

- Plan ahead, be aware, and follow safety procedures.
- No smoking
- Wear appropriate personal protective equipment (e.g., flame-resistant lab coats)
- Never work alone and have a procedural checklist.

Facilities/Building Related

- Do not wedge, prop, or tie open doors.
- Do not block doors or exits.
- Practice good housekeeping. Keep aisles clear from chemicals, bottles, pails, clothing, cardboard, etc.
- Do not allow combustible materials such as cardboard and paper to accumulate.
- Do not block emergency equipment (e.g., fire extinguishers, fire alarm pull stations, sprinkler heads).
- Sprinkler heads require 18 inches of vertical clearance below them and four feet of horizontal clearance to achieve a proper spray pattern.
- Know where emergency exits, fire extinguishers, and pull stations are located.

Chemicals

- Know your chemical inventory and dispose of outdated/unused materials.
- Limit the total volume of flammables and combustibles.
- Purchase the smallest container needed.
- Store flammables and combustibles away from heat sources in flammable storage cabinets.
- If they must be cold, store flammables in explosion-proof refrigerators. Do not store flammables in standard refrigerators.
- Keep containers capped and do not store them on the floor.
- Always work in a fume hood to control vapors.

Electrical

- Frayed or cracked electrical cords need to be repaired or replaced. Never use equipment with a damaged cord.
- Never pair extension cords and power strips together (daisy chaining).
- Extension cords may not be used as permanent wiring solutions.
- Do not overload electrical outlets or run electrical cords under carpets or through doors.

9 Hazard Communication

Hazard communication is a set of processes and procedures that employers must implement in the workplace to effectively communicate hazards associated with chemicals during handling, storage, and exposure. Dartmouth College does this through labeling, signage, and safety data sheets.

9.1 Labels

Container labels are an essential form of hazard communication in the lab and are legally required. They provide information to you, your co-workers, and emergency response personnel. It is essential that all containers in the lab have, at a minimum, a legible label to identify the contents – even if it is water or a benign material.

Hazardous chemical containers must have one of the following (see example below):

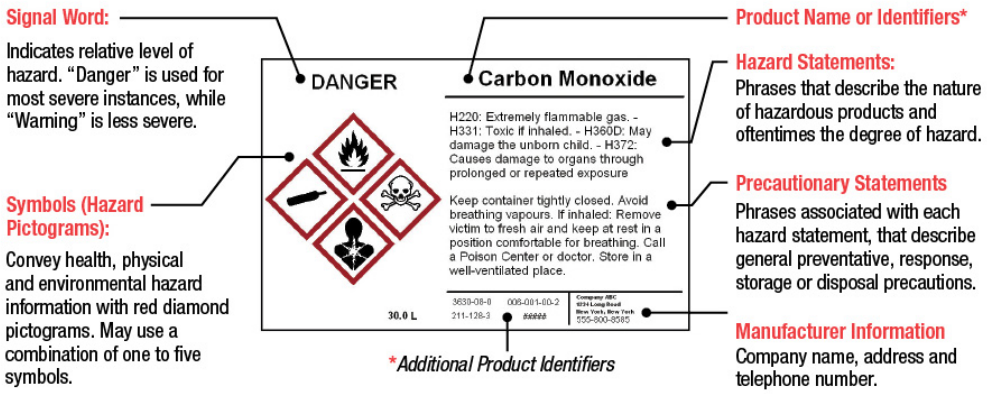
- Original manufacturer label that must contain:

1. Product identifier.
2. Signal word.
3. Hazard statement(s).
4. Precautionary statement(s).
5. Pictograms.
6. Name/address/phone number of the manufacturer.
7. The date received is written on it.

- Printed label identifying:

1. Original manufacturer's label contents or the product identifier.
2. Signal words.
3. Pictograms or a combination so that the label provides specific information regarding the hazards of the chemical.
4. Owner.
5. Date prepared if the chemical is not in the original container.

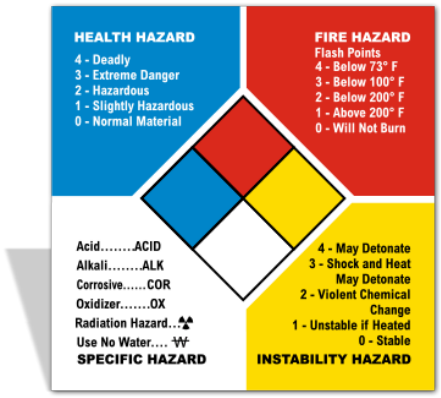
GHS Compliant Label



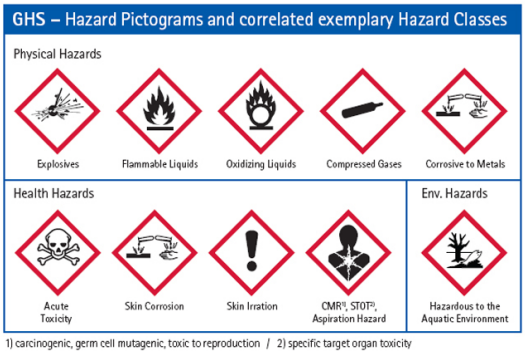
The container label may contain other pertinent hazard information for personal safety and storage. Some typical hazard warning examples are below:

4. Severe Hazard
3. Serious Hazard
2. Moderate Hazard
1. Slight Hazard
0. Minimal Hazard

Hazardous **M**aterials **I**dentification **S**ystem (HMIS)



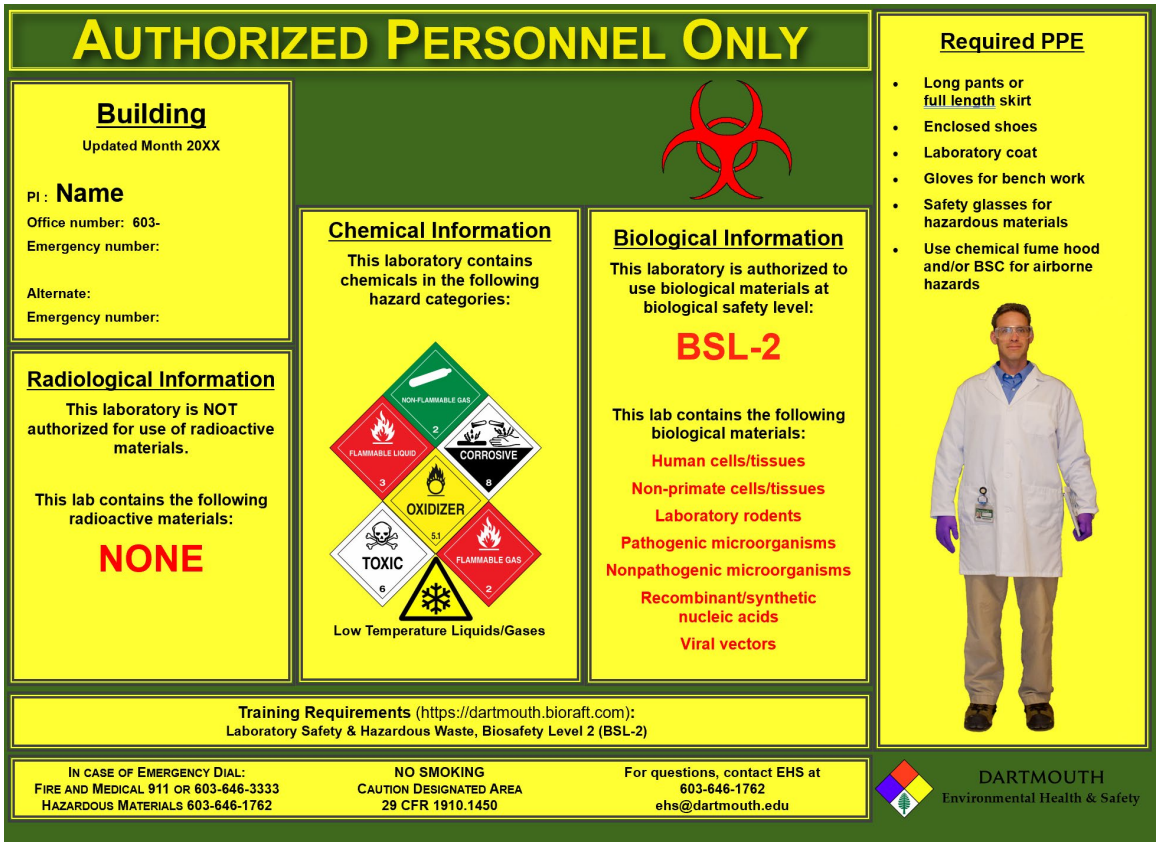
National Fire Protection Association (NFPA) 704 Diamond



United Nations

European Union Hazard Symbols

9.2 Door Signs



All laboratories containing hazardous materials have specific door signs indicating the potential hazards within. Emergency contact information with an after-hours telephone number will be indicated on the signs.

The sign also details the PPE needed for the space, the training requirements for working in the lab, and EHS contact information.

9.3 Safety Data Sheets

The Occupational Safety and Health Administration (OSHA) requires that information on hazardous chemicals' physical and health effects be readily available to employees who must work with or potentially be exposed to such substances (29 CFR 1910.1200 and 29 CFR 1910.1450). The required form of this information is fact sheets known as Safety Data Sheets (SDS). According to OSHA, these sheets must be readily available to employees during working hours in an easily accessible location.

Chemical manufacturers are required to provide Safety Data Sheets (SDS). They are a good starting point for safety and handling information. They can be supplemented by literature searches and safety databases (e.g., National Toxicology Program, EPA Integrated Risk Information System). Labs can use the Chemical Environmental Management System (CEMS) to find the current SDS tied to each chemical container.

When ordering any chemical, please review the associated SDS. Laboratories must make readily accessible current SDSs for any commercial products used in the lab (mixtures, experimental compounds, proprietary compounds, etc.) and any SDS not available through online sources.

10 Chemical Handling and Storage

This section discusses chemical characteristics and the hazards they pose. Chemicals are generally categorized in distinct classifications, each having unique properties. Understanding these differences is critical in working safely with these materials. Understanding the proper handling of chemicals and how these materials could potentially enter your body is also critically important.

10.1 Chemical Classifications

Chemical hazards can be broadly broken into five categories defined as follows:

10.1.1 Flammable and Combustible Liquids

- Local fire departments set and enforce flammable storage limits.
- Always store flammable liquids in rated cabinets when not in use, and never store them on the floor or near heat or ignition.
- Liquids may be defined as combustible, flammable, or extremely flammable, with progressively smaller storage limits reflecting increasing hazard (see table below).
- Contact EHS for assistance in determining your flammable liquid storage limits and options to ensure safety.

Flashpoint	<73°F	73 - 140° F	140 - 200° F
Description	Extremely Flammable	Flammable Liquids	Combustible Liquids
Storage limits with rated cabinet	1 Gal/4 Liters	20 Gal/80 Liters	40 Gal/160 Liters

10.1.2 Corrosives

- Corrosive materials include solids and liquids at pH extremes and those that can damage intact skin or mucous membranes on contact.

- Contact with corrosives must be eliminated by minimizing volumes/use and continuous use of protective equipment (e.g., gloves and chemical splash goggles).
- The federal hazardous waste laws go further to define corrosive wastes as any liquid with a pH ≤2 (acid) or ≥12.5 (base). This waste must be collected for disposal by EHS and cannot be neutralized without a permit from the State of New Hampshire.

10.1.3 Reactives

- Reactive chemicals include highly unstable compounds or chemicals that react with air (e.g. white phosphorous), water (e.g. sodium metal), heat (azobisisobutyronitrile), or friction/shock (picric acid) to explode, decompose violently, ignite/burn, give off toxic gases (e.g. sodium cyanide or sulfide) or polymerize/self-heat (monomers).
- Additional considerations must be given for compounds that will explode or become uncontrollable if combined with other compounds in a procedure.
- In general, these are materials that may undergo chemical or physical changes during routine use in a manner that may overcome standard control measures and cause severe acute or lethal injuries.

10.1.4 Compressed Gases, Cryogenic Liquids, and Toxic Gases

- Compressed gases and cryogenic liquids are similar in that they can create pressure hazards, health hazards, and/or flammable atmospheres.
- One special property of compressed gases and cryogenic liquids is that they undergo substantial volume expansion when released into the air, displacing oxygen potentially to dangerously low levels.
- Toxic gases pose additional potential acute health hazards to lab personnel.

10.1.5 Toxic Materials

- Toxic materials can harm humans or the environment and can be measured in various ways.
- Toxicity is categorized as acute (single or one-time exposures with immediate effects) or chronic (lower, long-term exposures and/or delayed effects).
- Many toxic materials can produce both acute and chronic health effects with effects that are duration and dose dependent. More importantly, the toxic effects of some research chemicals have not yet been thoroughly identified. The following terms, located in the table below, are important in evaluating toxicity:

Acute Toxicity Table

Items in red denote particularly hazardous substances where additional care is required.

Toxicity Classes per. Gosselin, Smith, and Hodge		
Probable Oral Lethal Dose (Human)		
Toxicity Rating	Dose	For a 70-kg Person (150 lbs)
6 Super Toxic	< 5 mg/kg	1 grain (a taste - less than 7 drops)
5 Extremely Toxic	5-50 mg/kg	4 ml (between 7 drops and 1 tsp)
4 Very Toxic	50-500 mg/kg	30 ml (between 1 tsp and 1 fl ounce)
3 Moderately Toxic	0.5-5 g/kg	30-600 ml (between 1 fl oz and 1 pint)
2 Slightly Toxic	5-15 g/kg	600-1200 ml (between 1 pint -1 quart)
1 Practically Non-Toxic	Above 15 g/kg	More than 1200 ml (more than 1 quart)

10.2 Chemical Handling

10.2.1 Introduction

All chemicals can have toxic effects at some dose level and particular route(s) of exposure. It is, therefore, wise to minimize exposure to chemicals. Chemicals can have local or systemic effects. Local toxicity refers to the direct action of chemicals at the point of contact. Systemic toxicity occurs when the chemical agent is absorbed into the bloodstream and distributed throughout the body, affecting one or more organs. Health effects can be acute or chronic. Acute effects last for a relatively short time and then disappear. Chronic effects are not reversible.

Do not confuse acute and chronic exposure with acute and chronic effects. Acute exposures to chemicals are for short periods. Chronic health effects can develop from acute exposures depending on the properties and amount of the chemical. Acute or chronic adverse health effects can also occur with chronic (repeated) exposure to chemicals, even at low concentrations.

10.2.2 Routes of Exposure

Inhalation involves airborne contaminants that can be inhaled directly into the lungs through the nose or mouth. These contaminants include dust, mists, fumes, vapors, and gases. Inhalation is the most common route of entry a chemical can take to enter the body.

Eye and Skin Absorption involves hazardous chemicals that are absorbed through the skin or eyes by direct contact. These chemicals include particulates (dust, smoke), liquids, gases, and vapors.

The eyes are of particular concern due to their sensitivity to irritants. Ocular exposure can occur via splash or rubbing the eyes with contaminated hands. Few substances are innocuous with eye contact, and several can cause burns and loss of vision. The eyes have many blood vessels and rapidly absorb many chemicals.

Ingestion involves hazardous chemicals that enter the body through the mouth. These include chemical dusts, particles, and mists inhaled through the mouth and swallowed or contaminated objects, such as hands, food, and cigarettes, that come in contact with the mouth.

Injection may occur through the misuse of syringe needles or through accidents with broken glass or other sharp objects that have been contaminated with chemicals. Injections can also occur through high pressure streams of liquids or gases. Injection is not a common route of entry.

10.2.3 Handling Practices for Chemicals

Access Control

- The Principal Investigator must control access to laboratories that contain chemicals.
- Keep the laboratory door closed while experiments are in progress. This practice not only protects persons who might otherwise enter the laboratory, but it also reduces interruptions to laboratory staff that could lead to accidents.
- Laboratory hoods offer the most worker protection when the doors to the laboratory are closed.

Personal Practices

- Wash your hands immediately after completing any procedure involving chemicals and when leaving the laboratory.
- Soap must be either liquid or foam in a pump dispenser.
- Do not use bar soap in laboratories.
- Do not use liquid soap bottles that you must invert and squeeze.
- Soap dispensers can be wall-mounted or freestanding countertop bottles.

Do not eat, drink, smoke, chew gum, apply cosmetics, store utensils, or store food or food containers in the lab. These activities should only take place in a kitchen, break room or office area.

Ensure no chemicals, procedures, or laboratory equipment end up in the kitchen, break room, or office area.

Remove gloves or other personal protective equipment that could introduce contamination to the food item area. Consider posting a reminder or labeling equipment.

Decontamination of Work Surfaces

- Protect work surfaces from contamination using "bench paper" (disposable plastic-backed absorbent paper) or stainless-steel trays. Place the plastic side down and the absorbent side facing up.
- Change worn or contaminated bench paper and dispose of it properly.
- Decontaminate other items and equipment with appropriate solvents when contaminated during experiments.

Minimizing Aerosols

Since a procedure with an open vessel of liquids or powders generates aerosols, you should develop techniques that will minimize the creation of aerosols.

- Such techniques might include discharging liquids from pipettes as close as possible to the fluid level of the receiving vessel or allowing the contents to run down the wall of the receiving vessel. Dropping the contents from a height generates more aerosols.

Also, avoid rapid mixing of liquids with pipettes by alternating suction and expulsion or forcibly expelling material from a pipette. Take extra care when discarding contaminated gloves or plastic-backed absorbent paper used to cover the work surface to avoid aerosolizing contaminants.

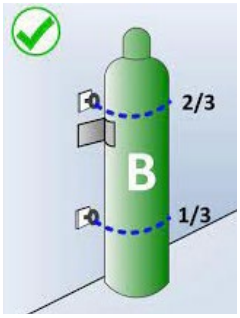
Use of Chemical Fume Hoods

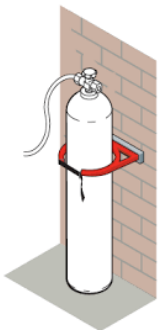
When used properly, chemical fume hoods are among the most effective means for controlling exposures to toxic chemicals since they move substances away from you before they can reach your breathing zone.

10.2.4 Compressed Gases

The use of compressed gases on campus must be in accordance with recommendations published by the Compressed Gas Association. The following rules summarize basic guidelines for the use and storage of compressed gases:

- All cylinders must have labels that clearly identify the contents.
- Cylinders must always be supported/restrained, whether full or empty.
    - The primary support chain/strap should fall at the 2/3 height mark of the cylinder. Additional support is acceptable and encouraged, but not required.





Acceptable methods of support are:

a. Wall-mounted or bench-mounted (secured) gas cylinder brackets/racks.
b. Chains or belts anchored to walls or benches.
c. Specific compressed gas cylinder carts or free-standing dollies designed for transporting cylinders, which include safety chains/straps.
    i. **Carts and dollies are only for transporting cylinders and are not designed as permanent storage locations. Cylinders must be removed from a cart and secured against a wall or bench.**

- Ensure chains, belts, or wall anchors supporting multiple cylinders have the strength to support the weight of the entire potential load. Do not overload support systems.
    - A commercially available purpose built cylinder support should be the standard
- Gas cylinders must have the valve protection cap in place except when in use.
- A cylinder connected to a piece of equipment and properly supported is "in use".
- Remove the pressure regulators and replace valve protection caps before moving cylinders, even if you have secured the cylinders to a dolly or hand truck.
- Researcher movement of compressed gas cylinders should be minimal and is restricted to changing out cylinders. Airgas (or an alternate supplier) will relocate cylinders as needed.
- Post all hydrogen and/or acetylene storage and usage locations with permanent placards that read: "HYDROGEN/ACETYLENE – FLAMMABLE GAS – NO SMOKING – NO OPEN FLAMES."
- Gas cylinders must be in an upright position and always secured. Consult with EHS if there is a need to use cylinders in any position other than vertical, with the valve up.
- Do not move cylinders by spinning, sliding, rolling, etc. For movement within laboratories, one may carry cylinders weighing less than 50 pounds if desired.
- Store cylinders with high health hazards, such as ammonia, carbonyl sulfide, hydrogen cyanide, hydrogen sulfide, methylamine, and nitric oxide, in hoods or other enclosures that vent directly outside. Contact EHS to discuss proper securement and storage of high hazard gases.
- Installed piping systems for flammable gases, toxic gases, and oxygen must be in accordance with OSHA, NFPA, and ANSI standards and approved by EHS.
- Pressure regulators and gauges must be compatible with the cylinder valves and gases.
- Although oxygen is quite safe under normal temperatures and pressures, elevated temperatures and/or pressures (or contamination) may result in the rapid and violent oxidation of normally non-reactive materials.
- There are two general types of compressed gas cylinders:
    - Returnable (owned by a company).
    - Non-returnable.

Suppliers will accept the return of their cylinders even if they are not empty. Suppliers will not accept non-returnable cylinders under any circumstances. Additionally, they generally will not accept the return of another vendor's cylinder.

Disposal of non-returnable cylinders containing highly toxic or reactive gas can be expensive. Therefore, compressed gases can be purchased in returnable cylinders if available.

10.2.5 Hydrogen Gas

If your lab intends to work with hydrogen gas, consult EHS prior to setup or purchasing any material. Depending on the use and application, there may be additional precautions needed to safely perform your work. Contact EHS for an assessment.

(See Appendix S for the Guideline for Hydrogen Use in the Laboratory)

Lecture Bottles

Lecture bottles are small, compressed gas cylinders, typically 12–18 inches long and 1–3 inches in diameter. Lecture bottles present a significant hazard in the laboratory. They are comprised of hazardous or toxic gases unavailable in larger cylinders or impractical to possess in larger volumes.

Generally, the practices applied to larger compressed gas cylinders also apply to lecture bottles. Below are some special considerations when utilizing lecture bottles.

- Lecture bottles with particularly hazardous or toxic contents may require ventilated storage such as gas cabinets or ventilated enclosures.
- Assign a designated area in the lab for lecture bottle storage. Avoid storing bottles in random locations because of their small size.
    - Lecture bottle storage should be arranged according to hazard class.
- Outdated lecture bottles containing corrosive gas pose a significant explosion hazard.
- Store lecture bottles in an upright position to avoid valve damage.
- Remove regulators and replace protective caps or plugs when lecture bottles are not in use.
- Lecture bottles must be properly secured during use, and lecture bottles containing hazardous gases (corrosive or poisonous) must be used in a fume hood or gas cabinet.
- Lecture bottles must be properly labeled. Re-label the lecture bottle if the label becomes illegible or falls off. Labeling the regulator with the gas it was last used for is a good idea to prevent accidental misuse in the future.
    - When purchasing lecture bottles, the manufacturers' return policy should be considered. The disposal cost of a lecture bottle may exceed the difference in purchase price. It is best to purchase lecture bottles from vendors that will allow the return of the bottle.
- Inspect the lecture bottle and regulator before use. Never use lecture bottles or regulators that are damaged or corroded.

10.2.6 Cryogenic Liquids

Responsibilities

Personnel responsible for any cryogenic equipment must conduct a safety review before operating the equipment. Supplementary safety reviews must follow any system modification to ensure that no potentially hazardous condition is overlooked or created and that updated operational and safety procedures remain adequate.

Clothing and Personal Protective Equipment

Wear the appropriate clothing and PPE when working and transferring cryogenic materials.

- Safety glasses are a minimum to be worn during the transfer and normal handling of cryogenic fluids. Face shields must be worn over safety glasses if there is the potential for splashing in the face, such as filling dewars.
- Loose fitting, insulating protective gloves must be worn when handling cryogenic fluids.
- Shirt sleeves should be rolled down and buttoned over glove cuffs, or equivalent protection, such as a lab coat, should be worn to prevent liquid from spraying or spilling inside the gloves. Do not wear short sleeves when working with cryogenic liquids.
- Long pants without cuffs and that don't expose skin must be worn.
- Shoes that cover the feet are required. These must not allow cryogenic materials to come into contact with the skin. Shoes must not allow a cryogenic liquid to become trapped in the material or soak in liquid in the event of a spill. Leather or other non-woven material is recommended.

Safety Practices

- Cryogenic fluids must be handled and stored only in containers and piping systems specifically designed to withstand extremely cold temperatures, in accordance with applicable standards, procedures, and proven safe practices, and be based on the specific cryogen.
- 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 the chest level of the person pouring the liquid and on a steady surface.
- Only conduct such operations in well-ventilated areas to prevent possible gas or vapor accumulation that may produce an oxygen-deficient atmosphere and lead to asphyxiation. If this is not possible, an oxygen monitor must be installed.
- Small spaces, environmental chambers, and cold rooms often do not have sufficient exhaust ventilation to support the storage and use of cryogenic materials. Contact EHS with any questions and to conduct a risk assessment.
- All cryogenic systems, including piping, must have pressure relief devices to prevent excessive pressure build-up. Containers vent continuously, but if they show signs of blockage by not venting at all, or there is frost buildup on the outside, which indicates that there is loss of vacuum, do the following:

    - **Do not attempt to remove a blockage;**
    - **Move the vessel to a remote location or notify others of the problem;**
    - **Contact the supplier for assistance with the vessel.**

- The caps of liquid nitrogen dewars are designed to fit snugly to contain the liquid nitrogen, but also allow the periodic venting that will occur to prevent overpressurization of the vessel. Do not attempt to seal the caps of liquid nitrogen dewars. Doing so can present

a significant hazard of overpressurization that could rupture the container and cause splashes of liquid nitrogen. Depending on the amount of liquid nitrogen that may be spilled, this could cause an oxygen deficient atmosphere within a laboratory due to the sudden release and vaporization of the cryogenic liquid.

- In the event of a spill, oxygen deficiency or a flammable atmosphere will exist beyond any visible fog cloud.

First Aid

Emergency treatment if skin or eyes come into contact with cryogenic liquid or vapor 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.
- If clothing becomes soaked with liquid, it should be removed as quickly as possible, and the affected area should be flooded with water as above.
    - Where clothing has frozen to the underlying skin, cold water should be poured on the area, but no attempt should be made to remove the clothing until it is completely free.
- If inhalation of the cold vapors has occurred, move the person to warm, fresh air. The person may be suffering from frostbite in their throat and lungs, and asphyxia.
- Do NOT rub frostbitten skin, as tissue damage may occur. Place in a warm bath not above 105°F (40°C).
- For emergencies, call **911** (5555 on the DHMC Campus).
- Report the incident to your PI or supervisor.
- Complete an injury report.

10.2.7 Dry Ice

Dry ice is the solid form of carbon dioxide available in flakes, pellets, or blocks and is non-combustible. It is most often used for rapidly cooling materials or shipping biological samples. Dry ice poses unique hazards to those who may work with or around it. Users should contact EHS if they plan on shipping materials on dry ice with questions before beginning work.

Training is required prior to shipping with dry ice. Training can be found here:

https://dartmouth.bioraft.com/rafttraining/course/293

Hazards

Carbon Dioxide Solid is NOT considered a Hazardous Substance by the OSHA Hazard Communication Standard (29 CFR 1910.1200). However, it is classified as a Dangerous Good for transport purposes under the Department of Transportation (DOT).

The precautions associated with handling this material are as follows:

Hazard Symbols	*Types of Hazards*
	**Contact Hazard**: At -109 °F (-79 °C), skin contact with dry ice can lead to severe frostbite; skin cells freeze and quickly become damaged.
	**Asphyxiation Hazard**: Dry ice will sublime (change from solid to gas) at temperatures above -109 °F. This releases potentially substantial volumes of CO2 (1 pound solid = 250 liters gas), causing dizziness, headaches, difficulty breathing, loss of consciousness, and death. This is especially of concern in nonventilated or confined spaces.
	**Over-pressurization Hazard**: Due to the rapid emission of large volumes of CO2 gas, any dry ice stored in a closed container can pressurize the container. Given enough time at normal room temperature, such a container may violently rupture if the gas cannot escape.

Precautions

Before starting work:

- Review the safety data sheet: Dry Ice (Carbon Dioxide, Solid) [CAS No. 124-38-9]
- Be familiar with emergency procedures.
- Be familiar with materials that dry ice is incompatible with.
- Use only the quantity needed at the time.

During work:

Perform all operations in a well-ventilated area. Avoid inhalation. Avoid skin contact with dry ice. This can lead to frostbite. Use appropriate personal protective equipment (PPE):

- Wear closed-toed shoes that cover the feet.
- Wear a lab coat or a garment covering the ankles.
- Wear appropriate eye protection, including goggles and/or a face shield. Use tongs to handle dry ice when possible.
- Use loose-fitting, thermally insulated gloves (e.g., leather or cloth) to handle dry ice manually. Nitrile exam gloves do not provide enough protection. If a nitrile glove material comes into contact with dry ice while you are wearing it, it may freeze to your hand and be very hard to remove. **Never handle dry ice with your bare hands.**

- Gloves must be thoroughly inspected before each use. Do not put on or continue to use damaged gloves.

Use materials and containers appropriate for dry ice use and remain aware of potential incompatibilities:

- **Never store dry ice in a tightly sealed container** or any container with a screw-top lid that will not vent. Styrofoam is an appropriate storage material since it is insulated and not airtight. When it sublimates to carbon dioxide gas, the gas pressure greatly expands. This expansion will cause an airtight container to expand and possibly violently rupture.
- Do not store dry ice in metal, plastic, or glass containers unless the container is specifically rated for use with dry ice. The extremely cold temperature is likely to fracture or break these containers.

<u>After completing work:</u>

- Disposal:
    - Place in a well-ventilated location, such as a fume hood, to allow the remainder of the dry ice to sublimate.
    - Never dispose of dry ice in a trash can or chemical waste container.
    - Never dispose of dry ice in a sink, toilet, or other fixture; the temperature difference can damage the plumbing or cause destruction of the fixture.
- Return container to storage:
    - Always store dry ice in a well-ventilated location.
    - Do not store large quantities.
    - Do not store containers inside a fume hood without ensuring proper airflow through the hood.
    - Do not store/use dry ice in confined areas with limited ventilation. This includes cold rooms, walk-in refrigerators, environmental chambers, and refrigerators/freezers.
    - Do not leave dry ice unattended in open areas.
    - Store in original containers or other appropriate containers.
    - Store away from incompatibles.
- Wash hands and forearms thoroughly with soap and water before leaving the lab.

<u>Emergency Procedures</u>

- If you see or receive a container where dry ice has caused swelling or bulging due to the container being sealed, there is the potential for the container to rupture. Do the following:

    - Do not try to release pressure in the container.

    - Leave the area, do not allow others to enter, and call Safety & Security at 603-646-3333.

First Aid

Emergency treatment if skin or eyes come into contact with dry ice is as follows:

- If dry ice comes into contact with the skin or eyes, flush the affected area with generous amounts of cold water. Never use dry heat. Splashes on bare skin cause a stinging sensation.
- If dry ice sticks to clothing, it should be removed as quickly as possible, and the affected area should be flooded with cold water as above.
- Where clothing has frozen to the underlying skin, cold water should be poured on the area, but no attempt should be made to remove the clothing until it is completely free.
- If inhalation of the cold vapors has occurred, move the person to warm, fresh air. In this case, the person may be suffering from frostbite of tissue in their throat and lungs, but also asphyxia.
- Do NOT rub frostbitten skin, as tissue damage may occur. Place in a warm bath not above 105°F (40°C).

Submit an injury report using this link.

Spill Response

- If spilled, dry ice will sublimate to carbon dioxide. The gas is heavier than air and is extremely cold. The gas will briefly accumulate in low areas until it warms and equilibrates with the air. Open the room or increase ventilation by opening the fume hood sash if a large amount has spilled or if the room is unventilated.
- For technical assistance, contact EHS 603-646-1762.

10.2.8 Hydrofluoric Acid

Hydrofluoric acid is an aqueous inorganic acid solution commonly used in research and industry for its ability to etch silicon compounds. It is essential for semiconductor and electronic fabrication, mineral processing, and glass etching. In addition to its useful properties, hydrofluoric acid also poses severe health risks upon exposure. Best management practices must be reviewed and continually employed while working with this material.

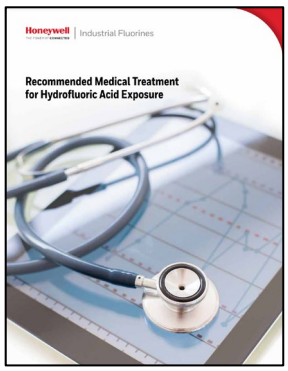
The Technical Info:

Hydrofluoric acid (CAS#7664-39-3) is the aqueous form of hydrogen fluoride gas, miscible with water. Both versions are commonly referred to as HF in research and industry. It has a molecular weight of 20.01 and is typically found in water concentrations of 48-52%. **Hydrofluoric acid is extremely corrosive!** Aqueous solutions diluted to 0.1 M will have a pH of approximately 1.0. Unlike other mineral acids, hydrofluoric acid will attack glass, concrete, rubber, quartz, and alloys containing silica.

Why So Dangerous?

Common mineral acids such as hydrochloric, phosphoric, nitric, and sulfuric acid can cause surface burns during dermal exposure. The area affected is localized; in other words, only the area contacted by the acid is affected. The mechanism for the local tissue corrosion is caused by the acid's active hydrogen cation (H+). Hydrofluoric acid will also cause local injuries; however, it does not stop there. The fluoride anion (F-) that dissociates from its hydrogen counterpart readily absorbs through the skin and performs its damage on the inside, penetrating deep into body tissues and bone, causing a systemic injury.

The fluoride ion has an affinity for calcium and magnesium, two minerals that are essential for bodily health. As the fluoride binds with calcium, it consumes the body's supply of this mineral in the blood and attacks bone structure, forming calcium fluoride salts. As serum calcium levels are depleted in the blood, a condition known as hypocalcemia, organ failure begins to occur, heart function becomes erratic, and can eventually fail, obviously resulting in death.



Any lab in possession of hydrofluoric acid must have:

1. **A Recommended Medical Treatment for Hydrofluoric Acid Exposure binder**
    a. ***IN THE EVENT OF AN HF EXPOSURE, THIS BINDER MUST BE TAKEN TO THE HOSPITAL WITH THE VICTIM***
2. **A fresh tube of calcium gluconate (Calgonate®) for treatment of hydrofluoric acid spills to the skin.**

Another quirk of hydrofluoric acid is that dermal burns may not be readily noticed or painful, unlike the warning properties of other acids. Skin contact with HF concentrations in the 20% to 50% range may not produce symptoms for one to eight hours. With concentrations less than 20%, the latency period may be up to twenty-four hours. A solution of only 1-2% HF exposed to greater than 10% of your body is fatal without medical attention; however, dermal burns are not likely to be immediate.

Moderately concentrated solutions of hydrofluoric acid (>40%) tend to fume and emanate hydrogen fluoride gas when exposed to air, producing yet another exposure risk through inhalation.

Before ordering or working with HF, consult with your PI to determine how it will be used, receive training, and develop specific handling/work protocols. EHS is also available for a safety consultation on using HF in the lab.

(Refer to Appendix L for more detailed information on HF)

10.2.9 Dichloromethane (Methylene Chloride)

Dartmouth College has developed a **Workplace Chemical Protection Program (WCPP) for methylene chloride** in response to the **U.S. Environmental Protection Agency's (EPA) 2024 final rule** under the Toxic Substances Control Act (TSCA), which significantly restricts the use of methylene chloride due to its acute toxicity and cancer risk. While most consumer, commercial, and industrial uses are now banned or will be phased out, limited laboratory use is still permitted under strict safety conditions.

This program, found in Appendix U, establishes the required controls to ensure the safe use of methylene chloride in research and academic settings. It incorporates **enhanced engineering controls, personal protective equipment (PPE), air monitoring, exposure assessments,** and **comprehensive worker training** to minimize risk to students, faculty, and staff. The program also includes procedures for chemical inventory management, safe handling, storage, spill response, and medical surveillance, as applicable.

The WCPP aligns with the stricter occupational exposure limits (OELs) mandated by the EPA, which exceed current OSHA requirements, and applies to all Dartmouth laboratories and workspaces where methylene chloride use is authorized. This program will be reviewed and updated regularly by the Environmental Health and Safety (EHS) team to ensure continued compliance and the health and safety of the Dartmouth community.

(Refer to Appendix R for more detailed information on Dichloromethane)

11 Particularly Hazardous Substances, Materials, and Equipment

This section details those materials that require special care and close management due to the hazards involved.

11.1 Overview of Working with Particularly Hazardous Substances

These substances include select carcinogens, reproductive toxins, and chemicals that have a high degree of acute or chronic toxicity. Acute toxicity can be defined with LD_{50} data (the dose which

is lethal to 50% of the test population), any substance with a published LD_{50} < 50 mg/kg (any route of exposure) should be considered highly toxic.

Examples of **highly toxic** substances include hydrogen cyanide, osmium tetroxide, phosgene, sodium azide, and tetrodotoxin.

The laboratory supervisor is responsible for ensuring appropriate additional precautions when working with such chemicals.

11.2 General Procedures for High Hazard Substances

- Maintain an accurate record of who uses these substances and the amounts used and stored in the laboratory.
- If toxicologically significant quantities of a particularly hazardous substance are used routinely or frequently, contact EHS at 603-646-1762 to determine if medical surveillance is warranted.
- Particularly hazardous substances must be kept in a secondary container to help prevent breaks and spills. This secondary container should be opened inside a chemical fume hood.
- A suitable label should be attached to this secondary container to alert others of the chemical contained therein and (if required) the need for special precautions. *For example: Warning -- Cancer Hazard or Highly Toxic.* Such labels are available from EHS.
- Access to the laboratory should be controlled using appropriate signs that warn of the hazards and indicate the precautions or approval needed for entry. Doors must be kept closed at all times.
- Additional containment devices (such as glove boxes, shielding, or protective filters) may be needed to safely handle, store, or protect equipment when using these chemicals.
- Define a designated area where the work with the material will be performed.

Note: Any chemical that carries a "skin" designation warning must be treated with extreme caution.

- In addition to using the proper gloves, eye/face protection, and other protective apparel or equipment may be needed. Examples could include chemically resistant gowns, aprons, gauntlets, or other specialized protective equipment.
- Work surfaces should be protected from contamination using disposable, absorbent, plastic-backed paper. Replace contaminated paper as necessary and treat it as hazardous waste.
- On completion of work and before leaving the laboratory, remove all protective apparel and thoroughly wash hands and forearms.

11.3 Carcinogens

Carcinogens are chemical or physical agents that cause cancer. Generally, they are chronically toxic substances, meaning they cause damage after repeated or long-duration exposure, and their effects may only become evident in the long term. Chronic toxins may have no immediately apparent harmful effects. These materials are separated into three classes:

1. Select Carcinogens.

2. Regulated Carcinogens.

3. 13 Carcinogens – ('Listed' Carcinogens).

11.3.1 Select Carcinogens

These materials have met certain criteria established by the National Toxicology Program (NTP) or the International Agency for Research on Cancer (IARC) regarding cancer risk via certain exposure routes. It is important to recognize that some substances involved in research laboratories are new compounds and have not been subjected to testing for carcinogenicity.

Select carcinogen means any substance that meets one of the following criteria:

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

(ii) It is listed under the category "known to be carcinogens" in the Annual Report on Carcinogens published by the National Toxicology Program (NTP) (latest edition); or

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

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

(A) After inhalation exposure of 6-7 hours per day, 5 days per week, for a significant portion of a lifetime to dosages of less than 10 mg/m^3;

(B) After repeated skin application of less than 300 (mg/kg of body weight) per week or

(C) After oral dosages of less than 50 mg/kg of body weight per day.

Some of these compounds are common materials used in many laboratories, such as acrylamide, chloroform, carbon tetrachloride, benzene, hydrazine, and thiourea. More than two thousand substances exhibit some evidence of carcinogenicity. Many of these also warrant careful planning and control procedures.

(See Appendix G for a select carcinogen list)

11.3.2 OSHA Regulated Carcinogens

OSHA regulated carcinogens (*29 CFR 1910 Subpart Z – Toxic and Hazardous Substances*) are a higher hazard class and have additional associated requirements. These materials are recognized as cancer-causing or potentially cancer-causing substances. Using these agents requires personal exposure monitoring or medical screening based on usage. When working with regulated carcinogens, reviewing and effectively applying engineering and administrative safety controls is particularly important. Any spill, release of, or suspected exposure to a regulated carcinogen must be reported to EHS immediately. Since there are additional regulations for using, handling, and storing regulated carcinogens, EHS should be contacted prior to use or if the intended use changes.

Working with the following carcinogens in a high volume or regularly (more than twice a week) requires additional care:

Chemical	Standard	Chemical	Standard
1,2-dibromo-3-chloropropane	1910.1044	Cadmium	1910.1027
1,3-butadiene	1910.1051	Chromium	1910.1026
2-acetylaminofluorene	1910.1014	coke oven emissions	1910.1029
3,3'-dichlorobenzidine and salts	1910.1007	ethyleneimine	1910.1012
4-aminodiphenyl	1910.1011	ethylene oxide	1910.1047
4-dimethylaminoazobenzene	1910.1015	formaldehyde/formalin	1910.1048
4-nitrobiphenyl	1910.1003	Lead	1910.1025
Acrylonitrile	1910.1045	methyl chloromethyl ether	1910.1006
arsenic (inorganic)	1910.1018	methylene chloride	1910.1052
Asbestos	1910.1001	Methylenedianiline	1910.1050
Benzene	1910.1028	N-nitrosodimethylamine	1910.1016
benzidine and salts	1910.1010	Respirable Crystalline Silica	1910.1053
Beryllium	1910.1024	vinyl chloride	1910.1017
bis-chloromethyl ether	1910.1008	α and β-naphthylamine	1910.1004 & .1009
		β-propiolactone	1910.1013

11.3.3 13 Carcinogens – ('Listed' Carcinogens)

Refer to this list of thirteen chemicals that are considered to pose the highest cancer hazard. These materials have further requirements for their use in addition to the requirements for regulated carcinogens. These materials also appeared on the regulated carcinogen list but are recognized as the highest cancer hazard materials. In addition, they each have their own OSHA standards from 1910.1003 - 1910.1017 (13 carcinogens).

Chemical	Standard	Chemical	Standard
4-Nitrobiphenyl	1910.1003	4-Aminodiphenyl	1910.1011
alpha-Naphthylamine	1910.1004	Ethyleneimine	1910.1012
methyl chloromethyl ether	1910.1006	beta-Propiolactone	1910.1013
3,'-Dichlorobenzidine (and its salts)	1910.1007	2-Acetylaminofluorene	1910.1014
bis-Chloromethyl ether	1910.1008	4-Dimethylaminoazo-benezene	1910.1015
beta-Naphthylamine	1910.1009	N-Nitrosodimethylamine	1910.1016
Benzidine	1910.1010		

11.3.2.1 Formaldehyde Exposure Control Program

Formaldehyde is classified as a human carcinogen that is linked to nasal and lung cancer. Short-term exposure to formaldehyde can be fatal. Long-term exposure to low levels of formaldehyde may cause respiratory difficulty, eczema, and sensitization.

Formaldehyde is a colorless, highly toxic, and flammable gas at room temperature. It is a strong-smelling chemical that is commonly used in research and medical laboratories as an aqueous solution.

The Occupational Safety and Health Administration's (OSHA) Formaldehyde Standard (29 CFR 1910.1048) protects workers exposed to formaldehyde from formaldehyde gas, solutions, and materials that release formaldehyde.

Processes or occupational activities in Dartmouth laboratories that may result in formaldehyde exposure include (but are not limited to):

- Handling biological specimens/tissues preserved in formaldehyde.
- Sterilization or disinfection procedures.
- Embalming procedures.
- Gross Anatomy laboratory involving cadavers.

The use of formaldehyde should follow specific policies and procedures based on your work environment. Refer to the Formaldehyde Exposure Control Program for more information on responsibilities and requirements.

(See Appendix N for the Formaldehyde Exposure Control Program)

If you have any questions regarding formaldehyde use or would like to request monitoring for exposure to formaldehyde, please contact EHS at 603-646-1762 or ehs@dartmout.edu

11.4 Reproductive Toxins

The OSHA Laboratory Standard defines reproductive hazards as substances that cause chromosomal damage (mutagens) and substances with lethal or teratogenic (malformation) effects on fetuses. Teratogens may affect the embryo at any stage of its development, from fertilization to birth, although damage is most likely during the first 8 to 10 weeks of pregnancy. These can include chemicals, biological materials, and radioactive materials.

Several 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 should seek the advice of their physician before working with known or suspected reproductive toxins.

The following precautions should be taken when working with potentially toxic materials:

1. Wear protective equipment, including gloves, goggles, and a lab coat covering street clothes.
2. Gloves should be selected based on the properties of the chemicals in use.
3. Do not eat, drink, chew gum, or apply cosmetics in areas where chemicals are used.
4. Keep accurate records of the amounts of these substances used.
5. Have a plan, proper equipment, and materials ready to minimize exposure if an accident occurs.
6. Procedures should be done with the minimum amount of material needed to complete the task.
7. All procedures should take place in a “controlled area” that is clearly labeled.
8. Fume hoods or glove boxes should be used.
9. All work surfaces should be easily cleanable and covered in an impervious or disposable material.
10. Wash hands/arms and decontaminate the work surface and equipment thoroughly when done with the procedure.
11. Protective apparel worn while working with toxic materials should not be worn outside the laboratory.
12. Ensure that contaminated waste containers are transferred from the controlled area to a secondary container to avoid further contamination.

Examples of reproductive toxins commonly found in laboratories include:

1,3 - Butadiene	Lead
Ethylene thiourea	Dibromochloropropane
Arsenic	Mercury compounds
Fluorouracil	Ethylene dibromide
Benzene	Polychlorinated biphenols (PCBs)
Halothane	Ethylene glycol monomethyl (and ethyl)
Cadmium	Toluene
Ionizing radiation	Ethylene oxide
Carbon disulfide	Urethane

See the Dartmouth College Radiation Safety Program for information on working with radioactive sources and declaring a pregnancy. Or contact the Radiation Safety Officer at 603-646-1762

11.5 Controlled Substances

Because of their potential for abuse, controlled substances have specific regulatory requirements for their acquisition, storage, security, use, and disposal.

Contact EHS prior to obtaining a license or ordering controlled substances to ensure all requirements are met and EHS has an accurate inventory of DEA license holders

Controlled substances are any drugs or chemical substances whose possession and use are regulated under the United States Controlled Substances Act. Controlled substances have stimulant, depressant, or hallucinogenic effects on the higher functions of the central nervous system and tend to promote abuse or physiological/psychological dependence.

The Federal Drug Enforcement Administration (DEA) requires research personnel to have a DEA license. At Dartmouth, the principal investigator is the responsible individual. Special inventory, security, and recordkeeping requirements will apply when obtaining a DEA license.

(For more information on obtaining a DEA license and what is required for possession and use, see Appendix H , go to this link or contact EHS (603- 646-1762)).

If controlled substances are lost, stolen, or used in an unauthorized manner, the registrant must immediately contact EHS, Safety and Security (603-646-4000) and either Hanover (603-643-2222) or Lebanon Police (603-448-1212), and the DEA Office of Diversion Control. "Federal regulations require that registrants notify the Field Division Office of the Administration in his area, in writing, of the theft or significant loss of any controlled substance, disposal receptacles, or listed chemicals within one business day of discovering such loss or theft. The registrant shall also complete and submit to the Field Division Office in his area DEA Form 106 regarding the loss or theft (**21 C.F.R. §1301.76**(b) and **21 U.S.C. §830**(b)(1)(C)). The DEA Form 106 can be completed via **Theft/Loss Reporting Online (TLR)** or downloaded as a fillable PDF version and submitted to your **Local Diversion Field Office**."

12 Toxic Substances Control Act (TSCA) (Lautenberg Chemical Safety Act)

The Toxic Substances Control Act (1976), or TSCA, regulates new and existing chemicals for potential environmental and public health effects before production or transportation.

This law requires a basic hazard assessment for all new chemicals offered for transport or sale and requires documentation and communication of this hazard assessment.

In 2016, the Frank R. Lautenberg Chemical Safety for the 21st Century Act (Lautenberg Chemical Safety Act) was signed into law. The Lautenberg Chemical Safety Act amends the Toxic Substances Control Act (TSCA), the nation's primary chemicals management law.

This amendment includes improvements such as:

- Mandatory requirement for the Environmental Protection Agency (EPA) to evaluate existing chemicals with clear and enforceable deadlines;
- Risk-based chemical assessments;
- Increased public transparency for chemical information; and
- Provide consistent funding for the EPA to carry out its responsibilities under the new law.

Laboratories engaged in research must consider the applicability of the Toxic Substances Control Act (TSCA) regarding their operation. Most lab chemicals are already on the TSCA inventory (referred to as "existing" chemicals). Still, specialty chemicals or materials synthesized in our labs are likely not on the inventory and are thus "new chemicals". Documentation and evaluation of adverse health effects are required for both existing and new chemicals. In addition, new chemicals must be registered with TSCA or used under the research and development exemption.

12.1 You are subject to TSCA when you:

- Bring chemicals not on the TSCA inventory (e.g., "new chemicals") on campus or into the country.
- Purchase a "new" chemical from a domestic or foreign vendor.
- Synthesize a new chemical for use, transfer, shipment, or export.
- Transfer or ship a new chemical to another lab or institution in the US or overseas.
- Observe an adverse health or environmental effect associated with a new chemical or a new health effect associated with an existing chemical.

As the EPA becomes aware of activities at colleges and universities, it becomes increasingly important for Dartmouth College to demonstrate that a TSCA compliance program is in place. Most activities at Dartmouth College should be exempt from TSCA provided certain conditions

are met, but you must document that your work meets this exclusion. In rare cases, you may need to document your TSCA registration information.

12.2 Overview of Research and Development (R&D) Exemption Requirements

A chemical substance can be exempted from many TSCA requirements when it is imported, manufactured, or used in small quantities solely for purposes of non-commercial scientific experimentation, analysis, or research, and used under the supervision of a technically qualified individual.

- Laboratory work involving new chemicals must be overseen by a technically qualified individual (such as the Principal Investigator) and be laboratory-scale, non-production work.
- New chemicals must be appropriately labeled with the chemical name, a statement that the chemical will be used for research and development purposes only, and information regarding the potential hazards. If you create your own label, you must document this. An example label might read:
    - "[chemical name], for laboratory research and development purposes only, for use by technically qualified individuals only, liver toxin and suspected carcinogen, the physical, chemical, and toxicological properties have not been fully investigated, this product is not on the TSCA inventory."
- New chemicals can be shipped to offsite locations (e.g., for identification, analysis, or collaboration) provided that a hazard assessment is performed (toxicology research) and documented, the container is labeled as above, and an SDS sheet is developed. You will also need to document the names/addresses of those you distribute the material to and the date, amount distributed, and notices provided to them (container labels, warnings, SDS, etc.).
- All documentation must be kept on file in your lab for a minimum of 5 years.

The US Environmental Protection Agency (EPA) administers TSCA by:

1) Creating a list of widely available chemicals called the TSCA Inventory.
2) Regulating chemical imports and exports;
3) Collecting information on adverse environmental and health effects of new and existing chemicals;
4) Screening new chemicals intended for broad manufacture; and
5) Banning chemicals with unacceptable environmental and/or health risks from broad circulation in commerce (e.g., PCBs and asbestos).

NOTE: Laboratories synthesizing, storing, or using new chemicals that do not meet the requirements of the R&D exemption are subject to significant additional TSCA requirements

12.3 Additional requirements for import, export, and shipping chemicals

· **Imports:** Any chemicals imported from outside the US Customs Territory must be certified as TSCA compliant or not regulated by TSCA at the time of import.

· **Exports:** Any chemicals exported outside the US Customs Territory must be screened against certain EPA chemical lists. Some particular chemicals may require additional actions by the EPA prior to or within several days of export.

· **Shipments:** New chemicals shipped to other institutions or entities must be shipped for R&D purposes only. Containers of these chemicals and shipping documentation must be labeled. The environmental and health risks of these chemicals must also be evaluated and communicated to the receivers by preparing and shipping an SDS and/or shipment form with the substance.

· **Reporting:** Allegations of adverse reactions - Create and maintain records and report any allegations of adverse effects to human health or the environment potentially caused by R&D substances. Discovery of substantial risk - Document and report any significant risks to human health or the environment potentially associated with R&D substances.

12.4 Definitions/Clarifications

Chemical substances ***regulated*** by the Lautenberg Act include:

"Any organic or inorganic substances of a particular molecular identity, including any combination of such substances occurring, in whole or in part, as a result of a chemical reaction or occurring in nature, and any element or uncombined radical."

Chemical substance means any organic or inorganic substance of a particular molecular identity, including any combination of such substances occurring in whole or in part because of a chemical reaction or occurring in nature, and any chemical element or uncombined radical, except that "chemical substance" does not include:

(1) Any mixture *(individual components are chemical substances).*

(2) Any pesticide when manufactured, processed, or distributed in commerce for use as a pesticide.

(3) Tobacco or any tobacco product.

(4) Any source material, special nuclear material, or byproduct material.

(5) Any pistol, firearm, revolver, shells, or cartridges.

(6) Any food, food additive, drug, cosmetic, or device manufactured, processed, or distributed in commerce for use as a food, food additive, drug, cosmetic, or device.

Commercial Activities whose results are directly intended to produce commercial gain for those involved in the oversight or performance of the activity.

Laboratory is a contained research facility where relatively small quantities of chemical substances are used on a non-production basis and where activities involve the use of containers for reactions, transfers, and other handling of substances designed to be easily manipulated by a single individual.

Prudent and safe handling practices mean implementing safe chemical handling practices as delineated in the chemical hygiene plan.

Small quantities solely for research and development (or "small quantities solely for purposes of scientific experimentation or analysis or chemical research on, or analysis of, such substance or another substance, including such research or analysis for the development of a product") means quantities of a chemical substance manufactured, imported, or processed or proposed to be manufactured, imported, or processed solely for research and development that are not greater than reasonably necessary for such purposes.

Technically qualified individual means a person or persons (1) who, because of education, training, or experience, or a combination of these factors, is capable of understanding the health and environmental risks associated with the chemical substance that is used under his or her supervision, (2) who is responsible for enforcing appropriate methods of conducting scientific experimentation, analysis, or chemical research to minimize such risks, and (3) who is responsible for the safety assessments and clearances related to the procurement, storage, use, and disposal of the chemical substance as may be appropriate or required within the scope of conducting a research and development activity.

12.5 Chemicals or Activities not Regulated by Lautenberg Act

1. Foods, food additives, drugs, cosmetics, or devices are regulated by the Food and Drug Administration.
2. Radioactive materials are regulated by the Nuclear Regulatory Commission.
3. Tobacco, tobacco products, and ammunition are regulated by the Bureau of Alcohol, Tobacco, Firearms, and Explosives.
4. Pesticides are regulated by **FIFRA (Federal Insecticide, Fungicide and Rodenticide Act**)-pesticides officially recognized as pesticides through an experimental use permit or otherwise. FIFRA-regulated pesticides.
    a. Individual components of a given pesticide are regulated.

If you suspect that your operation does not meet the R&D exemption, please contact the EHS office at 646-1762 or ehs@dartmouth.edu for assistance.

13 Potentially Explosive and Reactive Chemicals

Various common chemicals in the laboratory pose the potential for accidental hazardous chemical reactions or explosions. A hazardous reaction occurs when two or more chemicals that are incompatible combine. This results in an undesirable or uncontrolled reaction with adverse consequences. Such reactions may result when incompatible chemicals accidentally spill, inadvertently mix as chemical waste, or combine unknowingly during experimental procedures.

Hazardous reactions may cause any one or more of the following:

- Dispersal of toxic dust, mists, and particles.
- Explosion.
- Fire.
- Formation of flammable gases.
- Formation of shock or friction sensitive compounds.
- Formation of substances of greater toxicity.
- Formation of toxic vapors.
- Heat generation.
- Pressurization in closed vessels.
- Solubilization of toxic substances.
- Violent polymerization.
- Volatilization of toxic or flammable substances.

Becoming complacent about the chemicals used daily in procedures is a common potential danger. It is prudent to check for incompatibility when changing chemical procedures. **Chemical incompatibility is the primary reason you do not alphabetically store chemicals on the shelf.** If there is an accident, adverse reactions may make the situation worse.

Reactive chemicals react violently with water, air, or other chemicals to produce toxic gases, heat, fire, or explosion.

Explosives:
Explosives are substances that can detonate or decompose rapidly and violently at room temperature and pressure with an essentially instantaneous release of large quantities of gases and heat. Gentle heat, light, mild shock, and chemical action can initiate these explosive reactions. Many of these compounds become more sensitive as they age or dry out. Examples include peroxides, nitroglycerin, and TNT.

Strong oxidizing agents:
Many strong oxidizing agents are capable of detonation or explosive decomposition under conditions of strong heat, confinement, or a strong shock. Violent reactions can occur when strong oxidizers are mixed with combustibles such as wood or paper. Strong oxidizing agents that

can cause explosions include perchlorates, inorganic nitrates, chlorates, chromates, and halogens. Strong oxidizing agents react violently with most organic compounds, powdered metals, sulfur, phosphorus, boron, silicon, and carbon.

Water reactive:

Chemicals that combine with water or moisture in the air to produce heat, flammable, explosive, or toxic gases are termed water-reactive chemicals. These chemicals present a severe fire hazard because sufficient heat is often released to self-ignite the chemical or ignite nearby combustibles. In addition, contact with the skin can cause severe thermal and alkali burns. Examples include strong acids and bases, alkali metals such as sodium and potassium, hydrides, and carbides.

Air reactive:

Air reactive (pyrophoric materials) chemicals ignite spontaneously in air at temperatures below 130 degrees F. Finely divided metal powders that do not have a protective oxide coat may ignite when a specific surface area is exceeded. The degree of reaction depends on the size of the particle, its distribution, and its surface area. Examples include white phosphorus, alkali metals (potassium, sodium, cesium), nickel, zinc, and titanium dusts, hydrides (barium, diborane, diisobutyl aluminum hydride)

Quenching of reactive chemicals

Water and air reactive chemicals used for experimentation must be completely used during the experiment and not generate unquenched waste material.

Individual labs must create their own standard operating procedure to ensure a full quench of water/air-reactive chemicals within an experiment. This may require separate procedures for each chemical. The individual laboratory procedures work in conjunction with this Laboratory Safety Manual to form the College Chemical Hygiene Plan.

Stock bottles that are empty or contain remaining water/air reactive materials DO NOT require quenching before disposal. Contact EHS for disposal (ehs@dartmouth.edu)

Special Organic Compounds: Peroxide-Forming Chemicals:

A chemical that, when exposed to air, forms explosive peroxides that are shock sensitive, pressure sensitive, or heat sensitive.

Reactive chemicals include:

Oxidizers • Bromine compounds • Nitrates • Permanganates • Picrates	**Spontaneous decomposition** • Benzoyl peroxide • Nitroglycerine
Water reactives • Alkali and alkaline earth metals • Anhydrous metal halides and oxides • Nonmetal halides and halide oxides	**Shock, friction, and static discharge sensitive** • Azides • Diazo compounds • Nitro compounds • Organic and inorganic peroxides • Picric acid
Air reactives • Alkyl metal derivatives • Carbonyl metals • Finely divided metals • White phosphorus	**Peroxides** • Dienes • Secondary alcohols • Aldehydes • Alkali metals • Organometallic compounds • Metal alkoxides
Temperature sensitive • Certain oxidizers and Azo compounds • Organic peroxides	

13.1 Peroxide Formers

Many laboratory solvents can undergo autoxidation under normal storage conditions to form unstable and potentially dangerous peroxide by-products. This process is catalyzed by light and heat and occurs when susceptible materials are exposed to atmospheric oxygen. The molecular structure is the primary factor in a material's potential for hazardous peroxide formation.

Under normal storage conditions, they can form and accumulate peroxides, which may explode violently when subjected to thermal or mechanical shock. This can occur even when the containers appear to be tightly closed.

If you notice visible crystals in a peroxidizable liquid or discoloration in a peroxidizable solid, such chemicals are extremely dangerous and might require special handling and disposal procedures.

DO NOT handle chemicals that you suspect might have significant peroxide contamination. Leave the chemicals in place and contact EHS!

13.1.1 General Handling Considerations for Peroxidizable Solvents

- Check peroxide-forming solvents for peroxides before distillation or evaporation.
- Solvents containing an inhibitor, such as Butylated hydroxytoluene (BHT), should be used when the presence of the stabilizing species does not interfere with the intended application.
- Uninhibited materials should be stored carefully and frequently checked for peroxide formation – depending on the material, testing frequency can range from three months to one year. Uninhibited materials need to be tested prior to each use. (***Refer to Appendix I for more details or contact EHS with questions.)***
- Purchase in limited quantities, and older materials should be used first.
- Store away from light and heat with tightly secured caps labeled with receipt and opening dates.
- Periodic testing to detect peroxides must be performed and recorded on the bottle.
- Contact EHS for peroxide former bottle labels with space for recording peroxide tests.
- Record the date purchased, opened, and tested on each potential peroxide former bottle.

13.1.2 Testing for Peroxides

Method A (Test Strip)

Peroxide test strips detect inorganic and organic compounds that contain a peroxide or hydroperoxide group. Test strips are suitable for the routine testing of peroxides formed from simple ethers such as diethyl ether, tetrahydrofuran, and p-dioxane. Use the EM Quantitative Peroxide Test (or equivalent brand), a color-metric dipstick test developed by Merck. Carefully read the instructions provided by the manufacturer. EHS will provide test strips upon request.

Method B (The Iodide Test)

Suitable for testing any peroxide-forming chemical:

- Wear chemical resistant gloves, a laboratory coat, and eye protection. Work in a fume hood.
- Dissolve 100 mg of potassium iodide in 1 ml of glacial acetic acid.
- Add the mixture to 1 ml of the chemical being tested. Use a 10 ml graduated cylinder.
- Determine the color of the resulting mixture by looking through the side of the cylinder with a piece of white paper behind the cylinder.
    - A pale or barely discernible yellow color indicates a peroxide concentration of 0.001 – 0.005%.
    - A bright yellow or brown indicates a peroxide concentration of 0.01% or greater.

The chemical is good for use if the peroxide concentration is less than 0.001% (10 ppm). If the peroxide concentration exceeds 0.001% (10 ppm), the chemical must be disposed of by EHS.

(Refer to Appendix I for a list of potential peroxide formers.)

13.2 Perchloric Acid

Perchloric acid is a strong oxidizing acid that can react violently with organic materials. Perchloric acid can also explode if concentrated above 72%.

For any work involving heated Perchloric acid (such as in Perchloric acid digestions), the work must be conducted in a special Perchloric acid fume hood with a wash down function. If heated Perchloric acid is used in a standard fume hood, the hot Perchloric acid vapors can react with the metal in the hood ductwork to form shock sensitive metallic perchlorates.

When working with Perchloric acid, remove all organic materials, such as solvents, from the immediate work area.

Due to the potential danger of Perchloric acid, if possible, try to use alternate techniques that do not involve using Perchloric acid. If you must use Perchloric acid in your experiments, only purchase the smallest container necessary.

(See Appendix M for more information on perchloric acid use.) Contact EHS with any questions

14 Nanoparticles

Nanoparticles are particles with at least one dimension of 100 nanometers (nm) or smaller. Engineered nanoparticles are seeing increased use in consumer products and the lab. Consumer products contain bound up or incorporated nanoparticles, which are not likely to become airborne in free form. Manufacturing and research materials are more varied in form – these procedures apply only to nanoparticles in the free, unbound state.

While the health hazards of nanoparticles are not fully understood, current evidence is that nanoparticles enter the body via inhalation and skin contact. Increased reactivity is assumed because of their size and relative surface area to mass ratio. Results from human and animal studies show that inhaled nanoparticles can deposit in the respiratory tract and enter the bloodstream. Nanoparticles pose the greatest risk when they are in the form of individual particles or particles from nanostructured materials that become airborne or come into contact with the skin.

14.1 Exposure Limits

There are currently no published exposure limits for nanoparticles from US regulatory or consensus standard groups. There are several proposed standards and industry standards of note:

5 ug/m3	Carbon nanotube – Bayer "baytubes" 2010
2.5 ug/m3	Carbon nanotube – Nanocyl 2009
1 ug/m3	Carbon nanofibers – NIOSH current intelligence bulletin 2013
300 ug/m3	Titanium oxide – NIOSH current intelligence bulletin 2013

These limits represent currently available data, and carbon nanotubes are the lowest levels currently detectable with available sampling tools.
The advised approach for nanoparticle control is maintaining exposures as low as reasonably achievable through containment, ventilation, and protective equipment.

14.2 Key points

- HEPA filtration is effective for the capture of nanoparticles in ventilation and respiratory protection.
- Chemical fume hoods, if used properly, are effective at the containment of nanoparticles. Some type of containment ventilation must be used to control exposure and environmental contamination.
- N95 respirators will provide effective filtration of nanoparticles, limited by fit and overall hygiene. N99 or N100 respirators offer significant improvements in capture. **EHS must approve the use of any respirator.**

14.3 Operations of Concern

The National Institute for Occupational Safety and Health (NIOSH) identified the following tasks that may increase the risk of exposure to nanoparticles:

- Working with nanoparticles in liquid media without adequate protection (e.g., gloves).
- Working with nanoparticles in liquid media during pouring or mixing operations or where a high degree of agitation is involved will increase the likelihood of inhalation and respirable droplets forming.
- Generating nanoparticles in the gas phase in non-enclosed systems will increase the chances of aerosol release to the workplace.
- Handling nanoparticle-based powders will lead to the possibility of aerosolization.
- Maintenance of equipment and processes used to produce or generate nanoparticles will pose a potential exposure risk to workers performing these tasks (e.g., vacuum chamber cleanout).
- Cleaning dust collection systems used to capture nanoparticles will pose a potential for skin and inhalation exposure (e.g., HEPA filter changeout).

14.4 Work Procedures

The same procedures, equipment, and work practices for handling toxic chemicals apply to nanoparticle work. At Dartmouth College, the following engineering, work practice, and ventilation controls are required when handling nanoparticles in the pure form, in solution, or when exposure risks exist:

- Restrict the handling of nanoparticles to areas well within the lab. Labs that handle nanoparticles must have non-recirculating ventilation systems (100% exhaust air). Lab pressurization must be negative to the hallway.
- Food and drink are restricted in all nanoparticle handling areas.
- Hand washing facilities must be provided in all labs. Hand washing must be performed after handling nanomaterials.
- Handle dry nanomaterials in a fume hood, glove box, or a vented HEPA-filtered enclosure. Do not work on the open bench with dry nanoparticles.
- Transport dry nanoparticles in closed containers.
- Aerosol producing activities (such as sonication, vortexing, and centrifuging) may not be conducted on the open bench. Perform these activities in a fume hood, biological safety cabinet, glove box, or a vented filtered enclosure.
- Clean bench tops and equipment surfaces with soap and water after each work activity.
- Spills of dry nanoparticles must be cleaned with a HEPA vacuum. Dry sweeping is prohibited. Large spills must be reported to EHS.
- Exhaust from all furnaces that produce nanoparticles must be trapped and connected to a local exhaust source.

14.5 Personal Protective Equipment

- Lab coats must be worn when handling nanomaterials in addition to closed-toe shoes and long pants.
- ANSI-approved safety glasses are required when working in any lab with hazardous materials. Splash goggles are required when liquid splash hazards exist (e.g., pouring, mixing).
- Gloves (disposable nitrile) must be worn when handling nanomaterials.
- Local exhaust snorkels or ventilated enclosures should be considered before respirators. All respirator use must be coordinated through EHS per our Respiratory Protection Program.

14.6 Nanoparticle Waste Disposal

All solutions and solid materials/contaminated debris must be disposed of as hazardous waste via EHS.

15 Department of Homeland Security (DHS) and the Chemical Facility Anti-Terrorism Standards (CFATS)

The Department of Homeland Security has identified several chemicals commonly used in laboratories that could potentially be used in acts of terrorism. Reporting is required if certain quantity thresholds are reached.

Using CEMS, EHS can identify areas where these chemicals are being used and stored. If quantity thresholds are approached, EHS will investigate. It is imperative to keep lab doors locked when no one is around and question unauthorized entry or people you don't recognize within your lab.

For the complete list of chemicals of interest and more details, go to the Cybersecurity and Infrastructure Security Agency website. If you have any of these chemicals and are not using the CEMS system, please contact ehs@dartmouth.edu

https://www.cisa.gov/sites/default/files/publications/appendix-a-to-part-27-508.pdf

> **NOTE:** *As of July 28, 2023, Congress allowed the statutory authority for the Chemical Facility Anti-Terrorism Standards (CFATS) program (6 CFR Part 27) to expire. Therefore, CISA cannot enforce compliance with the CFATS regulations at this time.*
>
> *The lapse of CFATS authorization means that CISA cannot require facilities to report their chemicals of interest or submit any information in CSAT, perform inspections, or provide CFATS compliance assistance, among other activities. CISA can no longer require facilities to implement their CFATS Site Security Plan or CFATS Alternative Security Program.*
>
> *CISA encourages facilities to maintain security measures. CISA's voluntary ChemLock resources are available on the ChemLock web pages.*
>
> *For updates and more information on the future state of the program, visit: https://www.cisa.gov/resources-tools/programs/chemical-facility-anti-terrorism-standards-cfats*

16 Storage of Hazardous Chemicals

Chemical storage is addressed in this section, including details on basic chemical storage guidance. Chemical hazard categories and compatibility are addressed. Details on chemical storage locations are also discussed.

16.1 Introduction

The proper storage of chemicals is critical to laboratory safety. Recognizing the hazards of particular chemicals will help determine proper storage and will minimize incompatible chemical reactions, spillage, breakage, or waste due to expiration.

Dartmouth uses the Chemical Environmental Management System or CEMS inventory management system tool to track chemical inventory and understand the chemical hazards in your lab. Safety Data Sheets (SDSs) are available for each chemical in the CEMS inventory.

Store chemicals by hazard class, not alphabetically. Alphabetical storage can place incompatibles near each other, potentially leading to unwanted interactions. Inspect chemical storage areas at least annually for outdated or unneeded items, illegible labels, leaking containers, etc. Use this opportunity to correct issues found and not let them linger. Set aside those materials that are no longer needed/usable/wanted for disposal via EHS. See the Hazardous Waste Guide for Research Areas for more details on waste disposal. Contact ehs@dartmouth.edu with any questions or to request a waste pick up.

16.2 Closure of containers and container size

Closure of containers

Ensure containers are tightly sealed and closed. This will prevent leakage, odors, or reactions with air and tightly seal all containers of highly toxic, highly volatile, malodorous, carcinogenic, or reactive chemicals.

- A limited exception is freshly generated mixtures such as acids and organics that may generate gas pressure sufficient to burst a tightly sealed bottle.
- EHS has vented caps for certain types of bottles, or you may keep the lid loose until sufficient time passes to complete the reactions, but then tightly close the lid.
- Until all reactions are completed, the bottle's contents are not waste but are instead the last step of the chemical procedure.

The best seal is the screw cap with a conical polyethylene or Teflon insert. Seal the caps with tape or Parafilm® as a further precaution. Additional protection can include wrapping the container in an absorbent paper, sealing it inside a plastic bag, and storing the bag inside a metal can with a friction fitting lid.

Container size

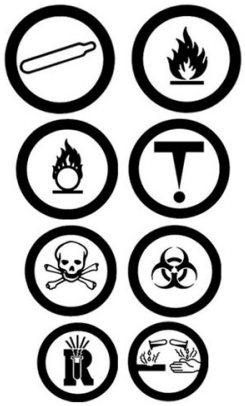
Keep the quantity of accumulated chemicals in the laboratory to a minimum to reduce the risk of exposure, fires, and waste disposal problems. Smaller package sizes provide the following advantages:

- Reduced storage hazards.
- Reduced storage space.
- Safety in handling smaller quantities.
- Reduced losses due to out-of-date chemicals.
- Minimized the cost of disposal of “leftovers”.

Frequently, it costs many times more than the original purchase price to dispose of leftover chemicals. Buy only what you need, not the “good deal”.

16.3 Container management

Most chemical manufacturers include chemical storage symbols on their labels. Many manufacturers use symbols that include a hazard ranking system, such as the National Fire Protection Association (NFPA 704) diamond symbol or the Hazardous Materials Identification System (HMIS) colored rectangle (noted in section 9). Picture glyphs are another common label element. Below are examples of the glyphs from the European Union and Canada commonly seen on U.S. chemical labels and safety data sheets. The current Globally Harmonized System of pictograms is also noted.



Incompatible chemicals must be physically separated during storage. This means segregating chemicals by physical properties – flammables, oxidizers, acids, bases, etc., and storing them in appropriate cabinets or containment bins (bins are free from EHS).

(A segregation chart is available in Appendix D of this manual and later in this section.)

The fire code requires that flammable liquids be stored in rated storage cabinets when they are not in use. These are typically double walled metal cabinets stamped with the "FM" (Factory Mutual) rating. They are designed to protect the flammables inside from fires in the lab.

- The total amount of flammable material allowed in any lab is limited by code; never store more than you can fit in your rated cabinets.
- Small volumes (2 liters or less) can be stored in standard cabinets away from heat or ignition sources.

Never store hazardous chemicals under sinks, overhead, on countertops, on the floor, or on open shelves. Specially designed cabinets are best, but cabinets with doors are acceptable.

Use appropriate plastic bins (available from EHS) as secondary containment for liquids and to segregate incompatible materials. Contact EHS for assistance.

Purchase the smallest chemical container necessary. Don't be tempted to buy a large bottle because pricing discounts are offered for a high-volume purchase. This practice is wasteful if, eventually, the remaining material is disposed of as hazardous waste. Not to mention the expense of the disposal. Smaller bottles will also take up less storage space in the lab.

16.4 Chemical Storage

Storage by compatibility

Store chemicals in the laboratory according to their compatibility. Do not store chemicals in alphabetical order, as this might place incompatible chemicals next to each other (examples include acetic acid and acetaldehyde, sodium cyanide and sulfuric acid, and sodium borohydride and sodium chlorate), increasing the potential for accidental mixing of incompatible chemicals. Incompatible chemicals should be stored separately, especially chemicals with an NFPA 704 or HMIS reactive rating of 3 or higher, and in dedicated and labeled cabinets. Within any compatibility group, you can arrange chemicals alphabetically to facilitate ease of retrieval. The following are recommended compatibility groupings:

Group 1 - Acids, Inorganics

Store acids in acid/corrosive cabinets. Place acids in plastic trays for secondary containment in case of breakage. Segregate inorganic and oxidizing acids from organic compounds, including organic acids (e.g., acetic acid) and other combustible materials. Segregate nitric acid (>40%) from organic chemicals, including organic acids. Store acids separate from bases and other reducing agents. Inorganic salts, except those of heavy metals, may be stored in this group. Glacial acetic acid should be stored with acids but physically segregated.

Storage Reminders

- Segregate organic and inorganic acids.
- Segregate oxidizing acids from organic acids and flammable and combustible materials.
- Segregate acids from bases.
- Segregate acids from reactive metals such as sodium, potassium, and magnesium.
- Store acetic acid as a corrosive liquid. This organic (carboxylic) acid will react if it encounters an oxidizing acid and must be physically segregated in a pail/bin. (Alternatively, store it in the flammable cabinet but physically segregate it)
- Nitric acid and hydrochloric acid may be stored in the same corrosive storage cabinet but must be kept in separate bins. These can combine to form chlorine and nitrosyl chloride gases, which are toxic.
- Segregate acids from chemicals that could generate toxic or flammable gases upon contact, such as sodium cyanide, iron sulfide, and calcium carbide.

Group 2 - Bases

Segregate bases from acids and oxidizers. The preferred storage container for inorganic hydroxides is polyethylene instead of glass. Place containers in trays for secondary containment in case of leakage or breaks.

Storage Reminders

- Segregate bases from acids, metals, explosives, organic peroxides, and easily ignitable materials.
- Do not store aqueous sodium and potassium hydroxide solutions in aluminum bins. These will corrode aluminum.

Group 3 - Organic chemicals

Segregate organic compounds from inorganics. Organics and inorganics with NFPA 704 or HMIS reactive hazard rating of two (2) or less may be stored together. Chemicals with a reactive hazard rating of three (3) or four (4) will be stored separately.

Group 4 - Flammable and Combustible Organic Liquids

Store flammable and combustible materials away from sources of ignition such as heat, sparks, or open flames, physically segregated from oxidizers, and within flammable storage cabinets.

Storage Reminders

- Store in approved safety cans or flammable cabinets.
- Segregate from oxidizing acids and oxidizers.
- Keep away from any source of ignition: heat, sparks, or open flames.

- Only laboratory-safe, explosion-proof, or certified flammable liquid refrigerators can store solvents. Never store flammable liquids in a domestic refrigerator (very small amounts of 1 pint or less are acceptable in a standard refrigerator).

Group 5 - Inorganic Oxidizers and Salts

Store inorganic oxidizers in a cool, dry place away from combustible materials such as zinc, alkaline metals, formic acid, and other reducing agents. Inorganic salts may also be stored in this group. Store ammonium nitrate separately.

Storage Reminders

- Keep away from combustible and flammable materials.
- Avoid reducing agents such as zinc, alkali metals, hydrazine, oxalic acid, and formic acid.

Group 6 - Organic Peroxides and Explosives

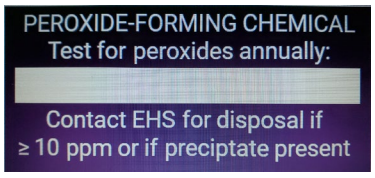
They are shock and heat sensitive (e.g., benzoyl peroxide), and readily decompose in storage. Store shock and heat-sensitive chemicals in a dedicated cabinet.

Some non-peroxide chemicals can readily form shock-sensitive, explosive peroxides when stored in the presence of oxygen. Examples include ethyl ether, tetrahydrofuran, and cumene. Dispose of or use these by their expiration date. See section 15 for information on safe storage of peroxidizable compounds.

Common explosive compounds include 2,4,6-trinitrotoluene (TNT), nitroglycerin, and several metal fulminates and azides. 2,4,6-trinitrophenol, or picric acid, is normally sold as a saturated solution containing at least 40% water and classified as a flammable solid. If allowed to dry to less than 10% water, picric acid becomes a DOT Class 1.1 explosive. In research, nitroglycerin is usually sold as a tincture mixed with alcohol, but if the alcohol evaporates, the result is explosive nitroglycerin. Please get in touch with EHS if you use or handle compounds that are explosive or can become explosive with age or evaporation.

Storage Reminders

- Most peroxide-forming chemicals are also flammable liquids. Therefore, store them in airtight containers in a flammable storage refrigerator.
- Segregate from oxidizers and acids.
- **Test at least annually for peroxide formation by purchasing test strips.**



- (See section 14.1 and Appendix I)

Group 7 - Reactives

Water Reactives

Store water reactives in a cool, dry place protected from water sources. Alkali metals (lithium, sodium, potassium, rubidium, and cesium) should be stored under mineral oil or in waterproof enclosures such as glove boxes. Be aware of atmospheric conditions such as high humidity. A Class D fire extinguisher should be available in case of fire. Contact EHS if one is not available in your laboratory. As an added precaution, store containers in trays or other sand-filled secondary containers.

Pyrophorics (Air Reactives)

Store pyrophorics in a cool, dry place and provide an airtight seal. Store white or yellow phosphorus underwater in glass stoppered bottles inside a metal can for added protection.

Storage Reminders

- Store in a glove box or explosion-proof refrigerator after the material has been opened.

Group 8 - Cyanides and Sulfides

Cyanides and sulfides react with acids to release highly toxic gases. They must be isolated from acids and other oxidizers.

Storage Reminders

- Segregate from aqueous solutions, acids, and oxidizers.

Group 9 - Carcinogens, Highly Toxic Chemicals, and Reproductive Toxins

The preferred storage method is a dedicated lockable storage cabinet for carcinogens and highly toxic chemicals. Stock quantities of reproductive toxins are to be stored in designated storage areas. Use unbreakable, chemically resistant secondary containers. Post the storage cabinet with a sign stating, “CANCER SUSPECT AGENT”, “HIGHLY TOXIC CHEMICALS”, or “REPRODUCTIVE TOXINS”. Maintain a separate inventory of all highly acute toxins, carcinogens, and reproductive toxins. See section 12 for a listing of reproductive toxins and common carcinogenic and highly toxic chemicals.

Compatibility Group	Group Name	Chemical Class
Group 1	Acids, Inorganics	Inorganic acids (except nitric), sulfur, arsenic, halides, sulfates, sulfites, thiosulfates, halogens, phosphorus, phosphates
Group 2	Bases	hydroxides, oxides, silicates, carbonates
Group 3	Organic Chemicals	alcohols, glycols, amines, amides, hydrocarbons, esters, aldehydes, phenol cresols, organic sulfides, organic acids
Group 4	Flammable and Combustible Organic Liquids	ethers, aliphatic solvents, aromatic solvents
Group 5	Inorganic Oxidizers and Salts	borates, chromates, manganates, permanganates, chlorates, perchlorates, chlorites, hypochlorites, hydrogen peroxides, amides, nitrates, nitrites, azides
Group 6	Organic Peroxides and Explosives	peroxides, azides, hydroperoxides
Group 7	Reactives	air and water reactives, metals and hydrides
Group 8	Cyanides and Sulfides	cyanides, cyanates, sulfides, carbides, nitrides
Group 9	Carcinogens, Highly Toxic, Reproductive Toxins	highly toxic compounds, carcinogens, mutagens, teratogens

16.5 Storage locations

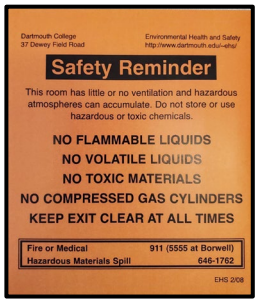
Ideally, incompatible chemicals such as acids and alkalis would be stored separately to prevent mixing in the event of an accidental spill or release of the materials. Due to limited storage space within the laboratories, however, this isn't always possible. If space is limited, you can store incompatible chemicals in the same storage cabinet if you segregate the chemicals according to their hazard class and store them in tubs, trays, or buckets while in the cabinet. These secondary containers reduce the chance that incompatible chemicals will inadvertently contact each other.

1. Laboratory fume hoods are not a location for long term chemical storage.
    - Fume hood storage should be limited to "in use" materials.
    - Upon completion of your work, chemicals must be returned to their normal storage area.
    - Storage of chemicals in fume hoods can block and disrupt air flow and affect hood capture.

2. Flammable solvents that require storage at reduced temperatures must be stored in refrigerators or freezers designed for storing flammable liquids, or "explosion-proof" refrigerators.

   - **Ordinary household refrigerators are inappropriate for storing flammable liquids because of interior arcing contacts. All chemicals should have tightly sealed caps because refrigerators and freezers have no interior space venting.**
     - If flammable solvent must be kept cold and the lab does not have an "explosion-proof" refrigerator, a single small bottle (1 pint or less) may be stored in a standard refrigerator temporarily but should then be removed upon completion of the experiment.
     - NO FOOD OR BEVERAGES MAY BE STORED IN ANY LAB REFRIGERATOR

3. Environmental rooms, such as cold and warm rooms, have closed air circulation systems that recirculate escaped vapors within the chamber. The refrigeration coils in cold rooms are aluminum and subject to damage from corrosive atmospheres.
   - **<u>Cold rooms are unacceptable storage areas for corrosives, flammables, dry ice, highly toxic chemicals, radioactivity, or compressed gases.)</u>**
   - To the right is the warning label used on Dartmouth environmental rooms



4. Cabinets - You can use cabinets under hoods and laboratory benches to store chemicals. In some cases, laboratory furniture manufacturers design cabinets specifically for storing flammable and/or corrosive materials. However, laboratory chemicals should not be stored near or under sinks where there may be exposure to water. Storage of cleaning supplies under sinks is acceptable. Cabinets for chemical carcinogens or highly toxic chemicals should have a lock. Regulations of the Drug Enforcement Administration and the Bureau of Alcohol, Tobacco, Firearms, and Explosives require locked storage for controlled substances and some specific explosive compounds.

5. Desiccator jars and cabinets are useful for storing air and water-reactive, toxic, and malodorous chemicals. For especially malodorous compounds such as mercaptans, replace the desiccator material with a vapor adsorber (e.g., charcoal) to control odors.

6. Benchtops and shelves for chemical storage are undesirable and are vulnerable to accidental breakage by the laboratory, housekeeping, and emergency response personnel. Do not store liquids or highly toxic materials on shelves above eye level. When storing chemicals on open shelves, consider several factors such as compatibility grouping, the container material, the physical state of the chemical (it's riskier to store liquids on open shelves compared to solids), the relative toxicity of the chemical, and the height and depth of the shelving.

17 Transportation of Hazardous Chemicals

Transportation of chemicals is one of the most hazardous aspects of chemical use. Careful planning and execution of chemical movements are crucial to avoiding a hazardous material spill or incident. This section details reminders regarding chemical moves. Contact EHS with any questions at 603-646-1762 or ehs@dartmouth.edu

- *Hand Transportation*:
  - The transportation of hazardous chemicals by hand (e.g., walking while carrying chemicals or pushing them on a hand cart) is appropriate within buildings or between interconnected buildings within the Dartmouth controlled properties, and if appropriate PPE and packing/secondary containment are met (see below).
  - If an elevator is used to move an asphyxiant, avoid passenger elevators if possible. A freight or service elevator should be used and never ride with material.
  - If a passenger elevator is required, no passengers may ride in the elevator between floors. Work as a team to ensure no others enter the elevator and have someone ready to receive the material on the correct floor.

- *Packaging/Secondary Containment*:
    - Hazardous chemicals in unopened Department of Transportation (DOT)-approved packaging may be carried by hand or transported on a hand cart.
    - Hazardous chemicals not in DOT-approved packaging may be transported by hand if their volume is no greater than 500 ml. If the volume is greater than 500 ml, a bottle carrier or handcart is required.
- *Transportation and PPE*:
    - When transporting between labs via hallways, stairways, or elevators, PPE needs to be worn; however, remember that only one glove or no gloves should be worn when opening doors or pushing elevator buttons to limit the contamination outside the lab.
- *Transporting of Gas Cylinders*:
    - Gas cylinders must only be moved with the safety cap on and if the person moving them is physically able. Sufficient physical strength and balance are needed to move gas cylinders.
    - If the distance is greater than 2 feet, a gas cylinder cart is needed for transport. Cylinders must be properly secured to the cart before being moved. Transporting cylinders outside the lab or between buildings must only be done by Airgas or a similar licensed contractor.
    - Gas cylinders must never be stored on gas cylinder carts, which are only used for transporting.
- *Vehicular Transport*:
    - Transport of hazardous materials in motor vehicles is strictly regulated by the US Department of Transportation (DOT; CCR Title 49 Subtitle B Chapter I).
    - Transport of hazardous materials by laboratory personnel using motor vehicles is NOT allowed, except under the limited conditions specified in 49 CCR § 173.6 "materials of trade exceptions" (MOTs).
- *Mailing of Hazardous Materials*:
    - Hazardous materials may NOT be sent using Hinman mail service.
    - Sending of hazardous materials by parcel carriers (UPS, FedEx, etc.) is heavily regulated (49 CFR, IATA, etc.), including stringent documentation, packing, and labeling requirements.
    - There are registration and training requirements to be approved by your shipping company as an originator of hazardous shipments.
    - There may be less onerous "limited quantity" and excepted quantity shipping options available for small size shipments such as samples for analysis.
    - Contact your shipping company for more information and follow all of their hazardous material shipping requirements. **The liability and potential fines for shipping hazardous materials incorrectly can be severe.**

18 Solvent Purification and Distillation Units

Dartmouth College has adopted a policy of purifying all solvents through solvent purification columns that do not use heat or drying agents (e.g., potassium or sodium). This avoids the high-risk thermal solvent distillation procedures that may lead to fires, explosions, or personnel exposures. Solvent purification columns have proven their ability to provide dry and pure solvent.

The steps outlined below address basic procedures for the setup and operation of solvent purification columns at Dartmouth College.

18.1 Common Hazardous Chemicals Purified on Site

- Flammable Liquids: Tetrahydrofuran (THF), Diethyl ether, Toluene, Dimethylformamide (DMF), Benzene, Ethyl Acetate, and Hexanes.
- Toxic Liquids: Methylene Chloride (MeCl, dichloromethane or DCM)

18.2 Required Personal Protective Equipment

- Eye Protection: Chemical splash goggles or face shield
- Protective Clothing: Flame-resistant lab coat, closed-toe shoes, nitrile gloves (4 mm thick single-use or 16 mm thickness optional)

18.3 Engineering / Ventilation Control

- The solvent purification system must be installed with a rated FM/UL flammable liquid storage cabinet or inside a functioning chemical fume hood.
- Ensure that all heat generating equipment has over temperature shut off controls installed.
- Ensure a reliable supply of low-pressure (<20 PSI) dry inert gas (e.g. nitrogen or argon) to eliminate the chance of ignition in the systems.

18.4 Special Handling Procedures and Storage Requirements

- Follow all manufacturer/provider guidance on installation and use.
- If using glassware, inspect for defects before use.
- Benzene and methylene chloride are confirmed human carcinogens - avoid inhalation and skin contact. Both must be handled inside the fume hood.
    - Methylene chloride can pass through nitrile gloves (polyvinyl alcohol rubber is best), and there is no approved respirator for this solvent.

- Ensure all storage containers are labeled with the name and any hazard warning (e.g., flammable, toxic). Store the flammables in FM/UL-rated flammable storage cabinets before they are transferred into the distillation flask.
- The ethers (glyme, THF, ether, dioxane) can form explosive peroxides when exposed to air and stored for a time. They must be tested periodically or if they are over one year old. Contact EHS ehs@dartmouth.edu for assistance.
- Use secondary containment carriers whenever transporting hazardous material outside of the lab. Use due care and caution when moving hazardous materials.
- Solvent or silica gel used in these systems is regulated as hazardous waste when disposed of. Label and contain waste properly and contact EHS to request waste pick up.

18.5 Exemptions

Exemptions to this policy may be approved on a case-by-case basis. Requests must be in writing, including specific procedures, and be signed by the PI, department chair/dean, and EHS.

19 Additive Manufacturing (3D Printing)

3D printing, a form of additive manufacturing, has become increasingly popular due to its affordability and versatility. It is now widely used in laboratories, offices, workshops, maker spaces, and even residential environments such as dorm rooms and apartments. This technology allows users to create three-dimensional objects by depositing material layer by layer, often using thermoplastics that are heated and extruded through a nozzle.

However, many 3D printers lack built-in exhaust ventilation or filtration systems, which can lead to the release of airborne particles and volatile organic compounds (VOCs) during the printing process. These emissions may pose health risks if inhaled, making it essential to carefully consider the location of the printer and the selection of printing materials. Additionally, the specific hazards associated with 3D printing depend on factors such as the type of printer, the chemical composition of the filaments or resins used, and any post-processing techniques, such as sanding or chemical smoothing, that may generate additional risks. Proper safety measures, including adequate ventilation, material handling precautions, and personal protective equipment, are necessary to mitigate these potential hazards.

The **Additive Manufacturing Safety Program** at Dartmouth College aims to protect students, faculty, and staff by assessing risks, providing safety guidelines, and ensuring compliance. This program applies to all 3D printers used across disciplines, and a copy is available on the **EHS homepage**. For questions, contact **Environmental Health and Safety at 603-646-1762 or** ehs@dartmouth.edu.

20 Waste Management

20.1 Hazardous Waste Disposal

Dartmouth College is committed to meeting all federal, state, and local regulations in the management of hazardous materials, including hazardous waste.

Responsibility for compliance with hazardous waste regulations begins with the waste generator (Trustees of Dartmouth College, the Hazardous Waste Manager [Environmental Health and Safety], and all individuals who generate and/or handle hazardous waste at the College) and remains the responsibility of the College forever – from generation to collection and finally disposal by a licensed vendor. **Dartmouth College is responsible for any hazardous waste it generates in perpetuity.**

All laboratory personnel must follow hazardous waste management rules and regulations when working with hazardous chemicals. Please refer to the Hazardous Waste Guide for Research Areas found on the EHS homepage for specific waste disposal rules. The Guide includes information on the disposal of chemical, radiological, and biological wastes.

Disposal of hazardous waste via drains, evaporation, or standard trash is strictly forbidden and a violation of hazardous waste rules, both State and Federal.

20.1.1 Hazardous Chemical Waste Collection

1. Apply a completed green hazardous waste label to each container as soon as you first add waste.
2. Identify all constituents in the waste by full name.
    a. NO ACRONYMS, FORMULAS, OR BRAND NAMES
3. Do not mix incompatible wastes. Keep segregated.
   Containers must be closed except when adding waste. Caps must be tight.
4. Liquid waste must be in secondary containment.
5. Store waste 'at or near the point of generation'. Do not relocate containers to other rooms, etc.

Process waste containers (e.g., HPLC) must have a cap with tight fitting hole for the fill tube. **Request a waste pick up from EHS after the containers reach 3/4 full.**

20.1.2 Hazardous Chemical Waste Disposal

E-mail: ehs@Dartmouth.edu with the following information:

1. Your name and the name of the Principal Investigator.
2. Location of the Waste (Room number and location within the room).
3. Description of waste contents.
4. Volume of waste.

20.1.3 Radioactive Waste Collection

Refer to the Hazardous Waste Disposal Guide for detailed information

20.1.4 Radioactive Waste Disposal

Radioactive waste disposal is arranged through BioRAFT. Log in to BioRAFT and complete the online form. EHS will collect the waste following completion of the request.

20.1.5 Biological Waste

Refer to the Hazardous Waste Disposal Guide or Biohazard Waste Guide for detailed information

For waste disposal questions, please contact EHS at 603-646-1762

21 Biological Hazards

For all biological safety information, please refer to the EHS homepage, which includes information on policies, injury reporting, animal biosafety, the Institutional Biosafety Committee, biological safety cabinets, biological shipping, and biological work registration through BioRAFT.

21.1 Special Note on Select Agent Toxins and Biological Toxins

Some toxins are subject to additional controls through the CDC and the Department of Agriculture. These laws and policies are intended to:

1. Safeguard the use, disposal, transport, and storage of these agents.
2. Collect and provide information on the location and movement of select agents.
3. Establish a procedure to alert authorities if unauthorized access to these agents occurs or is attempted.

At Dartmouth College, all Select Agent work (including work with exempt quantities of toxins) must be authorized by the Institutional Biosafety Committee (IBC). All requests to obtain, use, and dispose of Select Agents must go through the Biological Safety Officer in EHS.

The select agent list and relevant regulatory program information are maintained by the CDC and can be found on the select agent website http://www.selectagents.gov/. The regulations covering select agents include the Code of Federal Regulations, *Title 7, Part 331 (agriculture), Title 9, Part 121 (animals and animal products), and Title 42, Part 73 (public health).*

For more information, see IBC Policy 120: Select Agents and Toxins, available on the EHS website.

For questions, please contact the Biological Safety Officer at 603-646-1762.

21.2 Autoclave Safety

Autoclave use can pose physical hazards (e.g., heat, steam, and pressure) and biological hazards (e.g., improperly autoclaved infectious materials). This section provides basic guidance on the safe operation of autoclaves.

TRAINING

The PI/Supervisor for each laboratory shall ensure personnel are provided with safety training before operating an autoclave. All training must be documented, and the records must be maintained in the lab with other safety training.

At a minimum, training must cover the safety guidance provided in this section as well as the operating instructions in the user manual for the specific model of autoclave.

GENERAL AUTOCLAVE SAFETY PRACTICES

Do not autoclave items containing corrosives, solvents, volatiles, toxic, or radioactive materials.

Prior to loading

1. Before using the autoclave, check inside the autoclave chamber for any items left by previous users that could pose a hazard.
2. Ensure that the drain strainer is clean before loading the autoclave.
3. Ensure that the door gaskets are still intact and pliable.

Loading the Autoclave

1. Load the autoclave as per the manufacturer's recommendation. DO NOT overload the autoclave.
2. All materials (e.g., bags, glassware, etc.) must be placed in a stainless tray provided by EHS on a shelf or rack, and never placed directly on the autoclave chamber bottom or floor.
3. Make sure that the door of the autoclave is fully closed and latched, and ensure that the correct cycle for the items being autoclaved has been selected before starting the cycle.

Opening the Autoclave

1. Wear the proper PPE, including:

    - Heat resistant gloves and arm sleeves.
    - Rubber apron– If no hot liquids are involved, a lab coat is sufficient.
    - Eye protection.
    - Face shield (when hot liquids are handled).
    - Closed-toe shoes and long pants.

2. Open the door slowly. Keep your head, face, and hands away from the opening.

3. Allow materials inside the autoclave to cool for at least 10 minutes with the door open before unloading the autoclave. Removing contents too soon may cause heat stress and fracturing of materials, especially glass.

MONITORING

Autoclave operators shall ensure that each autoclave is monitored as follows:

Heat Sensitive Tape Monitoring – Operators shall use heat sensitive sterilization indicator tape for **each load** to indicate that the load has undergone an effective steam sterilization process.

Note that this tape only indicates that the proper temperature for the cycle has been reached, but does not indicate that it was heated at the proper pressure or for the appropriate length of time.

Ensure that the heat sensitive tape used does not contain a lead-based indicator, as this type of tape must be collected and managed as hazardous waste.

INSPECTION AND MAINTENANCE

Manufacturer-recommended periodic inspection and preventive maintenance shall be conducted by Facilities, and recordkeeping shall be maintained.

EMERGENCY PROCEDURES

If an injury occurs during autoclave use, seek prompt medical attention.

Report the incident to your supervisor and fill out an employee injury report.

Biological Indicators

Operators who autoclave medical/ biohazardous orange bag waste must do the following:

At least four times per year, EHS will supply the lab with biological test indicators to be placed at the center of a load processed under standard operating conditions to confirm adequate sterilization.

ADDITIONAL PRACTICES FOR AUTOCLAVING LIQUIDS

When running an autoclave cycle with liquids, the cycle time is longer but uses lower temperatures to minimize evaporation of the liquids. Liquid cycles also have a longer depressurization time to avoid "boil-over" of liquids.

1. To prevent bottles from shattering during pressurization and heating, the caps of containers with liquids must be loosened before loading.
2. Use only borosilicate glass (Pyrex™ or Kimax™), which can withstand the high autoclave temperatures.
3. Liquids should be within a stainless steel autoclave tray containing an inch of water, to ensure even heating.
    a. Bottles of liquid should not be more than 2/3 full.
    b. Keep 1-2 inches of space between bottles.
4. After unloading from the autoclave, let the liquids cool for at least a full hour before touching with ungloved hands. Be sure to let others in the area know that a heat hazard is present.

ADDITIONAL PRACTICES FOR AUTOCLAVING DRY LOADS

1. Add ~250ml of water to the bagged waste to ensure adequate steam is generated.
2. Check plastic materials to ensure that they are compatible with being autoclaved.
    a. For example, polyethylene plastics (LDPE and HDPE) cannot be autoclaved.
3. After unloading from the autoclave, let the materials cool for a minimum of 15 minutes before touching with ungloved hands.

AUTOCLAVE FAILURE

Discontinue use immediately if an autoclave is not working properly. Post a sign alerting others not to use the autoclave.

Mechanical failures need to be attended to by a trained technician. Contact facilities if they arrange for the repair of your autoclave; otherwise, contact your autoclave contract service.

22 Radiological Hazards (Ionizing and Non-Ionizing)

For all radiological safety information, please refer to the EHS homepage, which will include information on isotopes, lasers, X-rays, MRIs, the Radiation Safety Committee, Radiation Safety Handbook, badge requests, pregnancy policy, use applications, and training through BioRAFT.

For questions, please contact the Radiation Safety Officer at 603-646-1762 or ehs@dartmouth.edu

23 Laboratory Move and Closure

EHS has a prescribed process for laboratory moves and closures to ensure all hazards have been removed from the laboratory. Appendix J (Laboratory Move or Closure Guidelines) details those steps laboratory personnel need to follow in preparation for vacating a laboratory space.

Contact EHS with any questions at 603-646-1762.

24 Appendices

24.1 Appendix A: OSHA Laboratory Safety Chemical Hygiene Plan Fact Sheet

OSHA® FactSheet

Laboratory Safety Chemical Hygiene Plan (CHP)

OSHA's Occupational Exposure to Hazardous Chemicals in Laboratories standard (29 CFR 1910.1450), referred to as the Laboratory standard, specifies the mandatory requirements of a Chemical Hygiene Plan (CHP) to protect laboratory workers from harm due to hazardous chemicals. The CHP is a written program stating the policies, procedures and responsibilities that protect workers from the health hazards associated with the hazardous chemicals used in that particular workplace.

Required CHP Elements

1. Standard operating procedures relevant to safety and health considerations for each activity involving the use of hazardous chemicals.
2. Criteria that the employer will use to determine and implement control measures to reduce exposure to hazardous materials [i.e., engineering controls, the use of personal protective equipment (PPE), and hygiene practices] with particular attention given to selecting control measures for extremely hazardous materials.
3. A requirement to ensure that fume hoods and other protective equipment are functioning properly and identify the specific measures the employer will take to ensure proper and adequate performance of such equipment.
4. Information to be provided to lab personnel working with hazardous substances include:
   - The contents of the Laboratory standard and its appendices.
   - The location and availability of the employer's CHP.
   - The permissible exposure limits (PELs) for OSHA regulated substances or recommended exposure limits for other hazardous chemicals where there is no applicable OSHA standard.
   - The signs and symptoms associated with exposures to hazardous chemicals used in the laboratory.
   - The location and availability of known reference materials on the hazards, safe handling, storage and disposal of hazardous chemicals found in the laboratory including, but not limited to, the Material Safety Data Sheets received from the chemical supplier.
5. The circumstances under which a particular laboratory operation, procedure or activity requires prior approval from the employer or the employer's designee before being implemented.
6. Designation of personnel responsible for implementing the CHP, including the assignment of a Chemical Hygiene Officer and, if appropriate, establishment of a Chemical Hygiene Committee.
7. Provisions for additional worker protection for work with particularly hazardous substances. These include "select carcinogens," reproductive toxins and substances that have a high degree of acute toxicity. Specific consideration must be given to the following provisions and shall be included 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.
8. The employer must review and evaluate the effectiveness of the CHP at least annually and update it as necessary.

Worker Training Must Include:

- 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.).
- The physical and health hazards of chemicals in the work area.

- The measures workers can take to protect themselves from these hazards, including specific procedures the employer has implemented to protect workers from exposure to hazardous chemicals, such as appropriate work practices, emergency procedures, and personal protective equipment to be used.
- The applicable details of the employer's written CHP.

Medical Exams and Consultation

The employer must provide all personnel 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:

- Whenever a worker develops signs or symptoms associated with a hazardous chemical to which the worker may have been exposed in the laboratory, the worker must be provided an opportunity to receive an appropriate medical examination.
- 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 must be established for the affected worker(s) as prescribed by the particular standard.
- 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 worker(s) must be provided an opportunity for a medical consultation to determine the need for a medical examination.
- All medical examinations and consultations must be performed by or under the direct supervision of a licensed physician and be provided without cost to the worker, without loss of pay and at a reasonable time and place.

For additional information on developing a CHP, consult the following sources:

- View the complete standard at the OSHA Web site, www.osha.gov.
- Appendix A of 29 CFR 1910.1450 provides non-mandatory recommendations to assist in developing a CHP.

This is one in a series of informational fact sheets highlighting OSHA programs, policies or standards. It does not impose any new compliance requirements. For a comprehensive list of compliance requirements of OSHA standards or regulations, refer to Title 29 of the Code of Federal Regulations. This information will be made available to sensory-impaired individuals upon request. The voice phone is (202) 693-1999; the teletypewriter (TTY) number is (877) 889-5627.

For assistance, contact us. We can help. It's confidential.

OSHA FS-3461 8/2011
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24.2 Appendix B: Lab Safety Inspection Form

EHS Comprehensive Lab Safety Inspection Quick Sheet

Logged into BioRAFT:

BIOLOGICAL	YES	NO	N/A
Is the lab free of obvious animal care concerns?			
Are all aspiration traps properly set up and maintained?			
Is all potentially biohazardous equipment labeled with the biohazard symbol?			
Are all biosafety cabinets currently certified?			
Is the lab's biological safety cabinet inventory on BioRAFT correct?			
Are all biosafety cabinets orderly and used properly?			
In BSL-2/2+ laboratories, do centrifuges have sealed rotors or safety cups?			
Are centrifuges and rotors used for biological material kept clean and periodically decontaminated?			
Are biological lab chairs non-porous (especially BSL-2/2+)?			
Is all liquid biological waste properly disinfected prior to disposal?			
Is the lab free of additional biosafety concerns not listed here?			
Is all solid, non-sharp biohazardous waste properly stored, then promptly autoclaved or boxed for incineration?			

CHEMICAL	YES	NO	N/A
Are all chemical containers compatible with their contents, intact, and clearly labeled?			
Are all compressed gas cylinders secured at all times and capped when not in use?			
Are fume hoods clean, organized for proper airflow, and closed when not in use?			
Are hazardous chemicals appropriately stored and segregated?			
Are all hazardous chemical waste containers properly stored and labeled?			
If the lab has hydrofluoric acid, is calcium gluconate gel (Calgonate) available?			
If the lab uses liquid nitrogen, are proper PPE available and used?			
Is the lab free of additional chemical safety concerns not listed here?			
Have all peroxide-forming chemicals been tested for peroxides within the past year?			
Are all the lab's chemicals and compressed gas cylinders in use or usable in the foreseeable future?			

GENERAL	YES	NO	N/A
Is the lab's IBC registration current or in the process of renewal?			
Is the lab's chemical registration current (for labs not inventoried in CEMS)?			
Is the lab's "Contact Info" section on BioRAFT complete and up to date?			
Are the lab's door signs accurate and up to date?			
Is the lab's radioactive material authorization current or being renewed?			
Are the lab member list and job activities up to date?			
Are all lab members up to date with required EHS training?			
Are electrical sources and equipment kept away from water?			
Are all electrical panels accessible and clear for at least three feet in front?			
Are electric cords in good condition and used properly?			
Does the lab have a working sink with soap and towels (or for clean rooms, nearby access)?			

Are an eye wash, emergency shower, and first aid kit available and maintained?			
Is bench paper clean and used appropriately?			
Are clean benches used only with non-hazardous materials?			
Is the lab's equipment in shared spaces labeled with names and contact information?			
Is a serviced fire extinguisher available nearby, easily located, and do lab members know where to find it and how to use it?			
Are floors, walls, and ceilings in good condition and free of spills, signs of leaks, obvious mold, structural problems, etc.?			
Is food and drink absent from the laboratory?			
Is the lab generally orderly and well-organized?			

	YES	NO	N/A
Do personnel wear appropriate clothing and PPE?			
Is the lab free of additional general safety concerns not listed here?			
If the lab ships hazardous materials, is at least one person designated and trained?			
Does the lab have at least one multipurpose chemical spill kit, or more as needed in different rooms?			
Are walkways kept clear of trip hazards and do they allow easy egress in the event of emergency?			
Is broken or non-recyclable glass disposed of in glass boxes?			
Is the general trash free of any hazardous material?			
Are sharps such as needles, syringes, razors, and scalpels disposed of in proper sharps bins?			
Is general trash and universal waste labeled and disposed of properly?			
RADIATION	YES	NO	N/A
If performed, do EHS swipes/surveys show compliance with ALARA?			
Is the lab’s laser and X-ray equipment inventory on BioRAFT correct?			
Is the lab free of additional radiation safety concerns not listed here?			
Are all radioisotope containers and associated equipment labeled?			
Are the lab’s RAM use logs available and maintained?			
Are both RAM postings conspicuous and current?			
Is radioactive material stored in a locked container (cabinet, freezer, etc.) and is the laboratory locked when not occupied?			
Does the lab have access to appropriate, serviced survey equipment for the radioisotopes being used, and are personal or room badges used correctly?			
Is radioactive waste properly contained and labeled?			
Are radiation-use areas clearly marked and/or protected?			
If any lab members use X-ray equipment, are they listed as users for that machine in BioRAFT, or for electron microscopes are they in the training log?			

Inspected by

24.3 Appendix C: Documentation of Training

Laboratory Safety Training Documentation
Date:_____ Principal Investigator(s):_____
Topic(s):_____
Presenter(s):_____

Printed Name	Signature	PI/Supervisor

Topics covered by training:

- ☐ **Review of CHP**
- ☐ **Health hazards of chemicals used**
- ☐ **Physical hazards of lab operations**
- ☐ **The SOPs for the laboratory**
- ☐ **SDS Location and interpretation**
- ☐ **Emergency response (spills, fire, or service interruptions)**
- ☐ **PPE selection and use**
- ☐ **Use of a fume hood**
- ☐ **Other engineering controls**
- ☐ **Chemical inventory control**
- ☐ **Chemical exposure symptoms**
- ☐ **Other _____**

_____

Remember: Include a brief description of the curriculum or topics covered in the section above, or attach a description of the material covered. Photocopy the title of any videos shown or include literature references for material covered.

24.4 Appendix D: Safe Storage of Hazardous Chemicals

Basic chemical segregation

CLASS OF CHEMICAL	RECOMMENDED STORAGE METHOD	EXAMPLES	INCOMPATIBILITIES – CONSULT SDS IN ALL CASES
Corrosives-acids	Separate acid storage cabinet	Mineral acids, hydrochloric acid, sulfuric acid, nitric acid, perchloric acid and chromic acid	Flammable liquids, oxidizers, poisons and bases
Corrosives-bases	Separate corrosive storage cabinet	Ammonium hydroxide and sodium hydroxide	Flammable liquids, oxidizers, poisons and acids
Flammable liquids	Grounded flammable storage cabinet	Acetone, benzene, diethyl ether, methanol, ethanol and toluene	Acids, bases, oxidizers and poisons
Flammable solids	Separate storage cage in dry, cool area	Phosphorus	Acids, bases, oxidizers and flammable liquids
General non-reactive	General shelving, preferably behind glass doors or below eye level	Sodium chloride and sodium bicarbonate	Consult SDS
Oxidizers	Separate metal storage cabinet	Sodium hypochlorite, peroxides, perchlorates, chlorates, nitrates, bromates and superoxides	Flammables, combustibles and reducing agents
Poisons	Separate area that is cool and dry within unbreakable containers	Cyanides and heavy metal compounds such as lead, cadmium and mercury	Flammable liquids, corrosives and oxidizers
Water reactive	Separate area that is cool and dry in water-tight cabinet	Sodium metal, potassium metal and lithium metal	All water-based compounds and oxidizers

24.5 Appendix E: High Hazard Lab Chemical Operations Form

HIGH HAZARD LAB OPERATIONS FORM

For work requiring prior approval as defined in the OSHA lab standard and the Chemical Hygiene Plan.
Refer to form key for help completing this form

1. Contact Information

A. PI:		B. Department:	
C. Work Location:		D. Room Number:	
E. Phone Number:		F. 24 Hour Emergency Number:	

2. Substance Information

A. Chemical Name/Synonyms:
B. CAS#:
C. Label Hazard Statements/Pictograms:
D. Chemical Source:
E. Description of Use:
F. Quantity Purchased:
G. Storage Location: Other:
H. Amount Used Per Experiment:
I. Concentration Used Per Experiment:
J. Nature of the Hazards:

3. Procedure

4. Exposure Controls

A. Administrative and Engineering Controls:

B. Personal Protective Equipment (Check all that apply):

☐ Safety Glasses ☐ Chemical Splash Goggles ☐ Face Shield ☐ Lab Coat

☐ Gloves - (Type):

☐ Apron ☐ N95 ☐ Respirator (Requires EHS Approval)

☐ Other (Describe):

5. Spills, Decontamination & First Aid

A. Spill Clean Up and Decontamination:

B. First Aid:

6. Waste Disposal

A. Type of Waste Generated (Check all that apply):

☐ Liquid ☐ Dry ☐ PPE ☐ Contaminated glassware/equipment

☐ Mixed Hazard (Rad, Bio, Chem) Specify mixture:

B. Expected Waste Volume Per Experiment:

C. Waste Handling:

7. Investigators Statement

The information supplied above is complete and accurate in regard to the procedures and materials to be used in this project. All personnel working on the project with the described material will receive training in all procedures and hazards prior to beginning work with the material. The below signed individuals agree to follow designated laboratory procedures and Dartmouth EHS safety policies.

A. Persons to be Authorized and Trained for this procedure

Name	Title	Signature
	PI	

Form Key

This key is intended as an aid in filling out the High Hazard Laboratory Operations Form. Those operations requiring prior approval are defined in the OSHA Lab Standard and the Dartmouth Chemical Hygiene Plan. Refer to the following as a guide for required material/project information concerning your high hazard work.

1. Contact Information

A-F. Indicate PI name, department, building work location, work location room number, daytime phone number and 24 hour emergency phone number.

2. Substance Information

A. Record the chemical name and any synonyms.
B. If available, fill in the Chemical Abstracts Service Number (CAS). A unique chemical identifier.
C. List all chemical hazard warnings from the label and SDS (MSDS)(i.e. Highly Toxic, Flammable, Irritant). Additionally, list any pictograms present and their corresponding meanings.
D. Where did this material come from? If from a vendor, list the name, address, phone number, stock and catalog number. Otherwise give as many details about its origin as possible.
E. A brief general description of the material, how it will be used and its purpose in this experiment. Layman's terms.
F. Indicate how much will be purchased.
G. Detail where the material will be stored in the lab.
H. Indicate the amount used in one experiment.
I. Record the concentration of the material used during the experiment.
J. Fully explain the nature of the physical and/or health hazards of the material. Identify symptoms of exposure, routes of entry, stability and known incompatibilities. Refer to and supply the SDS (MSDS).

3. Procedure

Fully detail the entire procedure to be followed for the experiment.

4. Exposure Controls

A. Indicate how any potential exposure to the material will be minimized. Detail what equipment will be used (fume hood, glove box, biosafety cabinet, etc.) to prevent exposure. Identify all locations where the material will be used. Detail any administrative controls (limiting time of use, breaks, etc.)
B. Detail all personal protective equipment needed for the experiment.

5. Spills, Decontamination & First Aid

A. Detail all spill control material (pads, brushes, bags, etc.) to be used and their location. Indicate how a spill will be handled in each stage of the experiment. List all decontamination solutions that will be used, their concentrations and how they will be applied. Indicate how it will be determined if a spill can be handled by the lab and when help (from EHS) will be needed. Specify how the spill area will be identified and access controlled if the spill is too large for the lab to handle.

B. Detail the procedure to be followed after an injury or personnel exposure. What first aid will be rendered? (Washing, eyewash, shower, povidone iodine, etc.) Who will be called? (Emergency 911, Potential exposure - Occupational Medicine 653-3850)

6. Waste Disposal

A. Identify what form the waste stream will take.
B. Indicate the estimated waste volume per experiment.
C. Detail types of generated waste and how it will be collected and disposed. Also detail any equipment decontaminations and resulting waste. List any PPE used and how it will be disposed.

7. Investigators Statement

A. List all persons authorized and trained for this procedure. Indicate name, title and have each person sign the form.

24.6 Appendix F: Lab Coat Policy

Lab Coat Policy

Policy: Lab coats are required at Dartmouth when working with hazardous materials, including work with hazardous chemicals, radioactive materials, and biological agents. In some cases, through a hazard assessment, laboratory supervisors may identify situations (a task, experiment, or area) where alternative or more protective apparel must be worn.

When properly used, lab coats:

- Provide protection of skin and personal clothing from incidental contact and small splashes.
- Prevent the spread of contamination outside the lab (provided they are not worn outside the lab).
- Provide a removable barrier in the event of an incident involving a spill or splash of hazardous substances.

Limitations of Lab Coats

In general, protective clothing, including lab coats, should not be used as a substitute for engineering controls such as a fume hood, a glove box, process enclosure, etc., or as a substitute for good work practices and personal hygiene. For significant chemical handling, it will be necessary to supplement lab coat use with additional protective clothing, for example, an apron and/or gauntlets for handling large quantities of corrosives. Conversely, use of engineering controls such as fume hoods does not preclude the need for wearing the proper PPE, including lab coats.

Some known limitations of lab coats include:

- Lab coats are not designed to be the equivalent of chemical protection suits for major chemical handling or emergencies.
- There are no design or test criteria specified in regulations or guidelines specific to lab coats.
    - Lab coats are not tested for typical conditions that might be encountered in a research lab with respect to chemical use or combined research activities.
    - There is little or no information provided by manufacturers or distributors about the capability of a lab coat for a combination of hazards. A coat that is described as “flame resistant”, such as treated cotton, may not be chemical resistant or acid resistant.
    - A coat that is advertised as flame resistant has not been tested using criteria involving flammable chemicals on the coat. The term “flame resistant” refers to the characteristic of a fabric that causes it not to burn in air. The testing criteria involve applying an open flame to the bottom edge of a strip of fabric in a test chamber for 12 seconds and then looking at char length, after flame, and after glow, testing the self-extinguishing properties of the fabric. The flame resistance

test criteria were intended to simulate circumstances of a flash fire, or electric arc flash, not a chemical fire.

Selection - Hazard Assessment

With the limitations above in mind, lab coats are made of different materials, and it is important to select a coat or coats of appropriate material for the types of hazards in the lab. The first step in this selection process is to determine the types of hazards that exist in your lab and the reasons for the lab coats. Some questions to consider are the following:

- Does your lab work primarily with chemicals, biological agents, radioisotopes, or a mix of things?
- Are the lab workers undergraduates, graduate students, or professional techs?
- Does your lab work involve animal handling?
- Are there large quantities of flammable materials (>4 liters) used in a process or experiment?
- Are there water-reactive or pyrophoric materials used in the open air (e.g., in a fume hood instead of a glove box)?
- Are there open flames or hot processes along with a significant number of flammables?
- How are hazardous chemicals used and what engineering controls are available (e.g., a fume hood or glove box)?
- Is there a significant risk of spill, splash, or splatter for the tasks being done?
- What is the toxicity of chemicals used, and is there concern about inadvertent spread of contamination?

Choosing the Right Lab Coat - While there are many different style features, from a protection standpoint, the best coats have the following characteristics:

- Tight cuffs (knitted or elastic)
- Snap closures on the front for easy removal in case of contamination.
- Coats with different properties are easy to tell apart (ex, FR coats should have outer markings clearly identifying them as FR coats and can be ordered in a different color than other coats present in the lab)
- Proper fit
- Appropriate material for hazards to be encountered.

One coat may not work for all lab operations. Some people may want to provide a basic poly/cotton blend coat for most operations but have available lab coats of treated cotton or Nomex for work involving pyrophoric materials, extremely flammable chemicals, large quantities of flammable chemicals, or work around hot processes or operations. If chemical splash is also a concern, use of an apron over the flame-resistant lab coat is recommended. Lab coat materials may be made of materials for limited reuse, or disposable one-time use.

Flame Resistant (FR) Lab Coats

Work with pyrophoric, spontaneously combustible, or extremely flammable chemicals presents an especially high potential for fire and burn risks to the skin. EHS recommends the use of fire retardant or fire resistant (FR) lab coats to provide additional skin protection where the individual will be working with these chemicals. The primary materials used for FR lab coats are FR-treated cotton or Nomex. Further information is available in the table at the end of this document, as well as from EHS.

Getting a Lab Coat - The Supervisor/PI is responsible for assuring that required PPE, including lab coats, is available, used, and maintained. There are several methods by which a lab can obtain lab coats.

- Rental coats/Laundry Service – there are several companies (Cintas, UniFirst) capable of providing lab coats in a rental/laundry system. The benefits of this type of program are that it limits up-front costs for labs and can include free repairs or replacements for coats damaged through normal wear and tear.
- Purchase reusable lab coats - Lab coats can be purchased from many sources; the table at the end of this document includes ordering information for a variety of coat styles offered.
- Purchase disposable lab coats -> Disposable coats can be purchased from companies such as VWR. For environmental and cost reasons, this is generally not the best solution. However, in cases where lab coats are rarely needed, or when a type of material not generally available in a reusable style is needed, this can be a viable option.

Lab Coat Use - When lab coats are in use, the following should be observed:

- Wear lab coats that fit properly. Lab coats are available in a variety of sizes. Some lab coat services also offer custom sizes (e.g., extra-long sleeves, tall, or women's fit). Lab coats should fasten close to the collar to provide optimal protection.
- Lab coats should be worn fully buttoned or snapped with sleeves down.
- Wear lab coats only when in the lab or work area. Remove lab coats when leaving the lab/work area to go home, to lunch, to the restroom, or to meetings in conference rooms, etc.

Spill or Splash

Laundry services are not equipped to handle significant contamination of lab coats with hazardous materials. In the event of a significant spill of a hazardous material on the lab coat, remove the coat immediately. If skin or personal clothing is impacted, it will be necessary to proceed to an emergency shower. Remove any contaminated clothing during a shower. Generally, significantly contaminated coats and clothing will be considered hazardous waste and must be managed based on the type of contamination. If you have questions about the significance of contamination from a specific incident, contact EHS.

If your coat becomes contaminated, please notify EHS. If the coat must be discarded, document the loss of the coat, and if the coat is part of a laundry service, notify the lab coat provider.

Lab Coat Cleaning/Rentals -

Personnel are not allowed to launder lab coats at home. Clean non-disposable soiled lab coats routinely by use of a laundry service or work area washers and dryers. Frequency of cleaning will depend on the amount of use and contamination.

Laundry Services - Several area laundry services provide routine laundering of reusable lab coats. Do not use a local dry cleaner that does not specialize in lab coats as they generally are not familiar with proper handling of potentially contaminated items.

Services available from lab coat preferred vendors include:

- Rent or buy lab coats in a variety of materials (100% cotton, poly/cotton blends, flame resistant cotton, Nomex, etc).
- Perform custom tailoring of coats.
- Repair minor damage (ex. Lost snaps, torn pocket)
- Pick up coats on a weekly, biweekly, monthly, or on-demand schedule.
- Provide storage options for clean and soiled coats.
- Service individual labs or centralized service areas.

In negotiating with a vendor, you should be sure they understand the possible contamination that may be on the lab coat. See the Spill or Splash section for more information on what to do in the event of contamination.

In addition to providing lab coats and laundering them, the lab coat companies can also provide solutions to some of the most common problems encountered when setting up or managing a lab coat system. For example, in many areas space is limited. These companies have experience assessing available space and can provide multiple solutions on how to best store clean and soiled lab coats, so they are conveniently located yet do not take up valuable lab space.

24.7 Appendix G: Select Carcinogens List

SELECT CARCINOGENS

*This list is based on the OSHA Select Carcinogen definition at the bottom of this document as of October 2009.

OSHA – Occupational Safety and Health Administration, U.S. Department of Labor

Group ORC: OSHA Regulated Carcinogen

Group S: OSHA Select Carcinogen

IARC – International Agency for Research on Cancer

Group 1: Carcinogenic to humans

Group 2A: Probably carcinogenic to humans

Group 2B: Possibly carcinogenic to humans

NTP – National Toxicology Program, Public Health Service, U.S. Department of Health and Human Services

Group 1: Known to be Human Carcinogen (K)

Group 2: Reasonably anticipated to be Human Carcinogen (R)

CHEMICAL NAME	CAS NUMBER	OSHA	IARC	NTP
AF-2[2-(2-Furyl)-3-(5-nitro-2-furyl)acrylamide]	3688-53-7	S	2B	
Acetaldehyde	75-07-0	S	2B	2
Acetamide	60-35-5	S	2B	
Acetic acid, cobalt(2+) salt	71-48-7	S	2B	
2-Acetylaminofluorene	53-96-3	ORC		2
Acrylamide	79-06-1	S	2A	2
Acrylonitrile	107-13-1	ORC	2B	2
Adriamycin	023214-92-8	S	2A	2
Adriamycin hydrochloride	025316-40-9	S		2
Aflatoxin B1	1162-65-8	S	1	
Aflatoxin M1	6795-23-9	S	2B	
Aflatoxins	1402-68-2	S	1	1
1-Amino-2-methylanthraquinone	82-28-0	S		2
2-Amino-5-(5-nitro-2-furyl)-1,3,4-thiadiazole	712-68-5	S	2B	
Amino-alpha-C (2-Amino-9h-pyrido[2,3-b]indole)	026148-68-5	S	2B	
2-Aminoanthraquinone	117-79-3	S		2
para-Aminoazobenzene	60-09-3	S	2B	
ortho-Aminoazotoluene	97-56-3	S	2B	2
4-Aminodiphenyl	92-67-1	ORC	1	1
Amitrole	61-82-5	S	2B	2
Ammonium dichromate (VI)	07789-09-5	S	1	
Anaesthetics, volatile	--	S	2A	
Analgesic mixtures containing phenacetin	--	S	1	1

CHEMICAL NAME	CAS NUMBER	OSHA	IARC	NTP
Arsenenous acid, calcium salt (2:1)	015194-98-6	S		1
Arsenenous acid, potassium salt	013464-35-2	S		1
Arsenic acid, calcium salt	010103-62-5	S	1	1
Arsenic acid, calcium salt (2:3)	7778-44-1	S	1	1
Arsenic acid, disodium salt, heptahydrate	010048-95-0	S		1
Arsenic acid, lead(2+) salt(1:1)	7784-40-9	S		1
Arsenic acid, monopotassium salt	7784-41-0	S		1
Arsenic acid, sodium salt	7631-89-2	S		1
Arsenic pentoxide	1303-28-2	S		1
Arsenic trioxide	1327-53-3	S	1	1
Arsenic, elemental, and inorganic compounds, as As	7440-38-2	R	1	1
Arsenious acid, monosodium salt	7784-46-5	S	1	1
Arsenious acid, calcium salt	027152-57-4	S		1
Arsonic acid, calcium salt (1:1)	052740-16-6	S		1
Asbestos	1332-21-4	R	1	1
Asbestos, Actinolite	077536-66-4	R	1	
Asbestos, Amosite	012172-73-5	R	1	1
Asbestos, Anthophyllite	077536-67-5	R	1	1
Asbestos, Chrysotile	012001-29-5	R	1	1
Asbestos, Crocidolite	012001-28-4	R	1	1
Asbestos, Tremolite	077536-68-6	R	1	
Atrazine	1912-24-9	S	2B	
Auramine	492-80-8	S	2B	
Azacitidine	320-67-2	S	2A	2
Azaserine	115-02-6	S	2B	
Azathioprine	446-86-6	S	1	1
Azbllen asbestos	017068-78-9	S		1
Barium chromate(VI)	010294-40-3	S	1	1
Benz[a]anthracene	56-55-3	S	2A	2
Benzal chloride	98-87-3	S	2A	
Benzene	71-43-2	ORC	1	1
Benzidine	92-87-5	ORC	1	1
Benzidine-based dyes	--	S	2A	

Benzo[a]pyrene	50-32-8	S	2A	2
Benzo[b]fluoranthene	205-99-2	S	2B	2
Benzo[j]fluoranthene	205-82-3	S	2B	2
Benzo[k]fluoranthene	207-08-9	S	2B	2
Benzofuran	271-89-6	S	2B	
Benzotrichloride	98-07-7	S	2A	2
Benzoyl chloride	98-88-4	S	2A	
Benzyl chloride	100-44-7	S	2A	
Benzyl violet 4B	1694-09-3	S	2B	
Beryllium aluminum alloy	012770-50-2	S	1	2
Beryllium aluminum silicate	1302-52-9	S	1	2
Beryllium and beryllium compounds	7440-41-7	S	1	2
Beryllium chloride	7787-47-5	S	1	2
Beryllium fluoride	7787-49-7	S	1	2
Beryllium phosphate	013598-15-7	S	1	2
Beryllium hydroxide	013327-32-7	S	1	2
Beryllium oxide	1304-56-9	S	1	2
Beryllium oxide carbonate	066104-24-3	S	1	2
Beryllium sulfate	013510-49-1	S	1	2
Beryllium sulfate tetrahydrate	7787-56-6	S	1	2
Beryllium zinc silicate	039413-47-3	S	1	2
N,N-Bis(2-chloroethyl)-2-naphthylamine	494-03-1	S	1	
(Chlornaphazine)				
Bis(chloromethyl)ether	542-88-1	ORC	1	1
Bischloroethyl nitrosourea (BCNU)	154-93-8	S	2A	2
Bitumens, extracts of steam-refined and air-refined	8052-42-4	S	2B, 3	
Bleomycin, chlorohydrate	067763-87-5	S	2B	
Bleomycin, sulfate	9041-93-4	S	2B	
Bleomycins	011056-06-7	S	2B	
Bracken fern	--	S	2B	
Bromacil	314-40-9	S		
Bromodichloromethane	75-27-4	S	2B	2
Bromoform	75-25-2	S		
1,3-Butadiene	106-99-0	ORC	2A	2
1,4-Butanediol dimethanesulfonate	55-98-1	S	1	1
(Busulphan;Myleran)				
Butylated hydroxyanisole (BHA)	025013-16-5	S	2B	2
beta-Butyrolactone	3068-88-0	S	2B	
CI Acid Red 114	6459-94-5	S	2B	
CI Basic Red 9	569-61-9	S	2B	2
CI Direct blue 15	2429-74-5	S	2B	
Cadmium carbonate	513-78-0	S		2
Cadmium chloride	010108-64-2	S	1	2
Cadmium fluoborate	014486-19-2	S		2
Cadmium fume (as Cd)	1306-19-0	S	1	2
Cadmium nitrate	010325-94-7	S		2

Cadmium oxide	1306-19-0	S		2
Cadmium sulfate	010124-36-4	S	1	2
Cadmium sulfide	1306-23-6	S	1	2
Cadmium, elemental, and compounds, as Cd	7440-43-9	ORC	1	2
Caffeic acid	331-39-5	S	2B	
Calcium chromate (VI)	013765-19-0	S	1	1
Captafol	0612-42-5	S	2A	
Carbon black	1333-86-4	S	2B	
Carbon tetrachloride	56-23-5	S	2B	2
Carrageenan, degraded	972-00-1	S	2B	
Catechol	120-80-9	S	2B	
Ceramic fibers	--	S		2
Ceramic fibres	--	S	2B	
Chlorambucil	305-03-3	S	1	1
Chloramphenicol	56-75-7	S	2A	
alpha-Chlordane	5103-71-9	S	2B	
beta-Chlordane	5103-74-2	S	2B	
Chlordane	57-74-9	S	2B	
gamma-Chlordane	5566-34-7	S	2B	
Chlordecone (Kepone)	143-50-0	S	2B	2
Chlorendic acid	115-28-6	S	2B	2
Chlorinated paraffins (C12, 60% Chlorine)	108171-26-2	S	2B	2
Chlorinated paraffins (C23, 43% chlorine)	108171-27-3	S		2
alpha-Chlorinated toluenes (Benzal chloride, Benzyl	--	S	2A	
chloride, Benzotrichloride)and bonzoyl chloride (combined exposures)				
2-(4-Chloro-2-methyl phenoxy) propionic acid	93-65-2	S	2B	
(Mecoprop)				
1-Chloro-2-methyl propene	513-37-1	S	2B	2
3-Chloro-2-methylpropene	563-47-3	S		2
4-Chloro-o-toluidine hydrochloride	3165-93-3	S	2A	2
4-Chloro-ortho-phenylenediamine	95-83-0	S	2B	2
para-Chloro-ortho-toluidine	95-69-2	S	2A	
para-Chloro-ortho-toluidine and its strong acid salts	--	S	2A	2
para-Chloroaniline	106-47-8	S	2B	
1-(2-Chloroethyl)-3-(4-methylcyclohexyl)-1-	013909-09-6	S	1	1
nitrosourea (Methyl-CCNU; Semustine)				
1-(2-Chloroethyl)-3-cyclohexyl-1-nitrosourea (CCNU)	013010-47-4	S	2A	2
Chloroform	67-66-3	S	2B	2
Chloromethyl methyl ether	107-30-2	ORC	1	1
Chlorophenols	95-57-8	S	2B	
Polychlorophenols and their sodium salts (mixed	--	S	2B	
exposures)				
Chlorophenoxy herbicides	--	S	2B	
2-(o-Chlorophenyl)-2-(p-chlorophenyl)-1,1,1-	789-02-6	S	2B	
trichloroethane				

2-(o-Chlorophenyl)-2-(p-chlorophenyl)-1,1-	53-19-0	S	2B	
dichloroethane				
Chloroprene	126-99-8	S	2B	
Chlorothalonil	1897-45-6	S	2B	
Chlorozotocin	054749-90-5	S	2A	2
Chromate(1-), Hydroxyoctaoxodizincatedi-,	011103-86-9	S	1	
Potassium				
Chromic acid, Lead(2+) Salt (1:1)	7758-97-6	S	1	1
Chromic acid, disodium salt	01137-77-5	S	1	1
Chromite (mineral)	1308-31-2	S		1
Chromium (VI) chloride	014986-48-2	S	1	
Chromium (VI) compounds	--	S	1	1
Chromium (VI) dioxychloride	014977-61-8	S	1	
Chromium and certain chromium compounds	--	S		1
Chromium carbamate (6Cl)	029689-14-3	S		1
Chromium phosphate	7789-04-0	S		1
Chromium triacetate	1066-30-4	S		1
Chromium(VI) oxide (1:3)	1333-82-0	S	1	1
Ciclosporin	079217-60-0	S	1	
Cisplatin	015663-27-1	S	2A	2
Citrus red no.2	6358-53-8	S	2B	
Coal gasification	--	S	1	
Coal tar	065996-89-6	S		1
Coal tar distillate	065996-92-1	S		1
Coal tar pitch volatiles, as benzene solubles	065996-93-2	S	1	
Coal tars	87-45-2	S	1	1
Cobalt (II) carbonate hydroxide (2:3) monohydroxide	051839-24-8	S	2B	
Cobalt alloy, Co,Cr	011114-92-4	S	2B	1
Cobalt and cobalt compounds	7440-48-4	S	2B	
Cobalt carbonate (1:1)	513-79-1	S	2B	
Cobalt carbonate, Cobalt dihydroxide (2:3)	012602-23-2	S	2B	
Cobalt carbonyl (co4(CO)12)	017786-31-1	S	2B	
Cobalt dinitrate hexahydrate	010026-22-9	S	2B	
Cobalt hydroxide	1307-86-4	S	2B	
Cobalt hydroxide oxide	012016-80-7	S	2B	
Cobalt molydate (VI)	013762-14-6	S	2B	
Cobalt naphthanate	061789-51-3	S	2B	
Cobalt oxide	1308-06-1	S	2B	
Cobalt triacetate	917-69-1	S	2B	
Cobalt(2+) oxide	1307-96-6	S	2B	
Cobalt(2+) sulfide	1317-42-6	S	2B	
Cobalt(II) acetate tetrahydrate	6147-53-1	S	2B	
Cobalt(II) chloride	7646-79-9	S	2B	
Cobalt(II) chloride, hexahydrate	7791-13-1	S	2B	
Cobalt(II) hydroxide	021041-93-0	S	2B	
Cobalt(II) nitrate (1:2)	010141-05-6	S	2B	
Cobalt(II) sulfate (1:1)	010124-43-3	S	2B	

Cobalt(III) oxide	1308-04-9	S	2B	
Cobalt, (mu-(Carbonato(2-)-O:O'))Dihydroxydi	012069-68-0	S	2B	
Cobalt, di-mu-carbonylhexacarbonyldi-, (Co-Co)	010210-68-1	S	2B	
Cobalt-aluminium-chromium spinel	--	S	2B	
Cobalt-chromium-molybdenum-alloy	012629-02-6	S	2B	
Cobalt-chromium-nickel-tungsten alloy	012638-07-2	S	2B	
Coke oven emissions	--	ORC		1
Coke production	--	ORC	1	1
Conjugated estrogens	012126-59-9	S		1
Conjugated estrogens	--	S		1
Creosote	81-58-9	S	2A	1
para-Cresidine	120-71-8	S	2B	2
Creosote, wood	8021-39-4	S		1
Crotonaldehyde	4170-30-3			
Cupferron	135-20-6	S		2
Cycasin	014901-08-7	S	2B	
Cyclophosphamide	50-18-0	S	1	1
Cyclophosphamide hydrate	6055-19-2	S	1	
Cyclosporin A	059865-13-3	S	1	1
DDD (dichlorodiphenyldichloroethane)	72-54-8	S	2B	
DDE (dichlorodiphenyldichloroethylene)	72-55-9	S	2B	
DDT	50-29-3	S	2B	2
Dacarbazine	0344-34-2	S	2B	2
Dantron (Chrysazin; 1,8-Dihydroxyanthraquinone,	117-10-2	S	2B	2
Danthron)				
Daunomycin	020830-81-3	S	2B	
Decabromobiphenyl (under polybrominated	013654-09-6	S		2
biphenyls)				
Di(2-ethylhexyl) phthalate	117-81-7	S	2B	2
N,N'-Diacetylbenzidine	613-35-4	S	2B	
2,4-Diaminoanisole (and its salts)	615-05-4	S	2B	
2,4-Diaminoanisole sulfate	039156-41-7	S		2
4,4'-Diaminodiphenyl ether	101-80-4	S	2B	2
2,4-Diaminotoluene	95-80-7	S	2B	2
Dibenz[a,h]acridine	226-36-8	S	2B	2
Dibenz[a,h]anthracene	53-70-3	S	2A	2
Dibenz[a,j]acridine	224-42-0	S	2B	2
Dibenzo[a,e]pyrene	192-65-4	S	2B	2
Dibenzo[a,h]pyrene	189-64-0	S	2B	2
Dibenzo[a,i]pyrene	189-55-9	S	2B	2
Dibenzo[a,l]pyrene	191-30-0	S	2B	2
7H-Dibenzo[c,g]carbazole	194-59-2	S	2B	2
1,2-Dibromo-3-chloropropane (DBCP)	96-12-8	ORC	2B	2
3,3'-Dichloro-4,4'-diaminodiphenyl ether	028434-86-8	S	2B	
para-Dichlorobenzene	106-46-7	S	2B	2
3,3'-Dichlorobenzidine	91-94-1	ORC	2B	2
3,3'-Dichlorobenzidine and 3,3'-Dichlorobenzidine	--	S		2
hydrochloride				

3,3'-Dichlorobenzidine dihydrochloride	612-83-9	S		2
1,2-Dichloroethane	107-06-2	S	2B	2
Dichloromethane (Methylene Chloride)	75-09-2	ORC	2B	2
2-(2,4-Dichlorophenoxy)propionic acid	120-36-5	S	2B	
1,3-Dichloropropene (technical-grade)	542-75-6	S	2B	2
Dichlorvos	62-73-7	S	2B	
Diepoxybutane	1464-53-5	S		2
1-1,2:3,4-Diepoxybutane	030031-64-2	S	2B	
Diepoxybutane, (+-)-1,2:3,4-	--	S	2B	
Diesel engine exhaust	--	S	2A	
Diesel fuels	--	S	2B	
Diethyl sulfate	64-67-5	S	2A	2
1,2-Diethylhydrazine	1615-80-1	S	2B	
Diethylstilbesterol (DES)	56-53-1	S	1	1
Diglycidyl resorcinol ether	101-90-6	S	2B	2
Dihydrosafrole	94-58-6	S	2B	
Dihydroxymethylfuratrizine	794-93-4	S	2B	
Diisopropyl sulfate	01062-97-3	S	2B	
3,3'-Dimethoxybenzidine (ortho-Dianisidine)	119-90-4	S	2B	2
3,3'-dimethoxybenzidine dihydrochloride	020325-40-0	S		2
Dimethyl sulfate	77-78-1	S	2A	2
trans-2-[(Dimethylamino)methylimino]-5-[2-(5-nitro-2-	025962-77-0	S	2B	
furyl)vinyl]-1,3,4-oxadiazole				
para-Dimethylaminoazobenzene	60-11-7	ORC	2B	2
2,6-Dimethylaniline (2,6-Xylidine)	87-62-7	S	2B	
3,3'-Dimethylbenzidine (o-Tolidine)	119-93-7	S	2B	2
Dimethylcarbamoyl chloride	79-44-7	S	2A	2
1,1-Dimethylhydrazine	57-14-7	S	2B	2
1,2-Dimethylhydrazine	540-73-8	S	2A	
3,7-Dinitrofluorantene	105735-71-5	S	2B	
3,9-Dinitrofluoranthene	022506-53-2	S	2B	
1,6-Dinitropyrene	042397-64-8	S	2B	2
1,8-Dinitropyrene	042397-65-9	S	2B	2
2,4-Dinitrotoluene	121-14-2	S	2B	
2,6-Dinitrotoluene	606-20-2	S	2B	
1,4-Dioxane	123-91-1	S	2B	2
Direct black 38	1937-37-7	S		2
Direct blue 6	2602-46-2	S		2
Disperse blue 1	2475-45-8	S	2B	2
Engine exhaust, gasoline	--	S	2B	
Epichlorohydrin	106-89-8	S	2A	2
1,2-Epoxybutane	106-88-7	S	2B	
Erionite	066733-21-9	S	1	1
Estrogens (not conjugated) Estradiol-17 beta	50-28-2	S		2
Estrogens (not conjugated) Estrone	53-16-7	S		2
Estrogens (not conjugated) Ethinylestradiol	57-63-6	S		2
Estrogens (not conjugated) Mestranol	72-33-3	S		2

Ethyl acrylate	140-88-5	S	2B	2
Ethyl bromide	74-96-4			
Ethyl methanesulfonate	62-50-0	S	2B	2
n-Ethyl-N-nitrosourea	759-73-9	S	2A	2
Ethylene dibromide	106-93-4	S	2A	2
Ethylene oxide	75-21-8	ORC	1	2
Ethylene thiourea	96-45-7	S	2B	2
Ethyleneimine (Aziridine)	151-56-4	ORC	2B	
FireMaster BP-6 (under polybrominated biphenyls)	--	S	2B	2
Formaldehyde	50-00-0	ORC	2A	2
2-(2-Formylhydrazino)-4-(5-nitro-2-furyl)thiazole	3570-75-0	S	2B	
Fowler's solution	1332-10-1	S	1	
Fuel oil, residual	068476-33-5	S	2B	
Furan	110-00-9	S	2B	2
Gasoline	86-61-9	S	2B	
Gasoline, unleaded	--	S	2B	
Glass wool fibers	--	S	2B	2
Glu-P-1 (2-Amino-6-methyldipyrido[1,2-a:3',2'-	067730-11-4	S	2B	
d]imidazole)				
Glu-P-2 (2-Aminodipyrido[1,2-a:3',2'-d]imidazole)	067730-10-3	S	2B	
Glycidaldehyde	765-34-4	S	2B	
Glycidol	556-52-5	S		2
Griseofulvin	126-07-8	S	2B	
HC Blue No. 1	2784-94-3	S	2B	
Heptachlor	76-44-8	S	2B	
Heptachlor epoxide	1024-57-3	S	2B	
Hexachlorobenzene	118-74-1	S	2B	2
Hexachlorocyclohexanes (all isomers)	608-73-1	S	2B	2
gamma-Hexachlorocyclohexane	58-89-9	S		2
beta-Hexachlorocyclohexane	319-85-7	S		2
alpha-Hexachlorocyclohexane	319-84-6	S		2
Hexachloroethane	67-72-1	S	2B	2
Hexamethyl phosphoramide	680-31-9	S	2B	2
Hot mate	--	S	2A	
Hydrazine	302-01-2	S	2B	2
Hydrazine sulfate	010034-93-2	S		2
Hydrazobenzene	122-66-7	S		2
IQ (2-Amino-3-methylimidazo[4,5-f]quinoline)	076180-96-6	S	2A	
Indeno[1,2,3-cd]pyrene	193-39-5	S	2B	2
Iron-dextran complex	94-66-4	S	2B	2
Isoprene	78-79-5	S	2B	
Kanechlor (under polychlorinated biphenyls)	037317-41-2	S		2
Lasiocarpine	303-34-4	S	2B	
Lead acetate	301-04-2	S		2
Lead acetate (II), trihydrate	6080-56-4	S		2
Lead and lead compounds, inorganic	7439-92-1	S	2B	
Lead chromate	7758-97-6	S		1
Lead chromate(VI) oxide	018454-12-1	S	1	1

Lead phosphate	7446-27-7	S	2B	2
Lindane	58-89-9			
Magenta (containing Cl basic red 9)	632-99-5	S	2B	
Mea-alpha-c (2-Amino-3-methyl-9H-pyrido[2,3-	068006-83-7	S	2B	
b]indole)				
Medroxyprogesterone acetate	71-58-9	S	2B	
MeIQ (2-Amino-3,4-dimethylimidazo[4,5f]quinoline	077094-11-2	S	2B	
MeIQx (2-Amino-3,8-dimethylimidazo[4,5-	077500-04-0	S	2B	
f]quinoxaline				
Melphalan	148-82-3	S	1	1
Merphalan	531-76-0	S	2B	
Meso-1,2:3,4-Diepoxybutane	564-00-1	S	2B	
5-Methoxypsoralen	484-20-8	S	2A	
Methyl mercury compounds	--	S	2B	
Methyl methanesulfonate	66-27-3	S	2A	2
2-Methyl-1-nitroanthraquinone (uncertain purity)	129-15-7	S	2B	
n-Methyl-N'-nitro-N-nitrosoguanidine (MNNG)	70-25-7	S	2A	2
n-Methyl-N-nitrosourea	684-93-5	S	2A	2
n-Methyl-N-nitrosourethane	615-53-2	S	2B	
2-Methylaziridine (Propyleneimine)	75-55-8	S	2B	2
Methylazoxymethanol acetate	592-62-1	S	2B	
Methylazoxymethanol and its acetate	590-96-5	S	2B	
5-Methylchrysene	3697-24-3	S	2B	2
4,4'-Methylene bis(2-chloroaniline)	101-14-4	S	2A	2
4,4'-Methylene bis(2-methylaniline)	838-88-0	S	2B	
4,4'-Methylene bis(n,n-dimethyl)benzenamine	101-61-1	S		2
4,4'-Methylenedianiline	101-77-9	ORC	2B	2
4,4'-Methylenedianiline dihydrochloride	013552-44-8	S		2
Methylthiouracil	56-04-2	S	2B	
Metronidazole	443-48-1	S	2B	2
Michler's ketone	90-94-8	S		2
Mineral Oil, petroleum distillates with certain solvent	064742-03-6	S	1	
and hydrotreatments. Consult MSDS for product				
status				
Mirex	2385-85-5	S	2B	2
Mitomycin C	50-07-7	S	2B	
Molybdate orange	012656-85-8	S	1	
Monocrotaline	315-22-0	S	2B	
5-(Morpholinomethyl)-3-[(5-nitrofurfurylidene)amino]-	3795-88-8	S	2B	
2-oxazolidinone				
Mustard gas	505-60-2	S	1	1
Nafenopin	3771-19-5	S	2B	
2-Naphthylamine	91-59-8	ORC	1	1
alpha-Naphthylamine	134-32-7	ORC		
Nickel alloy, Ni 47-59,Co 17-20,Cr 13-17,Mo 4.5-	011068-91-0	S	2B	

5.7,Al 3.7-4.7,Ti 3-4,Fe 0-1,C 0- 0.1 (AISI 687)				
Nickel biscyclopentadiene	1271-28-9	S		2
Nickel carbonyl (as Ni)	013463-39-3	S		2
Nickel compounds	--	S	1	
Nickel hydroxide	11113-74-9	S		2
Nickel sulfide (3:2)	012035-72-2	S		2
Nickel(II) acetate (1:2)	373-02-4	S		2
Nickel(II) carbonate (1:1)	3333-67-3	S		2
Nickel(II) hydroxide	012054-48-7	S		2
Nickel(II) oxide (1:1)	1313-99-1	S		2
Nickel(III) hydroxide	012125-56-3	S		2
Nickel, compd with pi-Cyclopentadienyl (1:2)	--	S		2
Nickel, metallic and alloys	7440-02-0	S	2B	2
Niridazole	61-57-4	S	2B	
Nitrilotriacetic acid and its salts	139-13-9	S	2B	2
Nitrilotriacetic acid disodium salt monohydrate	023255-03-0	S	2B	
Nitrilotriacetic acid monosodium salt	018994-66-6	S	2B	
Nitrilotriacetic acid sodium salt	010042-84-9	S	2B	
Nitrilotriacetic acid trisodium salt monohydrate	018662-53-8	S	2B	
Nitrilotriacetic acid, disodium salt	015467-20-6	S	2B	
Nitrilotriacetic acid, trisodium salt	5064-31-3	S	2B	
N-[4-(5-Nitro-2-furyl)-2-thiazolyl]acetamide	531-82-8	S	2B	
5-Nitroacenaphthene	602-87-9	S	2B	
2-Nitroanisole	91-23-6	S	2B	2
Nitrobenzene	98-95-3	S	2B	
4-Nitrobiphenyl	92-93-3	ORC		
6-Nitrochrysene	0287-49-6	S	2B	2
Nitrofen, (technical-grade)	1836-75-5	S	2B	2
2-Nitrofluorene	607-57-8	S	2B	
1-[(5-Nitrofurfurylidene)amino]-2-imidazolidinone	555-84-0	S	2B	
Nitrogen mustard	51-75-2	S	2A	2
Nitrogen mustard N-oxide	126-85-2	S	2B	
Nitrogen mustard N-oxide hydrochloride	302-70-5	S	2B	
Nitrogen mustard hydrochloride	55-86-7	S	2A	2
2-Nitropropane	79-46-9	S	2B	2
1-Nitropyrene	5522-43-0	S	2B	2
4-Nitropyrene	057835-92-4	S	2B	2
n-Nitrosobutylbutanolamine	01163-81-7	S		2
n-Nitrosobutylcarboxypropylamine	038252-74-3	S		2
N-Nitrosodi-n-butylamine	924-16-3	S	2B	2
N-Nitrosodi-n-propylamine	621-64-7	S	2B	2
N-Nitrosodiethanolamine	1116-54-7	S	2B	2
n-Nitrosodiethylamine	55-18-5	S	2A	2
n-Nitrosodimethylamine	62-75-9	ORC	2A	2
4-(N-Nitrosomethylamino)-1-(3-pyridyl)-1-butanone	064091-91-4	S	2B	2
(NNK)				
3-(N-Nitrosomethylamino)propionitrile	060153-49-3	S	2B	

N-Nitrosomethylethylamine	010595-95-6	S	2B	
N-Nitrosomethylvinylamine	4549-40-0	S	2B	2
N-Nitrosomorpholine	59-89-2	S	2B	2
N'-Nitrosonornicotine	016543-55-8	S	2B	2
N'-Nitrosonornicotine, (+-)	084237-38-7	S	2B	
N-Nitrosopiperidine	100-75-4	S	2B	2
N-Nitrosopyrrolidine	930-55-2	S	2B	2
N-Nitrososarcosine	013256-22-9	S	2B	2
Norethisterone	68-22-4	S		2
Ochratoxin A	303-47-9	S	2B	2
Octabromobiphenyl (under polybrominated biphenyls)	061288-13-9	S		2
Oestrogens, nonsteroidal	--	S	1	
Oestrogens, steroidal	--	S	1	
Oil orange SS	2646-17-5	S	2B	
Oxazepam	604-75-1	S	2B	
Oxymetholone	434-07-1	S		2
Palygorskite (attapulgite) (long fibres, > 5 micrometers)	012174-11-7	S	2B	
Panfuran S (containing dihydroxymethylfuratrizine)	794-93-4	S	2B	
Pentachlorobiphenyl	025429-29-2	S		2
Petroleum Residues , Thermal Cracked	064741-80-6	S	2A	
Phenacetin	62-44-2	S	2A	2
Phenazopyridine hydrochloride	136-40-3	S	2B	2
Phenobarbital	50-06-6	S	2B	
Phenoxybenzamine hydrochloride	63-92-3	S	2B	2
Phenyl glycidyl ether	122-60-1	S	2B	
o-Phenylenediamine	95-54-5			
Phenylhydrazine	100-63-0			
Phenytoin	57-41-0	S	2B	2
PhIP (2-Amino-1-methyl-6-phenyl-imidazo[4,5-b]pyridine)	105650-23-5	S	2B	
Piperazine Estrone Sulfate (under conjugated estrogens)	7280-37-7	S		1
Polybrominated biphenyl (FF-1)	067774-32-7	S	2B	2
Polybrominated biphenyls (PBBs)	059536-65-1	S	2B	2
Polychlorinated biphenyl (Aroclor 1254)	011097-69-1	S	2A	2
Polychlorinated biphenyl (Aroclor 1260)	011096-82-5	S		2
Polychlorinated biphenyls [PCBs]	1336-36-3	S	2A	2
Polychlorophenols and their sodium salts (mixed exposures)	--	S	2B	
Polycyclic aromatic hydrocarbons (PAHs)	--	S		2
Ponceau 3R	0983-56-4	S	2B	
Ponceau MX	3761-53-3	S	2B	
Potassium bromate	127-75-8	S	2B	
Potassium chromate (VI)	7789-00-6	S	1	1
Potassium dichromate (VI)	7778-50-9	S	1	1
Procarbazine hydrochloride	366-70-1	S	2A	2

Progesterone	57-83-0	S		2
Progestins	--	S	2B	
1,3-Propane sultone	1120-71-4	S	2B	2
beta-Propiolactone	57-57-8	ORC	2B	2
Propoxur (Baygon)	114-26-1	S		
Propylene oxide	75-56-9	S	2B	2
Propylthiouracil	51-52-5	S	2B	2
Radon and its decay products	010043-92-2	S	1	1
Reserpine	50-55-5	S		2
Rock wool fibers	--	S	2B	
Saccharin	81-07-2	S	2B	2
Saccharin calcium	6485-34-3	S		2
Saccharin, sodium salt	128-44-9	S	2B	2
Safrole	94-59-7	S	2B	2
Selenium sulfide	7446-34-6	S		2
Senarmontite	012412-52-1	S	2B	
Shale-oils	068308-34-9	S	1	
Silica, crystalline	014808-60-7	S	1	2
Silica, crystalline cristobalite	014464-46-1	S	2A	2
Silica, crystalline tridymite	015468-32-3	S	2A	2
Silica, crystalline tripoli	1317-95-9	S	2A	
Silicic acid, Beryllium salt	015191-85-2	S	1	
Slag wool fibers	--	S	2B	
Sodium dichromate (VI)	010588-01-9	S	1	1
Sodium estrone sulfate (under conjugated	438-67-5	S		1
estrogens)				
Sodium equilin sulfate (under conjugated estrogens)	016680-47-0	S		1
Sodium ortho-phenylphenate	132-27-4	S	2B	
Soots	--	S	1	1
Sterigmatocystin	010048-13-2	S	2B	
Streptozotocin	018883-66-4	S	2B	2
Strontium chromate (VI)	627-78-9	S	1	1
Styrene	100-42-5	S	2B	
Styrene-7,8-oxide	96-09-3	S	2A	
Sulfallate	95-06-7	S	2B	2
Sulfur trioxide	01197-44-6	S	1	
Talc (containing asbestos fibers)	--	S	1	
Talc containing asbestiform fibres	--	S	1	
Tamoxifen	010540-29-1	S	1	
Tars	--	S		1
2,3,7,8-Tetrachlorodibenzo-para-dioxin (TCDD)	1746-01-6		1	2
Tetrachloroethylene	127-18-4	S	2A	2
Tetrafluoroethylene	116-14-3	S	2B	
Tetranitromethane	509-14-8	S	2B	2
Thioacetamide	62-55-5	S	2B	2
4,4'-Thiodianiline	139-65-1	S	2B	
Thiotepa	52-24-4	S	2A	1

Thiourea	62-56-6	S	2B	2
Thorium dioxide	1314-20-1	S		1
2,6-Toluene diisocyanate	91-08-7	S	2B	
2,4-Toluene diisocyanate	584-84-9	S	2B	
Toluene diisocyanate (mixed isomers)	026471-62-5	S	2B	2
o-Toluenesulfonamide	88-19-7	S	2B	
o-Toluidine hydrochloride	636-21-5	S		2
ortho-Toluidine	95-53-4	S	2B	2
Toxaphene (Polychlorinated camphenes)	81-35-2	S	2B	2
Toxins derived from Fusarium moniliforme	--	S	2B	
Treosulphan	299-75-2	S	1	
Trichlormethine (trimustine hydrochloride)	817-09-4	S	2B	
Trichloroethylene	79-01-6	S	2A	
2,4,6-Trichlorophenol	88-06-2	S		2
1,2,3-Trichloropropane	96-18-4	S	2A	2
Tris(2,3-dibromopropyl)phosphate	126-72-7	S	2A	2
Trp-P-1 (3-Amino-1,4-dimethyl-5H-pyrido[4,3-b]indole)	062450-06-0	S	2B	
Trp-P-2(3-Amino-1-methyl-5H-pyrido[4,3-b]indole)	062450-07-1	S	2B	
Trypan blue	72-57-1	S	2B	
Uracil mustard	66-75-1	S	2B	
Urethane	51-79-6	S	2B	2
VM & P Naphtha	8032-32-4	S		
Valentinite	1317-98-2	S	2B	
Vinyl acetate	108-05-4	S	2B	
Vinyl bromide	593-60-2	S	2A	
Vinyl chloride	75-01-4	ORC	1	1
4-Vinyl cyclohexene	100-40-3	S	2B	
Vinyl fluoride	75-02-5	S	2A	
4-Vinyl-1-cyclohexene diepoxide	106-87-6	S		2
4-Vinylcyclohexene diepoxide	106-87-6	S	2B	
Zinc chromate (VI)	013530-65-9	S	1	1
Zinc chromate (VI) hydroxide	015930-94-6	S	1	

24.8 Appendix H: DEA Controlled Substances

Standard Operating Procedure for DEA Registration, Controlled Substance Use & Disposal

Purpose: To ensure compliance, security, and consistency in the use of controlled substances in research.

Procedure: Step 1:

PI applies for a Drug Enforcement Agency (DEA) controlled substances license.

- To obtain a license application, go online to: https://www.deadiversion.usdoj.gov/webforms/jsp/regapps/common/newAppLogin.jsp
- Complete the application and submit it with the registration fee. A state license is not required. In the field on the application that relates to an NH license, do not click the box or input anything into that field.
- Keep a copy for your files.
- Upon receipt of your DEA certificate, contact EHS for an inspection of your facility. A copy of your license must be uploaded to the "Documents" section on BioRAFT. Select file type "DEA Authorizations."

Step 2:

Upon receipt of your license certificate, the DEA licensee agrees to the following compliance elements:

- Establish a logbook or notebook for controlled substances. Schedule I substances must have their own logbook. A separate log sheet must be maintained for each substance. This log sheet must include date received, quantity, and drug name. See *Drug Tracking Form*, attached. The logbook should be kept in a lockable space within the lab (desk drawer, safe, etc.).
    - Electronic files are acceptable if stored securely and electronic signatures are not used (e.g. sign and scan).
    - Save all receipt and disposal documents for at least 2 years.
- Keep controlled substances in locked storage. For Schedule I-II substances, the storage must comply with 21 CFR 1301.72. For Schedule III-V substances, the locked storage must be attached to the wall or be sufficiently heavy to prevent it from being carried off, or otherwise comply with 21 CFR 1301.72. Schedule I-II substances must not be kept in the same storage location as Schedule III-V substances.
- Limit access to controlled substances.
    - For Schedule I substances:
        - Access is limited to the registrant and the specifically DEA-authorized personnel who are named in the DEA-approved research protocol.

- For Schedule II-V substances
    - Restrict access to only authorized members of your lab.
    - To authorize additional users, the *Controlled Substances Screening Guidance and Questionnaire* (attached) must be completed and saved.
    - Anyone in a lab may be authorized at the PI's discretion, with the exception of minors.
- Perform an initial controlled substance inventory form (attached) when you are DEA-approved, and before receiving any controlled substances
- Perform an inventory audit biennially (required minimum frequency) and annually (if desired). The biennial inventory **MUST** be taken on May 1 of each odd-numbered year. If May 1 falls on a weekend, inventory must be taken on the closest business day preceding May 1. Ensure that your stock matches what is stated in your logbooks. See controlled substances inventory forms (attached).
    - Separate inventory forms must be maintained for Schedule I-II and Schedule III-V substances, with initial and biennial (and annual if desired) inventories required for each category.
    - If your actual inventory does not match your logs, you must follow the steps detailed in the *Inventory Discrepancy Investigation Guidance* form (attached).
- Renew your license annually if you plan to continue using controlled substances.
- **BEFORE you allow your license to expire, please contact EHS immediately for disposal of any controlled substances in your inventory. Disposal of any controlled substance must occur prior to license expiration.**
- The DEA may inspect you at any time. Contact EHS when you become aware of a DEA inspection.

Step 3:

If you have old, unused, or outdated controlled substances, disposal will be by double-witnessed chemical deactivation. The lab should schedule a time for EHS to dispose of the controlled substance in the lab, and one authorized user must be present for disposal to sign as a second witness on the *Registrant Record of Controlled Substances Destroyed Form DEA-41* (attached).

- Chemical deactivation will be done by a New Hampshire-certified Hazardous Waste Coordinator and witnessed by the DEA registrant or another authorized user.
- Form DEA-41 will be signed by both parties.
- EHS will email a copy of DEA-41 to the registrant, which should be saved in the lab's logbook
- EHS will save a copy of DEA-41 to the EHS DEA shared file
- EHS will send the original DEA-41 form to the DEA at:
  324 South River Road
  Bedford, NH 03110
- Please contact EHS if you have any questions about this disposal process.

Drug Tracking Form

(Complete one form for each container)

Name of PI_____

Date Received_____ Expiration Date_____

Drug Name_____ Serial/Lot/Tracking# _____

Date of Use	Species	Animal ID #	Volume/ Quantity Used	Volume/ Quantity Remaining	Initials

Date Container Emptied or Disposed:_____

Controlled Substances Screening Guidance and Questionnaire

The following is based on 21 CFR § 1301.90 and § 1301.76 (2025).

For each person wishing to use controlled substances in the lab, the DEA license holder (typically the PI) must ask the following questions, the answers to which should not be recorded.

If an individual answers affirmatively to Question 1, they shall not be allowed to work with controlled substances. If an individual answers affirmatively to Questions 2 or 3, it is not necessarily disqualifying, but up to the registrant's discretion.

If the licensee feels it prudent, a background check may be performed, but written consent from the screened individual is required. The maintenance of fair employment practices, the protection of the person's right of privacy, and the assurance that the results of such inquiries will be treated by the employer in confidence will be explained to the employee.

Questions:

1. Have you ever been convicted of a felony offense relating to controlled substances, or had an application for registration with the DEA denied or revoked, or have you ever surrendered a DEA registration for cause?

2. Within the past five years, have you been convicted of a felony, or within the past two years, of any misdemeanor or are you presently formally charged with committing a criminal offense? (Do not include any traffic violations, juvenile offenses or military convictions, except by general court-martial.) If yes, furnish details of conviction, offense, location, date and sentence.

3. In the past three years, have you ever knowingly used any narcotics, amphetamines or barbiturates, other than those prescribed to you by a physician? If the answer is yes, furnish details.

Names, signatures, and dates should only be completed for screened individuals who are approved for controlled substance use. For those approved to work with controlled substances, this form must be signed and retained for at least 2 years past the individual's employment end date.

Screened Individual Name:

Signature: **Date:**

PI Name:

Signature: **Date:**

Controlled Substances Initial Inventory

X Schedule I-II (Exact Count Required) _____Schedule III-V (Estimates OK)

Initial inventory should always be zero. Separate sheets should be created and maintained for Schedule I-II controlled substances and Schedule III-V controlled substances. Inventory should be taken either at the beginning or end of the business day.

Registrant Information			
Registrant's Name: Jason Angell	**DEA #:** RR1234567	**Registered Address:** 37 Dewey Field Rd. Ste 6216 Hanover, NH 03755	
Date of Inventory: 1/12/2026	**Time Inventory Taken:** X Beginning of Day ____ End of Day	**Inventoried by (Print and Sign):** Jason Angell *Jason Angell*	**Witnessed by (Print and Sign):** Annette Chism *Annette Chism*

Complete Physical Inventory for ALL Schedule III-V Controlled Substances on hand at the time of inventory

	Name of Substance	Concentration/ Strength	Initial Volume/ Quantity of Container	Number of Containers	Total Quantity/Volume on Hand per Concentration/Strength	Open/ Unopened	Active/Expired
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							
16							

NO INVENTORY

Controlled Substances Initial Inventory
_____Schedule I-II (Exact Count Required) _____Schedule III-V (Estimates OK)

Initial inventory should always be zero. Separate sheets should be created and maintained for Schedule I-II controlled substances and Schedule III-V controlled substances. Inventory should be taken either at the beginning or end of the business day.

Registrant Information			
Registrant's Name:	**DEA #:**	**Registered Address:**	
Date of Inventory:	**Time Inventory Taken:** **____ Beginning of Day** **____ End of Day**	**Inventoried by (Print and Sign):**	**Witnessed by (Print and Sign):**

Complete Physical Inventory for ALL Schedule III-V Controlled Substances on hand at the time of inventory							
	Name of Substance	**Concentration/ Strength**	**Initial Volume/ Quantity of Container**	**Number of Containers**	**Total Quantity/Volume on Hand per Concentration/Strength**	**Open/ Unopened**	**Active/Expired**
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							

Controlled Substances **X** **Annual Inventory** **_____Biennial Inventory**
X **Schedule I-II (Exact Count Required)** **_____Schedule III-V (Estimates OK)**

Separate sheets should be created and maintained for Schedule I and II controlled substances and Schedule III-V controlled substances. Inventory should be taken either at the beginning or end of the business day. Biennial inventory **MUST** be taken on May 1 of each odd year, or if this day is on the weekend, the closest business day preceding May 1.

Registrant Information			
Registrant's Name: Jason Angell	**DEA #:** RR1234567	**Registered Address:** 37 Dewey Field Rd. Ste 6216 Hanover, NH 03755	
Date of Inventory: 1/12/2026	**Time Inventory Taken:** **X** **Beginning of Day** **____ End of Day**	**Inventoried by (Print and Sign):** Jason Angell Jason Angell	**Witnessed by (Print and Sign):** Annette Chism Annette Chism

Complete Physical Inventory for ALL Schedule III-V Controlled Substances on hand at the time of inventory

	Name of Substance	Concentration/ Strength	Initial Volume/ Quantity of Container	Number of Containers	Total Quantity/Volume on Hand per Concentration/Strength	Open/ Unopened	Active/Expired
1	Psilocybin	10 mg	50 tablets	1	50 tablets	Unopened	Active
2	Psilocybin	10 mg	50 tablets	1	24 tablets	Open	Active
3	Psilocybin	10 mg	50 tablets	1	50 tablets	Unopened	Expired
4	Fentanyl Citrate	50 mcg/mL	10 mL	2	20 mL	Unopened	Active
5	Fentanyl Citrate	50 mcg/mL	10 mL	1	5 mL	Open	Active
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							

Controlled Substances _____Annual Inventory _____Biennial Inventory
_____Schedule I-II (Exact Count Required) _____Schedule III-V (Estimates OK)

Separate sheets should be created and maintained for Schedule I and II controlled substances and Schedule III-V controlled substances. Inventory should be taken either at the beginning or end of the business day. Biennial inventory **MUST** be taken on May 1 of each odd year, or if this day is on the weekend, the closest business day preceding May 1.

Registrant Information			
Registrant's Name:	**DEA #:**	**Registered Address:**	
Date of Inventory:	**Time Inventory Taken:** **____ Beginning of Day** **____ End of Day**	**Inventoried by (Print and Sign):**	**Witnessed by (Print and Sign):**

Complete Physical Inventory for ALL Schedule III-V Controlled Substances on hand at the time of inventory

	Name of Substance	Concentration/ Strength	Initial Volume/ Quantity of Container	Number of Containers	Total Quantity/Volume on Hand per Concentration/Strength	Open/ Unopened	Active/Expired
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							

Inventory Discrepancy Investigation Guidance

Any time a discrepancy is noted on an inventory form, the licensee should document the issue using the following guidance. If there is any inventory discrepancy, contact EHS.

1. Internal Investigation
   - Double-check and reconcile
     - Recount the controlled substances and review all associated records including:
       - Drug Tracking Form
       - Controlled Substances Annual Inventory Reconciliation form
       - Ordering records
       - DEA Registrant Record of Controlled Substances Destroyed (DEA-41, provided to you by EHS)
       - Any notes or records of spills, accidental destruction, etc.
   - Identify the Cause
     - Common causes can include:
       - Recordkeeping error: A simple mistake in a log entry, such as a transcription error or a misplaced zero.
       - Calculation error: An incorrect calculation of remaining stock.
       - Spills or waste: A dose was accidentally spilled or wasted and not properly documented.
       - Manufacturer overfill or underfill: For multi-dose vials, slight variations in volume due to manufacturer overfill or underfill.
       - Dead space: The small amount of liquid that remains in the needle and syringe hub can cause minor discrepancies.
       - Theft or diversion: This is the most serious possibility and must be considered if other explanations are ruled out. Look for signs of tampering, broken seals, or suspicious activity.
   - Document Everything:
     - Document every step of the investigation. Note who conducted the recount, when it was done, what was found, and the suspected cause. This documentation is crucial for both internal records and, if needed, for the DEA.

2. Determining "Significant Loss"

The DEA requires the reporting of any "theft" and "significant loss." A "significant loss" is not defined by a specific quantity but is determined by a set of factors. The registrant, must use their professional judgment to decide if the loss is significant. Factors to consider include:

- The actual quantity of the controlled substance lost.
- The specific controlled substance lost. Is it a substance with a high potential for abuse (e.g., fentanyl, cocaine)?
- The reason for the loss. Can the loss be attributed to a specific individual, a new process, or a trend?
- A pattern of losses. Is this an isolated incident, or is it part of a recurring pattern?
- Local trends or indicators of diversion.
  - Even a small amount, such as a single dose, may be considered significant if it is a potent drug with a high potential for diversion or if it is part of a pattern of missing doses. When in doubt, it is recommended to err on the side of reporting.

3. Reporting to the DEA

If the lab determines the discrepancy constitutes a theft or a significant loss, they must take the following actions:

- Immediate notification: The DEA registrant must notify the nearest DEA Field Division Office in writing within one business day of the discovery. This can be done via email or a formal letter (as long as it's received within one business day).
- DEA Form 106: The registrant must then complete and submit DEA Form 106, "Report of Theft or Loss of Controlled Substances."
- This form must be submitted electronically through the DEA's secure network application.
    - It must be completed and submitted within 45 days of the discovery of the theft or loss.

4. Internal and Local Reporting

If the lab determines the discrepancy constitutes a theft or a significant loss, they must take the following actions:

- Report to Dartmouth EHS if this has not already been done.
- Contact the Dartmouth Department of Safety and Security, who may involve local law enforcement.

5. Important Considerations

Do Not Obliterate Records: When correcting a recordkeeping error, do not use white-out or completely erase entries. Instead, draw a single line through the incorrect entry, write the correct information, and initial and date the change. This maintains a clear audit trail.

Proactive Measures: After an investigation, the lab should review its procedures to prevent future discrepancies. This may include:

- Increasing the frequency of inventory checks.
- Reviewing security measures for the controlled substance storage.
- Providing additional training to all personnel with access to controlled substances.
- Ensuring that two people are involved in inventory counts as a check and balance.

OMB APPROVAL NO. 1117-0007 Expiration Date 1/31/2024

U. S. DEPARTMENT OF JUSTICE – DRUG ENFORCEMENT ADMINISTRATION

REGISTRANT RECORD OF CONTROLLED SUBSTANCES DESTROYED

FORM DEA-41

A. REGISTRANT INFORMATION

Registered Name:		DEA Registration Number:	
Registered Address:			
City:	State:	Zip Code:	
Telephone Number:		Contact Name:	

B. ITEM DESTROYED

1. Inventory

	National Drug Code or DEA Controlled Substances Code Number	Batch Number	Name of Substance	Strength	Form	Pkg. Qty.	Number of Full Pkgs.	Partial Pkg. Count	Total Destroyed
Examples	***16590-598-60***	***N/A***	***Kadian***	***60mg***	***Capsules***	***60***	***2***	***0***	***120 Capsules***
	0555-0767-02	***N/A***	***Adderall***	***5mg***	***Tablet***	***100***	***0***	***83***	***83 Tablets***
	9050	***B02120312***	***Codeine***	***N/A***	***Bulk***	***1.25 kg***	***N/A***	***N/A***	***1.25 kg***
1.									
2.									
3.									
4.									
5.									
6.									
7.									

2. Collected Substances

	Returned Mail-Back Package	Sealed Inner Liner	Unique Identification Number	Size of Sealed Inner Liner	Quantity of Packages(s)/Liner(s) Destroyed
Examples	***X***		***MBP1106, MBP1108 - MBP1110, MBP112***	***N/A***	***5***
		X	***CRL1007 - CRL1027***	***15 gallon***	***21***
		X	***CRL1201***	***5 gallon***	***1***
1.					
2.					
3.					
4.					
5.					
6.					
7.					

C. METHOD OF DESTRUCTION

Date of Destruction:		Method of Destruction:	
Location or Business Name:			
Address:			
City:		State:	Zip Code:

D. WITNESSES

I declare under penalty of perjury, pursuant to 18 U.S.C. 1001, that I personally witnessed the destruction of the above-described controlled substances to a non-retrievable state and that all of the above is true and correct.

Printed name of first authorized employee witness:	Signature of first witness:	Date:
Printed name of second authorized employee witness:	Signature of second witness:	Date:

E. INSTRUCTIONS

1. Section A. REGISTRANT INFORMATION: The registrant destroying the controlled substance(s) shall provide their DEA registration number and the name and address indicated on their valid DEA registration, in addition to a current telephone number and a contact name, if different from the name on the valid DEA registration.
2. Section B. (1) Inventory: This part shall be used by registrants destroying lawfully possessed controlled substances, other than those described in Section B(2). In each row, indicate the National Drug Code (NDC) for the controlled substance destroyed, or if the substance has no NDC, indicate the DEA Controlled Substances Code Number for the substance; if the substance destroyed is in bulk form, indicate the batch number, if available. In each row, indicate the name, strength, and form of the controlled substance destroyed, and the number of capsules, tablets, etc., that are in a full package (pkg. qty.). If destroying the full quantity of the controlled substance, indicate the number of packages destroyed (number of full pkgs.). If destroying a partial package, indicate the partial count of the capsules, tablets, etc. destroyed (partial pkg. count). If destroying a controlled substance in bulk form, indicate that the substance is in bulk form (form) and the weight of the substance destroyed (pkg. qty.). In each row, indicate the total number of each controlled substance destroyed (total destroyed).
3. Section B. (2) Collected Substances: This part shall be used by registrants destroying controlled substances obtained through an authorized collection activity in accordance with 21 U.S.C. 822(g). In each row, indicate whether registrant is destroying a mail-back package or an inner liner. If destroying a mail-back package, enter each unique identification number separated by a comma and/or as a list in a sequential range and total quantity of packages being destroyed. If destroying an inner liner, enter each unique identification number separated by a comma and/or as a list in a sequential range based on the size of the liners destroyed and the total quantity of inner liners being destroyed. In the case of mail-back packages or inner liners received from a law enforcement agency which do not have a unique identification number or clearly marked size, include the name of the law enforcement agency and, if known, the size of the inner liner or package. DO NOT OPEN ANY MAIL-BACK PACKAGE OR INNER LINER; AN INVENTORY OF THE CONTENTS OF THE PACKAGES OR LINERS IS PROHIBITED BY LAW AND IS NOT REQUIRED BY THIS FORM.
4. If additional space is needed for items destroyed in Section B, attach to this form additional page(s) containing the requested information for each controlled substance destroyed.
5. Section C. METHOD OF DESTRUCTION: Provide the date, location, and method of destruction. The method of destruction must render the controlled substance to a state of non-retrievable and meet all applicable destruction requirements.
6. Section D. WITNESSES: Two authorized employees must declare by signature, under penalty of perjury, that such employees personally witnessed the destruction of the controlled substances listed in Section B in the manner described in Section C.
7. You are not required to submit this form to DEA, unless requested to do so. This form must be kept as a record of destruction and be available by the registrant for at least two years in accordance with 21 U.S.C. 827.

Paperwork Reduction Act Statement: The information collected on this form is necessary for DEA registrants to record controlled substances destroyed in accordance with the Controlled Substances Act (CSA). The records that DEA registrants maintain in accordance with the CSA must be kept and be available, for at least two years, for inspection and copying by officers or employees of the United States authorized by the Attorney General. 21 U.S.C. 827. DEA estimates that it will take approximately 30 minutes to complete this form, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. The completion of this form by DEA registrants that destroy controlled substances is mandatory in accordance with 21 U.S.C. 827. Please note that an agency may not conduct or sponsor, and a person is not required to respond to, a collection of information unless it displays a currently valid OMB control number. Comments regarding this information collection, including suggestions for reducing the burden estimate, should be directed to the Drug Enforcement Administration, DEA Federal Register Representative/ODL, 8701 Morrissette Drive, Springfield, Virginia 22152.

24.9 Appendix I: Peroxide Formers

Peroxide Formers

List A Peroxides from Storage	List B Peroxides from Concentration	List C Peroxides from Polymerization
Butadiene *	Acetal	Butadiene **
Chloroprene *	Acetalaldehyde	Chlorobutadiene
Divinyl acetylene	Benzyl alcohol	Chloroprene **
Isopropyl ether	Chlorofluoroethylene	Chlorotrifluoroethylene
Potassium amide	Cumene (isopropylbenzene)	Styrene
Potassium metal	Cyclohexene	Tetrafluoroethylene **
Sodium amide	2-Cyclohexen-1-ol	Vinyl acetate
Tetrafluoroethylene *	Cyclopentene	Vinyl acetylene
Vinyldiene chloride	Decahydronaphthalene (decalin)	Vinyl chloride
	Diacetylene (butadiyne)	Vinyl pyridine
	Dicyclopentadiene	Vinyldiene chloride
* Indicates a peroxide former when stored as a liquid monomer.	Diethylene glycol dimethyl ether (diglyme)	** Can form explosive levels of peroxides if stored as a liquid. When stored as gas, peroxide accumulation may cause autopoly-merization.
	Dioxane	
	Ethyl ether	
	Furan	
	4-Heptanol	
	2-Hexanol	
	Methyl acetylene	
	3-Methyl-1-butanol	
	Methyl-isobutyl ketone	
	Methylcyclopentane	
	2-Pentanol	
	4-Penten-1-ol	
	Phenylethanol	
	Tetrahydrofuran	
	Tetrahydronaphthalene	
	Vinyl ethers	
	Other secondary alcohols	

List A chemicals should be tested for peroxide formation before using or discarded after 3 months.

List B chemicals should be tested for peroxides before distillation or evaporation and tested for peroxide formation or discarded after 1 year.

List C chemicals should be tested for peroxide formation or discard liquids aftter 6 months; and gases after 1 year.

24.10 Appendix J: Laboratory Move/Closure Guidelines

Dartmouth College
Environmental Health & Safety

37 Dewey Field Road, Suite 6216 Hanover, New Hampshire 03755
Tel: 603-646-1762, Fax: 603-646-2622, E-mail: ehs@dartmouth.edu
http://www.dartmouth.edu/~ehs/

Laboratory Move or Closure Guidelines

- One Month Before Move or Closure

- E-mail ehs@dartmouth.edu to notify us of the impending move or closure.
- Clean out refrigerators, freezers, cold rooms, warm rooms, and liquid nitrogen tanks. If these items are moving, ensure all containers are sealed and appropriately labeled. There should be no hazardous chemicals stored within--i.e., alcohols, phenol.
- Identify all unwanted, unused, and waste hazardous materials and set them aside for pick-up by EHS.
- Generate an inventory of all chemicals, biological, and radioactive material to be moved (rather than disposed). Inspect all chemical containers for proper labeling, container integrity, and adequate caps/lids. Do not move damaged, leaking, corroded, or otherwise compromised chemical containers. Contact EHS for transport assistance. If the lab is moving off-site, ensure the moving company is DOT HAZMAT certified.
- Identify and re-label all unknown chemical containers. If they are truly unknown, they are assumed to be hazardous wastes. Contact EHS for assistance and disposal.
- Return unwanted, unused gas cylinders to the vendor. Cylinders must not be left behind.
- Scientific equipment: if moving with the lab or for disposal: Wipe down with a mild soap or bleach solution and remove all hazard labels. If used with radioactivity, contact Radiation Safety Officer for a contamination survey prior to removal of any radiation stickers. If equipment is for disposal, attach a "*Procurement Property Management tag, Certification that Property is Free from*

Hazards". See clearance procedure at: *http://www.dartmouth.edu/~ehs/essential-info/hazard_clearance.html*

- Autoclave all biohazardous waste and labware. Chemically decontaminate all biohazardous liquids before drain disposal. Refer to the *Biohazardous Waste Guide* for assistance at: http://www.dartmouth.edu/~ehs/biological/policies_sops.html. EHS can provide assistance with large amounts of biological waste.

- Place all sharps waste, i.e., needles, syringes, razor blades, into the appropriate sharps containers.

- Controlled Substances: Contact EHS if you have a DEA license and wish to dispose of or transfer controlled substances.

- Shared Spaces: All shared space must be cleared of materials and cleaned by the departing staff, or another PI must assume responsibility for the space and its contents. These shared spaces include labs, equipment rooms, storage areas, cold/warm rooms, dark rooms, autoclave rooms, etc.

- Select Agents and Toxins: EHS must verify the depletion or destruction of all select agents and toxins. Consult the IBC Exempt and Excluded Select Agent Use Policy for decontamination and disposal guidance: http://www.dartmouth.edu/~ehs/biological/policies_sops.html. Contact EHS for disposal and decontamination assistance.

- Two Weeks Before Moving or Closing

- Prepare Biological Safety Cabinets (BSCs). Wipe down all BSCs, both interior and exterior surfaces, with 70% ETOH. If the lab is moving, contact TSS (or your certification vendor) for assistance in having the cabinet decontaminated.

- Decontaminate the interior of chemical fume hoods and benchtops with a warm soap and water solution. Pay special attention to old spills; use the spill kits provided by EHS and collect heavily contaminated items for disposal as hazardous waste. Always wear gloves and chemical splash goggles for this work.

- Schedule a final lab inspection with EHS.

- Moving Hazardous Chemicals

Hazardous materials or "HAZMAT" cannot be transported over the road without special training and licensing. HAZMAT includes material that is flammable, corrosive to skin or metal, poisonous, toxic, reactive, unstable, an oxidizer, or a compressed gas. For more information on whether your material is regulated, contact EHS for an interpretation.

If you wish to take hazardous materials with you: Most moving companies are NOT licensed or trained to move hazardous materials, so please make sure the moving company has all the proper licensing to do so. Personal vehicles may not be used for transporting hazardous materials--no exceptions.

Hazardous chemicals can be moved within or between buildings on contiguous properties with appropriate training and minimal packaging requirements. Remember - NEVER move hazardous chemicals in a vehicle.

Packaging required: Rigid, leak-proof, and shatter-proof outer container. Examples include, but are not limited to, plastic or rubber bottle carriers, plastic or metal-wheeled carts, or sturdy leak-proof bags.

Wear gloves, eye protection, and a lab coat when packing hazardous materials.

Absolutely no biohazard or black plastic bags may be used for packing or transport.

Biological materials being transported should be sealed in leakproof containers and placed into a secondary container to help prevent leaks and spills.

Avoid packing too many containers together. Use pieces of cardboard to cushion between bottles. No “glass on glass” contact.

24.11 Appendix K: Unattended Operation Door Sign

UNATTENDED LABORATORY OPERATION

AN UNATTENDED LABORATORY OPERATION THAT MIGHT CAUSE A HAZARDOUS CONDITION IF THERE IS EQUIPMENT OR BUILDING SERVICES FAILURE IS INSIDE THIS LABORATORY.		
The following hazards or hazardous materials could be present:		
Continuously Running Water (e.g., equipment cooling water)		Specify hazardous materials in use, other unattended operations, and access restrictions here:
In-process Hazardous Material Application (e.g., liquid chromatography, Western blot)		
Continuously Energized Magnetic Fields or Electricity		
Dates Posting is Valid:		
The following people should be contacted in the event of an emergency:		
Primary Contact Name:	**24-Hour Phone Number:**	
Secondary Contact Name:	**24-Hour Phone Number:**	
If a hazardous condition is suspected, notify the EHS immediately!		
Environmental Health & Safety	**Safety & Security**	**Emergency**
603-646-1762	**603-646-4000**	**911**

PLEASE POST THIS SIGN ON THE DOOR TO THE LABORATORY OR ON THE LAB HOOD IN WHICH THE OPERATION IS TAKING PLACE.

24.12 Appendix L: Hydrofluoric Acid

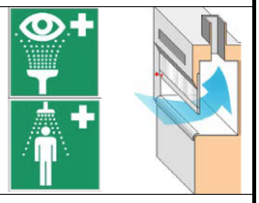
Dartmouth College Guidelines for Safe Use of

Hydrofluoric Acid

DANGER DANGER

Laboratories should create their own specific SOP's for the use of Hydrofluoric Acid

Hazards	**Potential Hazards**	**Fatal if swallowed, in contact with skin, or if inhaled.** • Causes **severe skin burns and eye damage.** •For further safety information, refer to Lab Chemical Safety Summary for hydrofluoric acid. (Pubchem), New Jersey Right to Know Fact Sheet on Hydrogen Fluoride and manufacturer Safety Data Sheet (SDS). • *Hydrofluoric acid penetrates the skin and dissociates into hydrogen and fluoride ions, which can subsequently cause tissue destruction, decalcification of bone, cardiac arrhythmia, and liver and kidney damage. Greater than 50% hydrofluoric acid usually causes immediate burns that are extremely painful and slow to heal. Exposure to lower concentrations may not be apparent for several hours but can still cause burns and further damage if not washed off.*
Hazard Controls-1	**Selection & Purchase**	• Consider the use of an alternative acid. • Purchase the smallest container at the lowest concentration practical. • Calcium gluconate gel is required to be in the room when Hydrofluoric Acid is in use. If you need calcium gluconate contact Dartmouth EHS: ehs@dartmouth.edu or 603-646-1762. • If there is a risk of **possibility of ingestion** have available **calcium carbonate antacid tablets (Tums).**
	Storage & Transport	• Store in compatible (e.g. polyethylene) primary and secondary containers. • **DO NOT** use glass containers – hydrofluoric acid dissolves glass. • Keep primary container tightly closed. • Store in a **dry** and **well-ventilated place**. • Store **below eye level** but **not on the floor**. • **Store away from bases, metals, and other incompatibles.** • **DO NOT** store under the sink. • Transport in a bottle carrier.
	Engineering Controls & Safety Equipment	• Eyewash and drench hose are required in immediate work area. • A safety shower will also be necessary for most uses of hydrofluoric acid. • All work must be done in a chemical fume hood
	Work Practice Controls	• *A lab-specific SOP approved in advance by the PI is required.* • *EHS also require the completion of a High Hazard Lab Chemical operations Form* • Before using this acid, make sure calcium gluconate gel and antacid tablets have not expired. • Have an **area** in the laboratory that is exclusively **designated for hydrofluoric acid use.** • **Notify all laboratory members** that you are actively using hydrofluoric acid and where. • Work within sight and/or hearing of **at least one other person** who is familiar with the hazards and lab-specific written procedures. • **Line all work surfaces** with plastic-backed absorbent paper and/or a containment tray that is compatible with hydrofluoric acid. • Always **add** hydrofluoric acid to water and not the reverse. • **DO NOT** use glass, ceramic or other incompatible containers.



Hazards Controls-2	**Work Practice Controls**	• **DO NOT** heat. • **DO NOT** breathe hydrofluoric acid vapors, mists, or gas. • DO NOT get in eyes, on the skin, or on clothing. • **Wash hands** immediately after handling. • Once work is complete, **decontaminate** the area by wiping with a 10% sodium carbonate (Na2CO3, also known as soda ash) solution.	
	Personal Protective Equipment (PPE)	• Dartmouth College has a Policy on PPE for Chemistry • **Eyes & Face**: Tight fitting safety goggles and it is *recommended* to wear a face shield (8" in length, minimum) • **Hands**: Use 5 mil Neoprene for <50 ml of 48% or less. Change gloves every 30 min. • For >50 ml, >48%, or for spills: use 17 mil (or thicker) Neoprene, 14 mil (or thicker) butyl, or 5 mil neoprene over laminate (e.g., Silver Shield). • Inspect gloves for defects prior to use. • Remove gloves after handling and take care to not touch the outer surface of the glove. • Dartmouth College Stockrooms provide **Purple Nitrile Gloves** which have a thickness of 0.09-0.15 mm from Cuff to Middle Finger. • **Body**: Fully buttoned lab coat, sleeves to wrist; clothing covering legs; closed toed shoes; rubber apron; chemical-resistant sleeves.	
Other	**Medical Emergencies**	• ***Immediate first aid and medical treatment is essential for people exposed to hydrofluoric acid.*** • Be familiar with the Recommended Medical Treatment for Hydrofluoric Acid Exposure binder. These binders are found in every lab possessing HF. ○ THIS BINDER MUST ACCOMPANY ANY HF EXPOSURE VICTIM TO THE HOSPITAL **For an actual chemical exposure/injury:** • Seek immediate medical attention at the emergency department for any exposure. • Persons helping an exposed colleague must wear PPE as indicated above. • Call 911 (if in Borwell, Rubin and Williamson dial 5555) from any phone to request assistance and/or emergency transport. • For exposure-related advice contact Dartmouth EHS at 603-646-1762. (EHS or EMS may recommend that person ingest calcium carbonate tablets (such as Tums) for skin exposure.) Report the injury/Illness after seeking treatment. **Skin exposure:** • Flush with water for 5 minutes then rub calcium gluconate gel onto the burn site. Continue to massage the calcium gluconate gel into the burn site during transportation to a medical facility and while waiting to see a physician. • Calcium gluconate gel will bind to the fluoride ions and prevent further tissue destruction, but it must be applied quickly (even if burns have not been felt) to be effective. • If not using calcium gluconate gel, continually rinse with water until treatment is provided. **Eye exposure:** • Flush eyes for at least 15 minutes with large amounts of gently flowing water. • Take the victim to a doctor, preferably an eye specialist, as soon as possible. Use ice water compresses on the eyes during transportation. **Ingestion:** • Administer a calcium-containing medication (such as Tums) if available. Magnesium-containing stomach medication or several glasses of milk may also be given.	

Other	**Emergencies & Spills**	• Any HF spill (no matter the size) is considered an emergency by EHS and will be cleaned up by EHS. • Contact Dartmouth EHS by calling 603-646-1762. • Contain the spill with paper towels or compatible spill pads (some spill pads have fiber glass these are not suitable for HF clean ups) until EHS arrives. • For fire or potential for a fire – Pull nearest fire alarm pull station, evacuate the building and go to a safe location to dial 911. (In Borwell, Rubin and Williamson, dial 5555)
	Waste	• Label any waste containers with the appropriate waste labels. • Store in **appropriate** secondary containers (no glass or metal secondary containers). • For waste pick up and disposal contact Dartmouth EHS by e-mailing ehs@dartmouth.edu
	Training	Dartmouth College requires certain training for employees. For this chemical Laboratory Safety/ Hazardous Waste Management is required. This training is mandatory for all personnel working in a teaching or research wet laboratory. It is an introductory program on laboratory safety and waste management in a biomedical, engineering, chemistry, earth science or physics lab at Dartmouth College. The course takes approximately 45 minutes to complete. Completion is required every three years.
	Medical Surveillance	
	Monitoring Requirements	• Exposure limits: ACGIH TLV – 2 ppm ceiling, 0.5 ppm average over 8 hrs. OSHA PEL: 3 ppm.
	Questions	Contact Dartmouth Environmental Health and Safety by e-mailing us a ehs@dartmouth.edu calling 603-646-1762 or vising our website.

"I have read and understand this Guidelines. I agree to fully adhere to its requirements."

Last	First	Dartmouth ID	Signature

Acknowledgement: Special thanks for Duke's Occupational & Environmental Safety Office for their permission to use this great design for our chemical guidelines. All Dartmouth High Hazard Guidelines are based on Duke OESO Chemical SOP's and Guidelines

24.13 Appendix M: Perchloric Acid

Health Hazards

At room temperature, perchloric acid up to concentrations of 72% has properties similar to other strong mineral acids. The acute toxicity of perchloric acid is moderate to high. It is a highly corrosive substance and causes severe burns on contact with the eyes, skin, and mucous membranes. Liquid or spray mist may cause tissue damage to the mucous membranes of the eyes. Inflammation of the eye is characterized by redness, watering, itching, and blurred vision. It can also lead to loss of vision or blindness. Skin contact may produce inflammation characterized by itching, reddening, and blistering. Inhalation of spray or mist may produce severe respiratory tract irritation, causing sore throat, coughing, labored breathing, and even lung edema. Ingestion of perchloric acid will cause mouth, throat, stomach, and intestinal tract burns, along with abdominal pain and diarrhea.

Epidemiological data available for occupational exposure to perchloric acid are limited, and exposure limits have not been defined (National Institute of Occupational Safety and Health, 2000). Prolonged or repeated inhalation may cause nosebleeds, nasal congestion, erosion of the teeth, perforation of the nasal septum, chest pains, and bronchitis. Prolonged or repeated eye contact may cause conjunctivitis. Repeated dermal exposure may cause sensitization, dermatitis, and destruction or ulceration of the skin. Perchloric acid has not been shown to be carcinogenic or to show reproductive or developmental toxicity in humans.

SAFETY PRECAUTIONS FOR PERCHLORIC ACID USE

Training

Students and employees who handle perchloric acid must have read the Safety Data Sheet (SDS) and receive training on the hazards of perchloric acid from their respective PI or laboratory supervisor. They must know what to do in the event of a spill or an exposure incident. The SDS must always be kept within the immediate vicinity of the working area along with the Standard Operating Procedure (SOP) developed by the PI/Lab Supervisor/Researcher.

Ventilation / Fume Hood

Perchloric acid must always be handled in a working fume hood to keep the level of exposure as low as possible. Perchloric acid digestion and other procedures performed above ambient temperatures must be done in a specially designed perchloric acid fume hood equipped with a wash-down system. Solutions of 72% (w/w) perchloric acid at room temperature have no vapor pressure and therefore no vapor should get into the hood. However, work involving anhydrous perchloric acid (>85% w/w) should always be done in a dedicated perchloric acid fume hood. Dedicated perchloric acid fume hood and ducts are made of stainless steel. An exhaust air scrubber system is present in the ductwork and behind the baffle to emit a fine water spray to dilute and wash down the acid fumes and vapors when the fume hood is in use. Solvents must never be used or stored in a designated perchloric acid fume hood.

Eye Protection

Splash goggles and a face shield MUST be worn when handling perchloric acid solutions.

Gloves

Natural rubber, neoprene, PVC, nitrile, and Viton gloves are suggested when working with 85% w/w.

Protective Clothing

A chemical apron over a lab coat with long sleeves MUST be worn when handling perchloric acid solutions. **No exposed skin is allowed; long pants, sleeves, and closed-toe shoes must be worn.**

Safe Work Practice

For < 72% Perchloric Acid at Room Temperature

At room temperature, perchloric acid up to concentrations of 72% has properties similar to other strong mineral acids. When used under these conditions, perchloric acid reacts as a strong non-oxidizing acid. The following precautions should be taken when using perchloric acid under these conditions:

- Substitute with less hazardous chemicals when appropriate.
- Use dilute solutions (<60%) whenever possible.
- Conduct operations involving cold perchloric acid in a properly functioning laboratory (chemical) hood with current certification sticker.
- Always transfer perchloric acid over suitable containment to catch any spills and afford a ready means of cleanup and disposal.
- Perform all operations on chemically resistant surfaces. Avoid contact with cellulose materials such as wood, paper, and cotton, which could result in a fire or explosion.

< 72% Perchloric Acid Heated

When heated to temperatures above 150°C, perchloric acid becomes a strong oxidizer and eventually becomes unstable and can react violently with many oxidizable substances and detonate. Vapors may also contaminate work surfaces or ventilation equipment with perchlorate residues, which may form highly unstable compounds, such as metallic perchlorates.

- Perchloric acid digestion and other procedures performed at elevated temperatures should be done in a specially designed perchloric acid fume hood.
- Never heat perchloric acid in an oil bath or with an open flame. Electric hot plates, electrically or steam-heated sand baths, heating mantles, or steam baths are preferred. Use explosion-proof electrical equipment.
- Avoid allowing hot perchloric acid to come into contact with any organic materials, including paper or wood, because a fire or explosion can occur. Avoid storing these materials in perchloric acid work hoods. Avoid using greases or hoses that are incompatible with perchloric acid.

- In wet digestions with perchloric acid, treat the sample first with nitric acid to destroy easily oxidizable matter.
- Do not distill perchloric acid in a vacuum, because the unstable anhydride may be formed and cause a spontaneous explosion.
- Wash down the perchloric acid hood after each use, following the operating instructions provided by the manufacturer of the perchloric acid hood.
- All apparatus should have glass-to-glass joints. Use silicon-based lubricants for glass-to-glass joints. Do not use rubber stoppers, tubes, or stopcocks.
- If an apparatus cracks or breaks due to thermal or mechanical shock, the hazards are sufficient to make it desirable to consider using quartz apparatus, since it is necessary in many experiments to chill perchloric acid rapidly from the boiling point.

For Anhydrous Perchloric Acid (> 85% concentration)

Anhydrous perchloric acid is very unstable and will usually explode when it encounters organic materials. Only experienced research workers should handle anhydrous perchloric acid and follow these additional precautions:

- Never work alone when handling anhydrous perchloric acid. A second worker must be informed of the work and should be in sound or sight contact with the worker using anhydrous perchloric acid.
- Use a safety shield to protect oneself against the effects of a possible explosion.
- The work must be done in a designated perchloric acid fume equipped with a wash-down system.
- No extraneous chemicals should be present in the fume hood while performing the work.
- Longer and thicker gloves (in addition to the recommended PPE) should be worn.
- Use only freshly prepared acid. Do not make any more anhydrous perchloric acid than is required for an experiment.

STORAGE, SPILL, AND WASTE ISSUES

Storage

The quantities of perchloric acid kept in storage should be kept to a minimum. Perchloric acid should be stored in its original container within compatible secondary containment, preferably glass or porcelain. Glass trays should be wiped periodically. Perchloric acid should be separated from other chemicals, but may be stored with other inorganic acids, preferably in a metal cabinet designed for acid/corrosive storage. Perchloric acid must be stored away from organic chemicals, flammable or combustible materials, and strong dehydrating agents such as sulfuric acid and anhydrous phosphorus pentoxide.

Perchloric acid is incompatible with the following chemicals and must not be stored with them because of the danger of explosion or fire:

Acetic Acid	Acetic Anhydride
Alcohols	Aniline
Antimony Compounds (Trivalent)	Bismuth
Dehydrating Agents	Diethyl Ether
Formaldehyde Mixtures	Fluorine
Glycerine	Glycols
Glycol Ethers	Hydriodic Acid
Hydrochloric Acid	Hypophosphites
Ketones	Lead Oxide Mixtures
Nitrogen Triiodide	Nitrosophenol
Organic Matter (paper, wood, cotton, etc)	Sodium Iodide
Sulfoxides and Sulfur Trioxide	

Spills

In the case of a small spill, the spill can be cleaned by laboratory staff, assuming that the correct equipment is present and that researchers understand the hazards associated with perchloric acid.

1. Neutralize it with soda ash (sodium carbonate) or other appropriate neutralizing agent.
2. Soak up the neutralized spill with an inorganic based absorbent (if possible).
3. Do not use organic materials, such as Kimwipes or toweling, as they **may spontaneously ignite** upon contact with perchloric acid.
4. If rags or paper towels are inadvertently used, wet them with water and place them in a tightly sealed plastic bag.
5. Do NOT use rags, paper towels, or sawdust and then put them aside to dry out, as such materials may spontaneously ignite.
6. A second neutralization and rinsing of the wetted area is recommended.
7. Perchloric acid waste must not be mixed with other wastes. It should be placed into acid resistant containers that are clearly labeled with green hazardous waste labels.
8. Contact EHS (ehs@dartmouth.edu) to request an immediate pick-up of the containers of spilled product and contaminated absorbent material.

Surfaces can also be tested to check for perchlorate contamination:

- Diphenylamine Test: Dissolve one gram of diphenylamine in 10 mL of “1 to 1” (18N) sulfuric acid to form a diphenylamine sulfate solution. Using a medicine dropper, apply this solution to the test surface. The liquid turns black upon contact with perchlorate. The solution also reacts with nitrates but turns blue.

- Methylene Blue Test: Use a 0.4% solution of methylene blue in water. Add a few drops of indicator solution to about 25 mL of trial solution, such as water used to test rinse from a length of potentially contaminated duct. Perchlorates will produce a violet precipitate.

In the event of a large spill located outside a chemical fume hood, contact EHS for assistance.

1. Notify all lab members.
2. Evacuate the area immediately.
3. Restrict access to the area.
4. Notify EHS at 603-646-1762, providing the following information:
    i. Name of hazardous material.
    ii. Quantity involved.
    iii. Location of the spill.
    iv. Actions taken so far.
5. Provide Safety Data Sheet (SDS) or appropriate documentation.

Waste Handling

Perchloric acid waste should never be mixed with other organic wastes. It should be kept in clearly identified containers labelled with a complete green hazardous waste label.

If a bottle containing perchloric acid has turned dark and has crystals forming around the bottom of the bottle, there is a potential explosion hazard. Do not touch the container, as it might be highly unstable and shock sensitive. Any attempts to move or open the container might result in an explosion.

Visually inspect the container in order to identify the content and to look for an expiration date.

1. Evacuate the laboratory and secure the area by restricting access.
2. Call EHS, indicating the possibility of dry perchloric acid being present in the laboratory.

EMERGENCY PROCEDURES

Skin Contact

1. Remove contaminated clothing and immediately wash the affected area with large amounts of water until all evidence of the chemical has been removed (approximately 15 minutes).
2. Apply a magnesia/glycerol paste (or anti-bacterial cream) to the affected area. A magnesia/glycerol paste should be in your first aid kit if perchloric acid is handled in your laboratory.
3. Call 911. Seek immediate medical attention by going to the ER or Occupational Medicine at DHMC

Eye Contact

1. Immediately wash the affected eye with large amounts of water until all evidence of the chemical has been removed (approximately 15 minutes).
2. Do not allow the victim to rub or keep their eyes closed.
3. Call 911. Seek immediate medical attention by going to the ER or Occupational Medicine at DHMC.

Inhalation

1. Immediately move the victim to fresh air.
2. Seek medical attention by going to the ER or Occupational Medicine at DHMC.

Ingestion

1. Wash out the mouth thoroughly with water and give water to drink (about 8 oz.) followed by Milk of Magnesia. Milk of Magnesia should be part of your laboratory first aid kit if perchloric acid is handled in your laboratory.
2. Do not induce vomiting.
3. Call 911. Seek immediate medical attention by going to the ER or Occupational Medicine at DHMC.

In all cases of exposure, a copy of the Safety Data Sheet (SDS) must be brought to the emergency room, as the treating physician might be unaware of the treatment measures for perchloric acid.

All perchloric acid incidents must be reported to your Supervisor, Environmental Health & Safety (EHS), and Risk Management.

An injury report must be filed for any incident involving perchloric acid spill or exposure.

If you have any concerns about the use of perchloric acid, please contact EHS at ehs@dartmout.edu or 603-646-1762.

24.14 Appendix N: Formaldehyde Exposure Control Program

Formaldehyde Exposure Control Program

DARTMOUTH

Contents

Section 1 – Introduction

Formaldehyde is a colorless gas with a potent smell, and frequently encountered in water-based solutions. It serves as a preservative in medical laboratories and mortuaries and is prevalent in various items, including chemicals, particle board, household products, glues, permanent press fabrics, paper product coatings, fiberboard, and plywood. Additionally, formaldehyde finds extensive application as an industrial fungicide, germicide, and disinfectant.

Formaldehyde is recognized as a confirmed cancer risk and known human carcinogen. Brief exposure to 0.1 part formaldehyde per million parts of air (ppm) concentrations can result in significant irritation of the eyes, nose, and throat. It also possesses sensitizing properties, potentially leading to severe allergic reactions affecting the skin, eyes, and respiratory system upon subsequent exposure. The National Institute for Occupational Safety and Health (NIOSH) identifies 20 ppm of formaldehyde as an immediately dangerous to life and health (IDLH) concentration.

Section 2 – Purpose

The Formaldehyde Exposure Control Program (Program) at Dartmouth College was developed to provide information on the hazards associated with formaldehyde and outline safe steps for students, faculty, and staff who handle or are exposed to all forms of formaldehyde.

This Program is applicable to all individuals, including students, faculty, and staff, who are involved with or may encounter various forms of formaldehyde. These forms include formaldehyde gas, aqueous solutions, solids, and any materials that have the potential to release formaldehyde.

Section 3 – Scope

This Program is in compliance with the Occupational Health and Safety Administration (OSHA) Standard 29 Code of Federal Regulations (CFR) 1910.1048, Formaldehyde.

The Formaldehyde Exposure Control Program is designed to achieve the following objectives:

- Protect the health and safety of students, faculty, and staff.
- Thoroughly assess the risks associated with formaldehyde exposure.
- Recognize formaldehyde-related hazards and establish control measures.
- Ensure adherence to local, state, and federal standards.
- Establish protocols for the execution and maintenance of this Program.

A copy of this program is available on the EHS website, in the EHS shared drive, and shall be provided to all students, faculty, and staff upon request, and shall be posted in areas of concern.

Questions about this program should be directed to Environmental Health and Safety at 603-646-1762 or at ehs@dartmouth.edu.

Section 4 – Definitions

Action Level (AL) - An airborne concentration of 0.5 ppm calculated as an 8-hour TWA for formaldehyde. Exposures at or above the action level trigger requirements for exposure assessment.

Administrative Controls - Changes in work procedures such as written safety policies, rules, supervision, schedules, and training with the goal of reducing the duration, frequency, and severity of exposure to formaldehyde.

Engineering Controls - To eliminate or reduce exposure to a chemical or physical hazard through the use or substitution of engineered machinery or equipment.

Exposure Assessment - Initial determination to find if any personnel may be exposed to formaldehyde at or above the exposure limits. Until the assessment is completed, users shall take the necessary precautions to maintain exposures within acceptable levels.

Immediately Dangerous to Life and Health (IDLH) - A condition that poses a threat of exposure to airborne contaminants when that exposure is likely to cause death or immediate or delayed permanent adverse health effects or prevent escape from such an environment.

National Occupational Safety and Health (NIOSH) - United States federal agency responsible for conducting research and making recommendations for the prevention of work-related injury and illness.

Respirator - A tight-fitting, air-purifying respirator with replaceable filters, cartridges, or canisters. These are attached to a rubber or silicone face piece that covers the nose and mouth and/or full face. This type of respirator requires the individual to be part of a respiratory protection program and needs to be medically cleared, trained, and fit tested annually.

Medical Surveillance - The analysis of health information to look for problems that be occurring in the workplace that require targeted prevention. Thus, surveillance serves as a feedback loop to the employer.

Occupational Health and Safety Administration (OSHA) - United States federal agency responsible for ensuring a safe and healthful working environment for workers by setting and enforcing standards and by providing training, outreach, education and assistance.

Parts per million (ppm) – Part(s) of formaldehyde per one million parts of air.

Permissible Exposure Limit (PEL) - Set by OSHA. This is set at 0.75 parts formaldehyde per million parts of air (ppm) measured as an 8-hour Time-Weighted-Average (TWA).

Personal Protective Equipment (PPE) - Equipment worn to minimize exposure to a variety of hazards.

Regulated Area – Workspaces in which formaldehyde concentrations exceed the PEL and/or STEL in monitoring assessments.

Short-term Exposure Limit (STEL) - Set by OSHA. The STEL is established at 2 ppm, averaged over a 15-minute duration, which is the maximum exposure allowed during a 15-minute period.

Time-weighted Average - An average exposure over a specified period, usually 15-minutes or 8-hours.

Work Practice Controls - Controls that reduce the likelihood of exposure by altering the manner in which a task is performed.

Section 5 – Responsibilities

Section 5.1 Environmental Health and Safety (EHS)

- Perform formaldehyde exposure assessments and provide users with written reports detailing the results and recommendations.
- Provide suggestions for minimizing formaldehyde exposure levels as needed - suitable work protocols, engineering controls, and personal protective equipment (PPE).
- Conduct reviews of engineering controls and work practices in locations where formaldehyde is utilized.
- Delivering training sessions to all users who encounter airborne formaldehyde exposure concentrations exceeding 0.1 ppm.

Section 5.2 Occupational Medicine

- Provide medical surveillance and screenings for faculty and staff as outlined in this Program.
- Keep medical records for faculty and staff exposed to formaldehyde in accordance with the guidelines specified in this Program.

Section 5.3 Dick's House

- Provide medical surveillance and screenings for students as outlined in this Program.
- Keep medical records for students exposed to formaldehyde in accordance with the guidelines specified in this Program.

Section 5.4 Principal Investigators and Lab Managers

- Identify areas where formaldehyde is used and inform EHS for exposure assessment.
- Ensure individuals handling or exposed to formaldehyde are informed of the associated hazards and employ appropriate safety measures.
- Notify EHS about any modifications in formaldehyde usage, work methods, or controls that might affect exposure levels.
- Adhere to the Chemical Hygiene Program for laboratories or Hazard Communication Program for non-laboratories for the storage and labeling of materials containing formaldehyde.

Section 5.5 Users

- Adhere to the procedures outlined in this Program.
- Use the designated Personal Protective Equipment (PPE).
- Attend and participate in relevant safety training sessions.
- Notify EHS about any modifications in formaldehyde usage, work methods, or controls that might affect exposure levels.
- Notify PI, lab manager, and/or EHS if there are any formaldehyde exposures.

Section 6 – Exposure Limits

The exposure limits for formaldehyde established by the Occupational Safety and Health Administration (OSHA) standard 1910.1048 are based on the measured concentration of formaldehyde gas in the air and the duration of exposure. These limits consist of:

- Permissible Exposure Limit (PEL): This is set at 0.75 parts formaldehyde per million parts of air (ppm) measured as an 8-hour Time-Weighted-Average (TWA).
- Short-Term Exposure Limit (STEL): The STEL is established at 2 ppm, averaged over a 15-minute duration, which is the maximum exposure allowed during a 15-minute period.
- Action Level (AL): The AL is defined as 0.5 ppm for an 8-hour TWA, and is the standards trigger for increased industrial hygiene monitoring and initiation of worker medical surveillance.

In cases where exposures reach or exceed the PEL, all provisions outlined in the plan must be put into effect within the work area. EHS (Environmental Health and Safety) will establish a monitoring program and implement exposure control measures to ensure that subsequent levels remain below both the PEL and AL, particularly if the AL is exceeded.

Section 7 – Exposure Assessments

An evaluation must be conducted for all operations, tasks, or job sites where there is a possibility of exposure to formaldehyde. The responsibility for notifying EHS of any activities that might lead to formaldehyde exposures not covered in this section, as well as any alterations in work procedures or practices that could impact exposures for the listed processes, falls on the users and Manager/Principal Investigator.

Formaldehyde should be managed within a functional chemical fume hood. However, when carrying out tasks such as preparing formaldehyde solutions or addressing formaldehyde spills outside of the fume hood, fluctuations in environmental conditions could potentially result in increased exposures.

Prior to utilizing formaldehyde in a setting beyond the chemical hood, it is essential to get in touch with EHS. This is done to evaluate the environmental conditions of the workspace and conduct exposure monitoring.

Section 8 – Exposure Monitoring

EHS will perform air monitoring within the user's breathing zone to evaluate the 8-hour and 15-minute exposure levels. Following the initial assessment, exposures will be reevaluated in accordance with the guidelines outlined below.

Formaldehyde air sampling strategy will include:

- Collection of personal breathing zone samples on representative individuals at maximum risk of exposure for the duration of the job for determining compliance with 8-hour time-weighted average (e.g. students, faculty/supervisors).
- Collection of 15-minute personal breathing zone samples during worst case tasks to characterize and determine compliance for short-term exposure limit.
- Observation and documentation of work activities.
- Follow validated sampling method (e.g. OSHA 52, OSHA 1007, NIOSH 2016, NIOSH 2539, NIOSH 2541) and/or choose an air sampling method

with known OSHA Compliance Accuracy (±25% for 8-hr TWA and STEL and ±35% for Action Level TWA). [1]

- Choice depends on availability of equipment, cost of equipment and analysis, and personnel.

Section 8.1 Repeated Monitoring when initial results are BELOW the Action Level

If the initial monitoring results are below the Action Level, further monitoring is necessary in the event of any alterations to the work that could potentially increase exposure levels. These changes encompass:

1. Change in Utilization: Monitoring will be repeated in response to alterations in the duration of exposure or modifications in the concentration or quantities of formaldehyde employed.
2. Operational Adjustments: Monitoring will be repeated upon changes in the machinery, procedures, workforce, control measures, or Personal Protection Equipment (PPE).
3. User Initiative: Monitoring will be repeated if a user makes a request or if a user reports symptoms or signs linked to formaldehyde exposure.

Section 8.2 Repeated Monitoring when initial results are ABOVE the Action Level

In cases where the initial monitoring outcomes indicate exposure equal to or above the action level, suitable engineering controls shall be put in place. If exposure persists at or above the action level or Short-Term Exposure Limit (STEL) following the implementation of controls, EHS will proceed with additional monitoring according to the subsequent protocol:

1. Exposures exceeding the action level: follow-up monitoring will be conducted every six months.
2. Exposures exceeding the short-term exposure limit: follow-up monitoring will be carried out annually.

Section 8.3 Termination of Monitoring

Exposure monitoring may be concluded if the results from two consecutive sampling periods, with a minimum interval of seven days between them, consistently indicate that employee exposure is below both the action level and the short-term exposure limit.

Section 8.4 Notification of Monitoring Results

EHS will deliver written notifications of all exposure monitoring findings to employees and supervisors within 15 days of obtaining the laboratory results.

[1] OSHA requires active sampling when the source of formaldehyde is formalin.

Section 9 – Regulated Areas

Workspaces in which formaldehyde concentrations exceed the PEL and/or STEL in monitoring assessments will be labeled as "regulated areas."

In regulated areas, signs must be visibly posted at all entry points and access routes, and these signs must display the following text:

DANGER
FORMALDEHYDE
MAY CAUSE CANCER
CAUSES SKIN, EYE, AND RESPIRATORY IRRITATION
AUTHORIZED PERSONNEL ONLY

Entrance to regulated areas will be restricted to authorized individuals who have received formal training in recognizing the dangers associated with formaldehyde.

Section 10 – Exposure Controls

In areas where formaldehyde exposure levels exceed exposure limits, formaldehyde exposure must be effectively managed and reduced to levels below the PEL and/or the STEL. This can be achieved through the implementation of the following control measures or a combination thereof.

Section 10.1 Engineering Controls

Control of formaldehyde exposure should primarily rely on engineering controls whenever possible. These engineering controls may involve measures such as improved ventilation to reduce formaldehyde gas concentrations or the use of physical barriers to prevent contact with liquid solutions containing formaldehyde.

In cases where engineering controls are not currently established or are not feasible, alternative measures, including work practice controls, administrative controls and the use of Personal Protective Equipment (PPE), must be employed to manage formaldehyde exposure effectively.

Section 10.2 Work Practice Controls

- Know the location of the nearest eyewash and safety shower.
- Know the location(s) of spill supplies, personal protective equipment, and other safety equipment.
- Never eat, drink, smoke, or apply cosmetics in a laboratory or near chemicals.
- Upon arrival, check shipments of formaldehyde for leakage before accepting the package and report any damages to the supervisor and receiving department.
- Never deface the labels on chemical containers and replace them if worn or illegible.

- Handle formaldehyde in a manner that minimizes the potential for skin exposure and releases into the air.
- Manipulate and transfer only the smallest volume of formaldehyde needed for your work and use standard equipment to ensure safe transfer and always handle under local exhaust ventilation.
- Keep spill absorbents available and situate the receiving container on a spill pad or other absorbent material.
- Keep containers closed except when actually transferring or using them.
- Store formaldehyde containers in a secure location as close to ground level as possible.
- Perform transfers and mixing in a laboratory hood or at another source of local exhaust, such as an elephant trunk.
- Never handle formaldehyde solutions at the open bench.

Section 10.3 Administrative Controls
Administrative controls encompass strategies that are designed to restrict user exposure to formaldehyde. This can be achieved by imposing limits on the quantities of formaldehyde used or the duration of time spent working with it. Additionally, access to areas where potential formaldehyde exposure exists can be restricted as part of these administrative controls.

Section 10.4 Personal Protective Equipment
Students, faculty, and staff should have access to and use appropriate personal protective equipment (PPE) when working with formaldehyde. This includes wearing lab coats, gloves, goggles, and face shields as necessary. Particularly, employees should avoid skin and eye contact with liquids containing one percent or more formaldehyde by wearing chemical-protective clothing that is impermeable to formaldehyde. It's essential that employees are familiar with the location and use of eyewash stations and emergency showers in case of accidental exposure.

Section 10.4.1 Respiratory Protection
The use of respirators is permitted in the following situations:

- During the time needed to install or implement feasible engineering and administrative controls.
- In work scenarios where feasible engineering or work practice controls are not yet effective in reducing exposure below the PEL/STEL.
- In work situations where engineering and work practice controls are not feasible.
- In emergencies where exposure could exceed the PEL/STEL.

Whenever respirator use is required, the individual should be provided with an appropriate respirator approved by the National Institute for Occupational Safety and Health (NIOSH) at no cost, and they must use it correctly. The selected respirator should effectively reduce the concentration of inhaled formaldehyde to at or below the PEL or STEL. EHS maintains a written Respiratory Protection

Program in compliance with the OSHA Respiratory Protection Standard (29 CFR 1910.134), which includes training and fit testing.

Students, faculty, and staff must obtain medical clearance from Dick's House, Occupational Medicine or a healthcare provider before undergoing fit-testing and using a respirator. In cases where an individual faces difficulties wearing a negative pressure respirator, a powered air-purifying respirator will be made available.

Section 10.5 Housekeeping and Spills
The workplace will be kept clean and devoid of any formaldehyde-contaminated debris. Any spills of formaldehyde should be managed according to the procedures detailed in the Chemical Hygiene Program.

Section 10.6 Hazard Communication
Every chemical container must be correctly labeled in accordance with the guidelines specified in the Chemical Hygiene Program for laboratory areas and Hazard Communication Program for non-laboratory areas.

Section 11 – Waste Disposal

All personnel must follow hazardous waste management rules and regulations when working with formaldehyde (e.g. labeling, storage and disposal). Please refer to the Hazardous Waste Guide for Research Areas found on the EHS homepage for specific waste disposal rules.

Section 12 – Medical Surveillance Program

Medical screenings or surveillance is mandatory in the following situations:

- When employees encounter concentrations equal to or exceeding the action level (AL) and/or STEL.
- When employees manifest signs and symptoms that suggest potential exposure.
- When employees are exposed to formaldehyde during emergency situations.

Medical surveillance will adhere to OSHA regulations, which encompass the following:

- Employees included in the medical surveillance program must fill out a medical disease questionnaire.
- Employees mandated to wear a respirator must partake in an annual medical assessment.
- If an employee is relocated, transferred, or placed under restrictions due to significant symptoms or medical issues arising from exposure, the

supervisor must ensure that the formaldehyde exposure at the new location does not meet or exceed the action level (AL) and/or STEL.
- Any employee who is not working due to a formaldehyde-related medical condition must arrange for a follow-up medical examination within six months of their removal to determine whether they can return to their original job status or if the exclusion from formaldehyde-related job functions is permanent.
- Employees possess the right to seek a second medical opinion concerning medical removal or restrictions.
- Employees exposed to formaldehyde during emergencies will receive a medical assessment as soon as possible. If there is a life-threatening condition resulting from exposure, they should seek immediate attention at the nearest emergency room and then follow up on the next business day at Occupational Medicine.

Section 13 – Training

Individuals assigned to a workplace where formaldehyde exposures are at or above 0.1 ppm must undergo training upon entering such an environment and then annually. EHS will conduct this training, which will cover:

- Explanation of the regulation, Safety Data Sheets, and labels.
- Information about the medical surveillance program, including signs and symptoms of exposure.
- Discussion of health hazards associated with formaldehyde, including cancer, skin and respiratory system irritation, eye and throat irritation, and acute toxicity.
- Instructions to report any adverse signs or symptoms suspected to be caused by formaldehyde exposure to their supervisor.
- Details about operations in areas with formaldehyde and safe practices to limit exposure.
- Explanation of the proper use and limitations of personal protective equipment (PPE).
- Guidance on handling spills, responding to emergencies, and cleanup procedures.
- Emphasis on the importance of engineering controls and safe work practices in reducing formaldehyde exposure.

Training can be arranged for groups upon request by contacting EHS.

Section 14 – Recordkeeping

EHS will maintain records of Exposure Monitoring, Training Attendance, and Respirator Fit Tests for 30 years.

Dick's House and Occupational Medicine will maintain records of medical surveillance and screenings for the length of employment plus an additional 30 years.

Section 15 – Program Evaluation

This Program will undergo an annual review and evaluation by EHS, unless changes in operations, the OSHA Formaldehyde Standard, 29 CFR 1910.1048, or other relevant OSHA standards necessitate an immediate re-validation of this Program.

Section 16 – References

1. OSHA Regulations (Standards – 29 CFR), Toxic and Hazardous Substances – 1910.1048, Formaldehyde
2. OSHA Fact Sheet Formaldehyde https://www.osha.gov/OshDoc/data_General_Facts/formaldehyde-factsheet.pdf.
3. EHS Chemical Hygiene Program
4. EHS Respiratory Protection Program
5. EHS Hazard Communication Program

Emergency Eyewash and Shower Procedure

DARTMOUTH

Section 1 - Purpose

The Emergency Eyewash and Shower Procedure serves to protect faculty, staff, and students who use corrosive materials at Dartmouth College.

Section 2 - Scope

This Procedure applies to all Dartmouth College faculty, staff, and students, and covers emergency eyewashes, eye/face washes, and showers, as well as supplemental devices such as eyewash bottles and drench hoses. Supplemental equipment is intended to supplement emergency eyewashes, eye/face washes, and showers, and not replace them.

This Procedure is implemented because Dartmouth College is subject the Occupational Safety and Health Administration (OSHA) standard on Medical and First Aid in 29 CFR §1910.151 (c). This Procedure applies to employees working with corrosive materials and is based on the American National Standards Institute (ANSI) Z358.1-2014 Emergency Eyewash and Shower Equipment standard.

Emergency eyewashes, eye/face washes, eyewash bottles, drench hoses, and showers are used as a form of emergency first aid aimed at limiting the effects of accidental exposure to corrosive materials.

Section 3 - Definitions

- Combination unit: Equipment with both an emergency shower and eyewash, eye/face wash, or drench hose.

- Corrosives: Materials that can destroy, by chemical action, living tissue, organic compounds, and metal.

- Drench hose: A supplemental device consisting of a flexible hose connected to a flushing fluid supply and used to provide fluid to irrigate and flush face and body areas.

- Emergency shower: A device specifically designed and intended to deliver flushing fluid in sufficient volume to cause that fluid to cascade over the entire body.

- Emergency decontamination unit: Emergency eyewashes, eye/face washes, eyewash bottles, drench hoses, and showers.

- Eyewash: A device used to provide fluid to flush the eyes.

- Eye/Face wash: A device used to provide fluid to flush the eyes and a portion of the face.

- Flushing fluid: Potable water, preserved water, preserved buffered saline solution or other medically acceptable solution manufactured in accordance with applicable government regulations.

- OSHA: Occupational Safety and Health Administration.

- Personal wash units: Eyewash bottles and single head drench hoses.

- Plumbed: A term used to describe equipment that is connected to a continual source of potable water.

- Self-contained: A term used to describe a stand-alone device containing flushing fluid.

Section 4 - Roles and Responsibilities

4.1 Environmental Health and Safety (EHS):

- Maintain the Procedure in accordance with applicable regulations and College guidelines.
- Support departments with implementation of the Procedure.
- Develop and maintain an annual inspection process for units involved in the Procedure.
- Review the Emergency Eyewash and Shower Procedure annually for updates with regulations and changes in conditions at the College.

4.2 Departments and/or Facility Managers

- Identify when corrosive use is taking place within their spaces and have emergency showers and eyewashes installed when required.
- Designate personnel to be responsible for regular inspection and testing of emergency, eyewashes, eye/face washes,

drench hoses, and showers located in their maintained spaces, and inspection of eyewash bottles.

- Train employees who may be exposed to corrosive materials in the location and proper use of emergency decontamination units.
- Provide support and training for employees who are affected by the requirements of the Procedure.

4.3 Designated Personnel

- Regularly, inspect and test emergency eyewashes, eye/face washes, drench hoses, and showers located in their maintained spaces and inspect eyewash bottles. *See Appendix A for regular interval inspection checklist.*
- Review the manufacturer's operation, inspection, and maintenance instructions for emergency decontamination units. Instructions should be readily accessible to maintenance and training personnel. *See Appendix C for installation requirements.*
- Report any deficiencies to the Facility manager or EHS.
- If use of the equipment is not possible, tag the unit "DO NOT USE".

4.4 Faculty, Staff, and Students

- Be trained in the location and proper use of emergency decontamination units.

4.5 Facilities Managers/Workers

- Be trained in the location and proper use of emergency decontamination units.
- Annually inspect and test emergency eyewashes, eye/face washes, drench hoses, and showers in their maintained spaces. *See Appendix B for annual inspection checklist.*
- Review the manufacturer's operation, inspection, and maintenance instructions for emergency decontamination units. Instructions should be readily accessible to maintenance and training personnel. *See Appendix C for installation requirements.*
- Correct any identified deficiencies in a timely manner.

Section 5 - Procedure Requirements

OSHA requires suitable facilities for quick drenching or flushing of the eyes and body shall be provided within the work area for immediate emergency use in locations where the eyes or body of any person may be exposed to injurious

corrosive materials. Dartmouth College has determined that emergency shower, eyewash, and eye/face wash units meet this requirement.

5.1 Required Equipment

Emergency shower, eyewash, and/or eye/face wash units are required in areas where corrosives are being used and must be located within 10 seconds of where the corrosive is being used.

When an individual gets a corrosive on their body or in their eyes the emergency shower, eyewash, or eye/face wash unit should be used immediately for 15 minutes.

5.2 Alternative Equipment

Eyewash bottles and single head drench hoses (personal wash units) are considered supplemental equipment only. Eyewash bottles and drench hoses do not meet ANSI's requirements for emergency showers, eyewashes, or eye/face washes and should not be used as an alternative to a 15-minute flushing station. A drench house may be considered an eyewash if the device meets the performance requirements of an emergency eyewash such as having an eyewash attachment.

An eyewash bottle or drench hose should be kept in the immediate vicinity of employees working with corrosives. The main purpose of this equipment is to supply immediate flushing. With this accomplished the individual should then proceed to an emergency shower, eyewash, or eye/face wash and flush for the required 15-minute period.

5.3 Combination Units

Combination units are equipment with both an emergency shower and eyewash, eye/face wash, or drench hose. These units must meet all the performance requirements of each piece of equipment.

Section 6 - Training and Emergency Actions

All faculty, staff, and students who work with corrosives must be trained in how to use emergency decontamination equipment.

If possible, have a robe or scrubs near emergency showers and drench hoses for an individual that may need to remove their contaminated clothing.

After someone has completed washing or flushing for 15 minutes, they should be taken for medical evaluation at the nearest emergency room. Have the affected individual bring the Safety Data Sheet (SDS) of the corrosive they were exposed to with them to the emergency room.

Department of Safety and Security (DoSS) should be called and notified of the spilled corrosive by any witnesses or by the affected person if it is unwitnessed. Risk Management should be informed within 24 Hours of the injury. Work control should be called to clean up any excess water.

See Appendix D for instructions on how to use an emergency decontamination unit. See Appendix E, F, and G for poster instructions on how to use an emergency eyewash, shower, and drench hose.

Section 7 - Inspections

7.1 Regular Interval Inspection

Inspections should be conducted at regular intervals by designated personnel. Departments may use water collection devices that will contain the water during the inspection. EHS has included a template checklist for equipment inspections, which is in *Appendix A*, but is summarized below:

1. If equipment or debris is blocking the emergency decontamination unit, it should be moved immediately.
2. Be in accessible locations that require no more than 10 seconds to reach. The emergency decontamination unit should be located on the same level as the hazard and the path of travel should be free of obstructions that may inhibit its immediate use.
3. The plumbed emergency eyewash, eye/face wash, drench hose, and shower unit should be activated weekly for a period long enough to verify operation and ensure that flushing fluid is available.
4. The emergency eyewash, eye/face wash, drench hose, and shower unit should deliver tepid flushing fluid (60-100 degrees Fahrenheit). In circumstances where chemical reaction is accelerated by flushing fluid temperature, EHS personnel should be consulted for the optimum temperature for each application.
5. The self-contained eyewash, eye/face wash, drench hose, and shower unit should be visually checked to determine if flushing fluid needs to be changed or supplemented.
6. The emergency eyewash and eye/face wash unit should be checked for protective covers over nozzles.
7. Empty or expired eyewash bottles should be replaced.
8. All inspections should be documented on a tag affixed to the unit.
9. Any eyewash, eye/face wash, drench hose, or shower unit in need of repair should be tagged out of service and scheduled for repair.

7.2 Annual Inspection

Designate personnel to be responsible for annual inspection and testing of emergency, eyewashes, eye/face washes, drench hoses, and showers located in their maintained spaces, and inspection of eyewash bottles. The performance requirements of the emergency eyewashes, eye/face washes, eyewash bottles, drench hoses, and showers should be inspected annually by the facility manager/worker for compliance with the with ANSI Z358.1-2014 Emergency Eyewash and Shower Equipment Standard. Facility managers/workers may use water collection devices that will contain the water during the inspection. Save annual inspection forms in a file or document compliance in a logbook. *See Appendix B for annual inspection checklist.*

7.3 Inspection Equipment Performance

1. If equipment or debris is blocking the emergency decontamination unit, it should be moved immediately.
2. Identify emergency decontamination unit with highly visible sign. The area around the emergency decontamination unit should be well lit.
3. Be in accessible locations that require no more than 10 seconds to reach. The emergency decontamination unit should be located on the same level as the hazard and the path of travel should be free of obstructions that may inhibit its immediate use.
4. The plumbed emergency eyewash, eye/face wash, drench hose, and shower unit should be activated for a period long enough to verify operation and ensure that flushing fluid is available.
5. The self-contained eyewash, eye/face wash, drench hose, and shower unit should be visually checked to determine if flushing fluid needs to be changed or supplemented.
6. The plumbed and self-contained eyewash, eye/face wash, drench hose, and shower unit should be connected to a flushing fluid supply to produce the required spray pattern for at least 15 minutes.
7. The emergency decontamination unit should deliver tepid flushing fluid (60-100 degrees Fahrenheit). In circumstances where chemical reaction is accelerated by flushing fluid temperature, EHS personnel should be consulted for the optimum temperature for each application.
8. The flow of flushing fluid of an emergency decontamination unit should be provided at a velocity low enough to be non-injurious to the user.
9. The valve on an emergency decontamination unit should:
    a. Be simple to operate and should go from “off” to “on” in 1 second or less.
    b. Be easy to locate and readily accessible to the user.
10. The valve on an emergency eyewash, eye/face wash, and shower unit should:

    a. Remain open without the use of the operator's hand until intentionally closed.
11. Emergency eyewash and eye/face wash equipment should be protected from airborne contaminants with protective covers.

7.4 Inspection Eyewash Bottle Equipment Performance

1. Eyewash bottles should be protected from freezing and not be exposed to temperatures exceeding 100 degrees Fahrenheit.
2. The expiration dates for eyewash bottles should be checked regularly and replaced when expired.

Appendix A – Regular Interval Inspection Checklist

Dartmouth College Regular Interval Checklist Emergency Eyewash and Shower Procedure Emergency Eyewashes, Eye/Face Washes, Eyewash Bottles, Drench Hoses, and Showers	
Department designated personnel must complete this checklist regularly.	
NAME:	**DATE:**
☐	Remove anything blocking equipment.
☐	Check that equipment location is 10 seconds away from corrosive materials and on the same level as the hazard, and the path of travel is free of obstructions.
☐	Run plumbed equipment long enough to verify operation and ensure flushing fluid is available.
☐	Check that the water is tepid (60-100 degrees Fahrenheit).
☐	Check that flushing levels are adequate in stand-alone equipment containing flushing fluid.
☐	Check that emergency eyewash and eye/face wash equipment have protective covers covering nozzles.
☐	Replace empty or expired eyewash bottles.
☐	Document inspection on tag affixed to equipment.
☐	Tag broken equipment out of service and contact Facility manager for repair.

Appendix B - Annual Inspection Checklist

Dartmouth College Annual Checklist Emergency Eyewash and Shower Procedure Emergency Eyewashes, Eye/Face Washes, Eyewash Bottles, Drench Hoses, and Showers	
Department designated personnel are required to complete this checklist annually.	
NAME: **DATE:**	
☐	Remove anything blocking equipment.
☐	Check that equipment is identified with a sign and is well lit.
☐	Check that equipment location is 10 seconds away from corrosive materials and on the same level as the hazard, and the path of travel is free of obstructions.
☐	Run plumbed equipment long enough to verify operation and ensure flushing fluid is available.
☐	Check that the flow of flushing fluid is provided at a velocity low enough to be non-injurious to the user.
☐	Check that the water is tepid (60-100 degrees Fahrenheit).
☐	In self-contained equipment, check that flushing levels are adequate.
☐	Check that the valve on equipment goes from “off” to “on” in 1 second or less.
☐	Check that the valve on equipment is easy to locate and readily accessible to the user.
☐	Check that the valve on showers, emergency eyewashes, and eye/face washes remain open without the operator’s hands.
☐	Check that emergency eyewash and eye/face wash equipment have protective covers covering nozzles.
☐	Replace empty or expired eyewash bottles.
☐	Document inspection in logbook.
☐	Tag broken equipment out of service and schedule for repair.

Appendix C - Installation Requirements

Installation of emergency decontamination equipment should follow the requirements in ANSI Z358.1- 2014 Emergency Eyewash and Shower Equipment Standard.

Emergency Eyewash, Shower, and Drench Hose Equipment Installation Requirements:

1. Assemble and install in accordance with the manufacturer's instructions, including flushing fluid delivery instructions.
2. Where the possibility of freezing conditions exists, the emergency unit should be protected from freezing or freeze-protected equipment should be installed.
3. If shut off valves are installed in the water supply line for maintenance purposes, provisions should be made to prevent unauthorized shut off.
4. Emergency units should be constructed of materials that will not corrode in the presence of the flushing fluid.

Emergency Eyewash Equipment Installation:

1. Be able to deliver flushing fluid at least 0.4 gallons per minute.
2. Be positioned with the flushing fluid nozzles not less than 33 inches and no greater than 53 inches from the surface on which the user stands and 6 inches minimum from the wall or the nearest obstruction.
3. A test gauge should be used to determine suitable eyewash pattern and should be a minimum of 4 inches with two sets of parallel lines equidistant from the center. The interior set of lines should be 1.25 inches apart and the exterior lines should be 3.25 inches apart. The flushing fluid should cover the area between the interior and exterior lines of the gauge at some point less than 8 inches above the eyewash nozzles.

Emergency Eye/Face Equipment Installation:

1. Be able to deliver flushing fluid at least 3 gallons per minute.
2. Be positioned with the flushing fluid nozzles not less than 33 inches and no greater than 53 inches from the surface on which the user stands and 6 inches minimum from the wall or the nearest obstruction.
3. A test gauge should be used to determine suitable eyewash pattern and should be a minimum of 4 inches with two sets of parallel lines equidistant from the center. The interior set of lines should be 1.25 inches apart and the exterior lines should be 3.25 inches apart. The flushing fluid should cover the area between the interior and exterior lines of the gauge at some point less than 8 inches above the eyewash nozzles.

Emergency Shower Equipment Performance Installation:

1. Be able to deliver flushing fluid at least 20 gallons per minute.
2. The spray pattern should have a minimum diameter of 20 inches at 60 inches above the surface on which the user stands.
3. The flushing fluid column should be at least 82 inches and no more than 96 inches from the surface on which the user stands.
4. The center of the spray pattern should be at least 16 inches from any obstruction.
5. The flushing fluid should be dispersed throughout the pattern.

Appendix D - Instructions for Use

Follow these steps in the event of an exposure. Everyone needs to read and understand this process as you may be in the role of victim, or you may be present and need to assist another person.

After use of unit Work Control should be called at 603-646-2508 to clean up excess water. All injuries should be reported within 24 hours to Risk and Internal Controls Services.

Eyewashes and Eye/Face Washes:

1. Get to or assist the victim to the eyewash. Sight may be impaired. Remove contacts if possible.
2. Activate the unit using the hands-free valve.
3. Hold the eyelids open with fingers if necessary.
4. Place the eyes in the stream of water.
5. Flush for 15 minutes.
6. Get medical attention. Have someone call **911**.
7. Provide the Safety Data Sheet (SDS) of spilled chemical(s) to EMS/emergency room personnel.

Emergency Showers:

1. Get to or assist the victim to the shower. Sight may be impaired. Remove contacts if possible.
2. Activate the unit using the hands-free valve.
3. Put modesty aside. Remove contaminated clothing first if possible. (Rinsing contaminated clothing will wash chemicals out of the clothing and onto the skin.) If this is not possible, remove contaminated clothing during the flushing process.
4. Flush for 15 minutes.
5. Get medical attention. Have someone call **911**.
6. Provide the Safety Data Sheet (SDS) of spilled chemical(s) to EMS/emergency room personnel.

Drench Hose:

1. Get to or assist the victim to the drench hose. Sight may be impaired. Remove contacts if possible.
2. Squeeze activation handle to start water.
3. Put modesty aside. Remove contaminated clothing first if possible. (Rinsing contaminated clothing will wash chemicals out of the clothing and onto the skin.) If this is not possible, remove contaminated clothing during the flushing process.
4. Flush for 15 minutes.
5. Get medical attention. Have someone call **911**.
6. Provide the Safety Data Sheet (SDS) of spilled chemical(s) to EMS/emergency room personnel.

Appendix E - Emergency Eyewash Instructions Poster

EMERGENCY EYEWASH INSTRUCTIONS

For chemical or debris removal from eyes.

1. **Squeeze/push activation handle to start flow of water.**
2. **Hold eyelids open and roll eyeballs up and down and sideways in stream of water.**
3. **Call 911.**
4. **Flush your eyes thoroughly for at least 15 minutes or until EMS arrives.**
5. **Report injury within 24 hours to Risk and Internal Controls Services.**

Call Work Control at 603-646-2508 for cleanup.

Contact Environmental Health and Safety at EHS@dartmouth.edu and (603) 646-1762.

Appendix F - Emergency Shower Instructions Poster

EMERGENCY SHOWER INSTRUCTIONS

For chemical decontamination.

1. **Remove any contaminated clothing.**
2. **Activate shower by pulling straight down on handle/ chain.**
3. **Wash contaminated parts of body under water stream.**
4. **Call 911.**
5. **Continue washing for at least 15 minutes or until EMS arrives.**
6. **Report injury within 24 hours to Risk and Internal Controls Services.**

Call Work Control at 603-646-2508 for cleanup.

Contact Environmental Health and Safety at EHS@dartmouth.edu and (603) 646-1762.

Appendix G - Drench Hose Instructions Poster

DRENCH HOSE INSTRUCTIONS

For chemical decontamination.

1. **Remove contaminated clothing.**
2. **Squeeze activation handle to start water.**
3. **Wash contaminated part of body with drench hose.**
4. **Call 911.**
5. **Continue washing for at least 15 minutes or until EMS arrives.**
6. **Report injury within 24 hours to Risk and Internal Controls Services.**

Call Work Control at 603-646-2508 for cleanup.

Contact Environmental Health and Safety at EHS@dartmouth.edu and (603) 646-1762.

24.16 Appendix P: Common Lab PPE Reference Guide

(Courtesy of UC Santa Cruz)

COMMON LAB PPE REFERENCE GUIDE

Lab Coats		
Type	Physical Characteristics	Applications
Traditional 	100% cotton to 65%/35% polyester/cotton General purpose protection. Protects skin and clothing from dirt, dyes, low-hazard chemicals, low-hazard biohazards, and radioactive material. Lightweight and breathable. Not intended for use when fire hazard is present. Example Source: Medline	Chemistry labs with low flammable solvent use, and no chemical (pyrophorics) or physical hazards likely to pose a risk of fire. Other lab environments without fire hazards, including those with: biological, radiation, physical and animal hazards.
Barrier 	99%/1% polyester/carbon Provides a good fluid barrier. Sleeves are cuffed, allowing gloves to be worn over sleeves. Does not permit blood or other potentially infectious materials to pass through due to 3-layer construction. Polyester material is very flammable, will melt and provide fuel source once ignited. Example Source: Medline	Working with human blood, body fluids, tissues, cells or other potentially infectious material which may contain bloodborne pathogens. Other lab environments without fire hazards in which cuffed sleeves and lower particle count are advantageous. Should never be worn around an open flame or if there is a potential for fire.
Flame Resistant 	100% Nomex (meta-aramid fiber) Material is intrinsically flame resistant (not chemically treated). Flame resistance properties will not diminish with laundering. Nomex is resistant to many solvents and corrosives but is a loose weave material; provides superficial fluid barrier only. Example Source: Bulwark	Working with water or air reactive chemicals, large volumes of flammable solvents, or potentially explosive chemicals. Environments where there is an open flame or the potential for a fire.

COMMON LAB PPE REFERENCE GUIDE

Eyewear		
Type	Physical Characteristics	Applications
Safety Glasses 	All safety glasses must comply with ANSI Z87.1-2010 requirements for minimum protection parameters. Polycarbonate lenses block 99.9% of UV light. Safety glasses will provide impact protection from direct trajectory hazards (foreign objects). They will not provide adequate protection for larger volumes of solvent that may bypass lenses. Example Sources: Uvex 3M Fisher	Most common type of eye protection. Lightweight, comfortable and unlikely to fog. Glasses are worn in low hazard environments and situations. Glasses will not protect from dust or liquid running down the face. Glasses allow a minimal gap between eyewear and face (8 mm or less).
Splash Goggles 	All splash goggles must comply with ANSI Z87.1-2010 requirements for minimum protection parameters. Splash goggles provide a better seal around the face, preventing liquid from contacting eyes. Splash goggles are designed with indirect ventilation. Example Sources: Uvex 3M Pyramex	Goggles are worn when there is the potential for splashes of hazardous material or a concentrated presence of foreign material (dust and debris). Goggles should be tested for a snug fit on the face for optimal protection.
Face Shield 	Face shields must comply with ANSI Z87.1-2010 requirements for minimum protection parameters. Face shields are required when there is need for protection of the entire face and throat. Primary eye protection must always be worn under a face shield. Example Source: Pyramex	Face shields are worn in situations where significant splashing or high hazard procedures. Dispensing cryogens, using strong corrosives or working with potentially explosive material.

COMMON LAB PPE REFERENCE GUIDE

Disposable Gloves		
Type	Physical Characteristics	Applications
Latex 	Provides some chemical resistance. Use manufacturer specific chemical resistance chart to verify suitability. Gloves are sensitive to UV radiation and will degrade. Keep covered to prolong life. As with any thin disposable glove, glove should be removed immediately upon chemical contamination. Note that some individuals may have sensitivities or allergies to latex. Example: Microflex – Evolution One	Most commonly used when working with aqueous material or biological hazards. Handling known or potentially infectious material. Working with animals.
Nitrile 	Wider chemical resistance then latex. Some resistance advantages over chloroprene; use manufacturer-specific chemical resistance chart to verify suitability. As with any thin disposable glove, glove should be removed immediately upon chemical contamination. Example: Kimberly-Clark – Purple Nitrile	Chemical, biological or other environment where incidental solvent exposure is possible. Should not be used when handling large amounts of solvent, pyrophoric or explosive material.
Chloroprene (aka Neoprene) 	Wider chemical resistance then latex. Some resistance advantages over nitrile; use manufacturer-specific chemical resistance chart to verify suitability. As with any thin disposable glove, glove should be removed immediately upon chemical contamination. Example: Microflex – NeoPro	Chemical, biological or other environment where incidental solvent exposure is possible. Should not be used when handling large amounts of solvent, pyrophoric or explosive material.

COMMON LAB PPE REFERENCE GUIDE

Reusable Gloves		
Type	Physical Characteristics	Applications
Trionic 	Trionic gloves are made by mixing latex, nitrile and neoprene. Generally has the best qualities of each material, though it is still susceptible to UV degradation. Excellent resistance to most acids and low particulate contamination. Review manufacturer chemical resistance data for specific protection information. Example: MAPA – Trionic E-194	Commonly used in electronics manufacturing and clean room environments. Reasonable cost for a reusable glove.
Nitrile 	Thicker version of disposable nitrile gloves; provides significantly better chemical protection. Review manufacturer chemical resistance data for specific protection information. Example: Ansell – AlphaTec (13 mil)	Chemical, biological or other environment where solvent exposure is likely. Gloves are rated to be immersed in solvent. Gloves should be cleaned and allowed to dry after each use.
Chloroprene (aka Neoprene) 	Thicker version of disposable chloroprene gloves, provides significantly better chemical protection. Review manufacturer chemical resistance data for specific protection information. Example: Ansell – Neoprene (18 mil)	Chemical, biological or other environment where solvent exposure is likely. Gloves are rated to be immersed in solvent. Gloves should be cleaned and allowed to dry after each use.

COMMON LAB PPE REFERENCE GUIDE

Reusable Gloves (continued)		
Type	Physical Characteristics	Applications
Viton/Butyl 	Developed in collaboration between UCSF and Ansell Ltd. The layered Viton-over-butyl glove provides excellent protection from chloroform and phenol. Combined thickness is as low as 8 mil, more similar to disposable gloves. Review manufacturer chemical resistance data for specific protection information. Example: Ansell – ChemTek Viton/Butyl	Used most frequently during phenol/chloroform extractions. Good chemical protection; can be used in other situations as appropriately indicated by chemical resistance data.
Laminated Film 	Multiple layers of polyethylene (PE) and ethylene vinyl alcohol (EVOH). Good chemical resistance to a wide array of chemicals. Review manufacturer chemical resistance data for specific protection information. Material is slick, may need to use a disposable overglove for dexterity and grip. Examples: Ansell – Barrier North (Honeywell) – Silver Shield	Working with larger volumes of chemicals, hazardous material spills, or where other glove materials are insufficient. Silver shield provides good resistance to methylene chloride (dichloromethane).
Nomex "Flight gloves" 	Made from Kevlar and Nomex, often with leather palm. Provides excellent flame protection for hands, but does not protect from chemicals. Should be worn under an appropriate chemical glove (nitrile or neoprene). Example: Hatch – BNG Flight Glove	Used when working with pyrophoric or potentially explosive material. Should be used in conjunction with Nomex or other flame resistant lab coat.

24.17 Appendix Q: Laboratory PPE Hazard Assessment

(Courtesy of University of Washington)

LABORATORY PERSONAL PROTECTIVE EQUIPMENT (PPE)
HAZARD ASSESSMENT

Purpose and Description

The Laboratory Personal Protective Equipment (PPE) Hazard Assessment Guide identifies hazards to which researchers may be exposed and specifies PPE to protect against these hazards during work operations.

This document must be completed by the Principal Investigator (PI), Lab Manager, or their designee. This person must conduct a laboratory hazard assessment that is specific to operations in their laboratory space(s). EHS personnel are available to assist with the hazard assessment and can review the form. EHS may be consulted by calling 603-646-1762. The PI/Lab Manager is responsible for ensuring PPE requirements are followed.

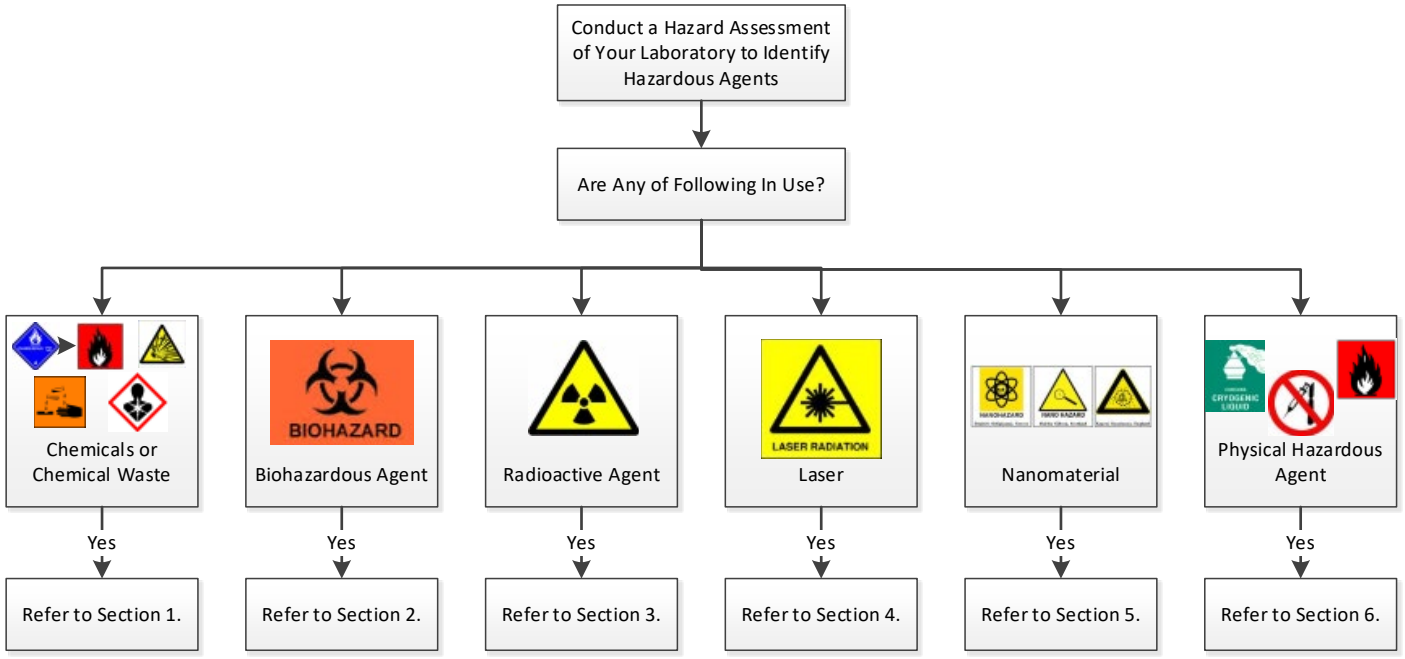
This hazard assessment guide consists of the following:

Section 1: Instructions and Guidance on PPE Selection

The Principal Investigator, Lab Manager, or their designee will conduct the hazard assessment.

Conduct a hazard assessment of the laboratory operations using this Laboratory PPE Hazard Assessment.

- Complete each section for the potentially hazardous agent(s) used in your laboratory: (1) chemical, (2) biohazard, (3) radioactive, (4) laser, (5) nanomaterial, and/or (6) physical.
- This guide will assist in identifying work tasks that require the use of PPE to protect lab staff from exposures to hazards. For each work task listed, check the "Yes" box if the work is performed in your laboratory. If not, check the "No" box. As needed, add tasks to the list to customize it for your laboratory.
- Note the required PPE for each task is designated by a check mark (✓) before the item.
- Check additional boxes (☐) as appropriate and/or check "Other PPE: Specify" and describe in the space provided the lab-specific PPE required for the work task.



GENERAL GUIDANCE ON PERSONAL PROTECTIVE EQUIPMENT (PPE) SELECTION

1. **Minimum Laboratory PPE.** In general, the minimum PPE that should be worn while performing laboratory work is the following:
    - Safety glasses
    - Disposable nitrile or other appropriate chemical resistant gloves
    - Lab coat (full length) and long pants, long skirt or equivalent leg covering (no shorts)
    - Laboratory footwear (as described below)
2. **Chemical-Resistant Gloves**. Chemical-resistant gloves must be selected based on the specific chemical(s) used and the manufacturer's glove permeation and compatibility charts.
3. **Laboratory Footwear.** Laboratory footwear should fully cover the feet to protect against chemical spills. Avoid sandals, flip-flops, flats, canvas/breathable fabric tops, and shoes constructed of mesh (such as athletic shoes) unless impervious chemical-resistant booties that protect the entire foot are worn over them.
4. **Airborne/Inhalation Hazard: Engineering Controls and Respiratory Protection**.
    - **Chemical Fume Hood**. When materials have a potential for becoming airborne, use a chemical fume hood or other engineering control whenever possible. Activities that generate airborne contaminants or odors that are not conducted inside a chemical fume hood or using some other engineering control (such as a local exhaust at the workbench) should be evaluated to determine if the activity presents an inhalation hazard.
    - **Biosafety Cabinet Use**. Use a biosafety cabinet to minimize exposure. Activities that cannot be conducted inside a biosafety cabinet should be separately evaluated by the Biosafety Officer. For BSL-2+ activities, the PPE requirements will be addressed by the Biosafety Officer and the Institutional Biosafety Committee.
    - **Respiratory Protection**. If respiratory protection is identified as a necessary control during the hazard assessment, users must be enrolled in the Dartmouth Respiratory Protection Program. This includes EHS performing a respirator-specific hazard assessment, as well as having all users undergo a medical evaluation to wear a respirator, respirator training, and respirator fit testing. Contact EHS at 603-646-1762 or respirator@dartmouth.edu for assistance in these steps. Guidance is available at https://www.dartmouth.edu/ehs/occupational/rpp.html.

1.0 CHEMICAL HANDLING PROTECTION (Page 1 of 5)

Task Performed Yes	Task Performed No	Task Performed in Lab (Modify wording to fit your needs)	Potential Hazards	PPE Designated For Lab-Specific Tasks
☐	☐	Work with solids of low or moderate toxicity	• Skin damage • Eye damage • Toxic by skin contact	✓ **Eyes:** Safety glasses ✓ **Hands:** Disposable nitrile or appropriate chemical resistant gloves ✓ **Body:** Lab coat; long pants, long skirt, or equivalent leg covering (no shorts); lab footwear (Refer to Page 3). ☐ **Face**: Face shield as splash or splatter may occur ☐ **Other PPE, Specify:**
☐	☐	Work with small volumes (<100 ml) of corrosive (acids or caustics) liquids or solids	• Skin damage • Eye damage • Toxic by skin contact	✓ **Eyes:** Safety glasses ✓ **Hands:** Disposable nitrile or appropriate chemical resistant gloves ✓ **Body:** Lab coat; long pants, long skirt, or equivalent leg covering (no shorts); lab footwear (Refer to Page 3).
☐	☐	Work with large volumes of corrosive (acids or caustics) or acutely toxic materials that may splash	• Inhalation • Skin damage • Eye damage • Toxic by skin contact	✓ **Eyes:** Safety goggles ✓ **Face:** Face shield as splash or splatter may occur ✓ **Hands:** Disposable nitrile or appropriate chemical resistant gloves ✓ **Body:** Lab coat; long pants, long skirt, or equivalent leg covering (no shorts); lab footwear (Refer to Page 3). ☐ **Body:** Chemical resistant apron ☐ **Inhalation:** Respiratory protection; *contact EHS for respiratory protection program assistance* ☐ **Other PPE, Specify:**
☐	☐	Work with small volumes (<100 ml) of flammable solvents or materials	• Skin damage • Eye damage • Toxic by skin contact	✓ **Eyes:** Safety glasses ✓ **Hands:** Disposable nitrile or appropriate chemical resistant gloves ✓ **Body:** Lab coat; long pants, long skirt, or equivalent leg covering (no shorts); lab footwear (Refer to Page 3).
☐	☐	Work with large volumes (>100 ml) of flammable solvents with a source of heat or ignition nearby	• Inhalation • Skin damage • Eye damage • Toxic by skin contact • Fire	✓ **Eyes:** Safety glasses ✓ **Hands:** Disposable nitrile or appropriate chemical resistant gloves ✓ **Body:** Lab coat; long pants, long skirt, or equivalent leg covering (no shorts); lab footwear (Refer to Page 3). ☐ **Face**: Face shield as splash or splatter may occur ☐ **Inhalation:** Respiratory protection; *contact EHS for respiratory protection program assistance* ☐ **Other PPE, Specify:**

1.0 CHEMICAL HANDLING PROTECTION (Page 2 of 5)

Task Performed Yes	Task Performed No	Task Performed in Lab (Modify wording to fit your needs)	Potential Hazards	PPE For Lab-Specific Tasks
☐	☐	Work with chemicals of high acute toxicity (e.g., hydrogen fluoride, hydrogen cyanide)	• Inhalation • Skin damage • Eye damage • Toxic by skin contact	✓ **Eyes:** Safety glasses ✓ **Hands:** Disposable nitrile or appropriate chemical resistant gloves ✓ **Body:** Lab coat; long pants, long skirt, or equivalent leg covering (no shorts); lab footwear (Refer to Page 3). ☐ **Eyes**: Safety goggles ☐ **Face**: Face shield as splash or splatter may occur ☐ **Inhalation:** Respiratory protection; *contact EHS for respiratory protection program assistance* ☐ **Other PPE, Specify:**
☐	☐	Work with a particularly hazardous agent such as: • Human carcinogen • Mutagen • Antineoplastic • Reproductive toxin	• Inhalation • Skin damage • Eye damage • Toxic by skin contact	✓ **Eyes:** Safety glasses ✓ **Hands: For Carcinogens, Mutagens, and Chemotherapy/Other Hazardous Drugs**: Disposable nitrile gloves; Double glove ✓ **Body:** Lab coat; long pants, long skirt, or equivalent leg covering (no shorts); lab footwear (Refer to Page 3) ☐ **Eyes**: Safety goggles ☐ **Face**: Face shield as splash or splatter may occur ☐ **Inhalation:** Respiratory protection; *contact EHS for respiratory protection program assistance* ☐ **Other PPE, Specify:**
☐	☐	Work with an apparatus with contents under pressure or vacuum (mm of Hg, psi, or torr)	• Skin damage • Eye damage	✓ **Eyes:** Safety glasses ✓ **Hands:** Disposable nitrile or appropriate chemical resistant gloves ✓ **Body:** Lab coat; long pants, long skirt, or equivalent leg covering (no shorts); lab footwear (Refer to Page 3) ☐ **Face**: Face shield ☐ **Eyes and/or Face**: For high risk activities - Safety goggles and face shield ☐ **Body:** For chemical use, chemical-resistant apron ☐ **Other PPE, Specify:**





1.0 CHEMICAL HANDLING PROTECTION (Page 3 of 5)

Task Performed Yes	Task Performed No	Task Performed in Lab (Modify wording to fit your needs)	Potential Hazards	PPE For Lab-Specific Tasks
☐	☐	Work with air or water reactive chemicals	• Exposure to toxic gases, heat, and/or energy • Inhalation • Skin damage • Eye damage • Fire	✓ **Eyes:** Safety goggles ✓ **Hands:** Disposable nitrile or appropriate chemical resistant gloves ✓ **Body:** Lab coat; long pants, long skirt, or equivalent leg covering (no shorts); lab footwear (Refer to Page 3) ☐ **Face**: Face shield as splash or splatter may occur ☐ **Hands**: Heat resistant or chemical resistant gloves; please specify: ☐ **Body:** Flame-resistant lab coat if a fire hazard is present ☐ **Other PPE, Specify:**
☐	☐	Work with pyrophoric materials	• Fire • Severe burns • Inhalation • Skin damage • Eye damage	✓ **Eyes**: Safety goggles ✓ **Hands**: Inner disposable nitrile or appropriate chemical resistant gloves ✓ **Body:** Flame resistant lab coat; long pants, long skirt, or equivalent leg covering (no shorts); lab footwear (Refer to Page 3) ✓ **Body:** Synthetic clothing must not be worn when working with pyrophoric materials ☐ **Face**: Face shield as splash or splatter may occur ☐ **Other PPE, Specify**:
☐	☐	Work with potentially explosive chemicals	• Detonation • Flying debris • Skin damage • Eye damage • Fire	✓ **Eyes**: Safety goggles ✓ **Hands**: Inner disposable nitrile or appropriate chemical resistant gloves ✓ **Body:** Flame resistant lab coat; long pants, long skirt, or equivalent leg covering (no shorts); lab footwear (Refer to Page 3) ✓ **Body:** Synthetic clothing must not be worn when working with explosive materials ☐ **Face**: Face shield as splash or splatter may occur ☐ **Eyes, Face, or Body**: Blast shield for high risk activities ☐ **Other PPE, Specify**:





1.0 CHEMICAL HANDLING PROTECTION (Page 4 of 5)

Task Performed Yes	Task Performed No	Task Performed in Lab (Modify wording to fit your needs)	Potential Hazards	PPE For Lab-Specific Tasks
☐	☐	Work with high temperature equipment or objects	• Burns • Fire	✓ **Eyes**: Safety goggles ✓ **Hands**: Inner disposable nitrile or appropriate chemical resistant gloves ✓ **Hands:** High temperature thermal insulated gloves ✓ **Body:** Flame resistant lab coat; long pants, long skirt, or equivalent leg covering (no shorts); lab footwear (Refer to Page 3) ✓ **Body:** Synthetic clothing must not be worn when working with high temperature equipment or objects ☐ **Face**: Face shield as splash or splatter may occur ☐ **Other PPE, Specify**:
☐	☐	Work with cryogenic material	• Burns • Frostbite • Eye damage	✓ **Eyes**: Safety glasses ✓ **Eyes:** Safety goggles for large volumes ✓ **Face**: Face shield as splash or splatter may occur ✓ **Hands**: Inner gloves - disposable nitrile or appropriate chemical resistant gloves ✓ **Hands**: Outer gloves - cryogenic low temperature insulated gloves ✓ **Body:** Lab coat; long pants, skirt, or equivalent leg covering (no shorts); lab footwear (Refer to Page 3) ☐ **Other PPE, Specify**:
☐	☐	List any other particularly hazardous lab task involving chemicals	Conduct risk assessment: Hazard depends on the task and chemical properties • Inhalation • Skin damage • Eye damage	✓ **Eyes:** Safety glasses ✓ **Hands:** Disposable nitrile or other appropriate chemical resistant gloves ✓ **Body:** Lab coat; long pants, long skirt, or equivalent leg covering (no shorts); lab footwear (Refer to Page 3) ☐ **Face**: Face shield as splash or splatter may occur ☐ **Body**: Chemical resistant apron ☐ **Inhalation:** Respiratory protection; *contact EHS for respiratory protection program assistance.* ☐ **Other PPE, Specify:**

1.0 CHEMICAL HANDLING PROTECTION (Page 5 of 5)

Task Performed Yes	Task Performed No	Task Performed in Lab (Modify wording to fit your needs)	Potential Hazards	PPE For Lab-Specific Tasks
☐	☐	Minor (or small) spill cleanup; spill can be cleaned up with a standard spill kit	• Inhalation • Skin damage • Eye damage	✓ **Eyes**: Safety glasses or goggles ✓ **Face**: Face shield as splash or splatter may occur ✓ **Hands**: Chemical resistant gloves for spill cleanup ✓ **Body:** Lab coat; long pants, skirt, or equivalent leg covering (no shorts); lab footwear (Refer to Page 3) ✓ As needed, contact EHS for assistance ☐ **Foot:** Shoe covers ☐ **Other PPE, Specify**:
☐	☐	Large spill cleanup; The spill is too large or complex to clean up with a standard spill kit	• Inhalation • Skin damage • Eye damage	✓ **Mandatory: Follow required procedures** • If possible, stop or contain the release. • Evacuate and secure the area. • Assist injured or contaminated persons. • Call 911 for assistance; report injuries, fires, or request cleanup assistance. • Call EHS for assistance
☐	☐			
☐	☐			

2.0 BIOHAZARDOUS AGENT PROTECTION GENERAL (Page 1 of 4)

Task Performed Yes	Task Performed No	Task Performed in Lab (Modify wording to fit your needs)	Potential Hazards	PPE For Lab-Specific Tasks
☐	☐	Work with human blood, body fluids, cell lines (primary or established), tissues, or bloodborne pathogens (BBP).	• Exposure to infectious material	✓ **Hand:** Nitrile gloves ✓ **Body:** Lab coat ✓ **Face:** Spatter shield on the tabletop if not working in a biosafety cabinet OR ✓ **Face:** Face shield if not working in a biosafety cabinet or behind a spatter shield OR ✓ **Face:** Safety glasses and a mask if not working in a biosafety cabinet or behind a spatter shield ☐ **Eye:** Safety glasses ☐ **Body:** Disposable gown (optional) ☐ **Other PPE, Specify:**
☐	☐	Work with animal and/or human specimens preserved in fixative (such as formalin or paraformaldehyde solution) Preserve animal and/or human specimens with fixative (such as formalin or paraformaldehyde solution)	• Exposure to fixative used to preserve the specimen If tissue is fixed, there is no longer an exposure to infectious material.	✓ **Eye:** Safety glasses ✓ **Hand:** Impermeable glove for preserved specimens that is chemical resistant to the fixative used ✓ **Body:** Lab coat ☐ **Body:** Disposable gown ☐ **Other PPE, Specify:**
☐	☐	Work with radioactive human blood, body fluids, or bloodborne pathogens (BBP).	• Exposure to infectious material • Cell damage • Potential spread of radioactive contaminants	✓ **Hand:** Nitrile gloves ✓ **Eye:** Safety glasses or safety goggles for splash hazard ✓ **Face:** Face shield as splash or splatter may occur ✓ **Body:** Lab coat ☐ **Body:** Disposable gown ☐ **Other PPE, Specify:**
☐	☐			

2.1 BIOHAZARDOUS AGENT PROTECTION – RISK GROUP 1, 2, 3 (Page 2 of 4)

Task Performed Yes	Task Performed No	Task Description (Modify wording to fit your needs)	Potential Hazards	PPE For Lab-Specific Tasks
☐	☐	Work with agents or recombinant DNA classified as Risk Group 1 and requiring Biosafety Level 1 (BSL-1) containment	• Biological agents that typically pose a minimal potential for infection by injection, skin exposure, ingestion, or inhalation	✓ **Hand:** Nitrile gloves ✓ **Body:** Lab coat ☐ **Eye:** Safety glasses for splash or other eye hazard ☐ **Eye:** Safety goggles for splash or other eye hazard ☐ **Body:** Disposable gown ☐ **Other PPE, Specify**:
☐	☐	Manipulation of recombinant DNA, cell lines, viruses, bacteria, or other organisms classified as Risk Group 2 and requiring Biosafety Level 2 (BSL-2) containment Perform aerosol generating procedure: Vortex, sonicate, pipette, tissue harvest	• Biological agents that pose a moderate potential for infection by injection, skin exposure, ingestion, or inhalation	✓ **Eye:** Safety glasses ✓ **Hand:** Nitrile gloves ✓ **Body:** Lab coat ☐ **Eye:** Safety goggles ☐ **Body:** Surgical gown ☐ **Other PPE, Specify**:
☐	☐	Manipulation of infectious materials classified as Risk Group 3 but manipulated in a BSL 2 facility with BSL-2+ containment practices.	• Biological agents that pose a moderate or serious potential for infection by injection, skin exposure, ingestion, or inhalation	✓ **Eye:** Safety glasses for splash or other eye hazard ✓ **Hands:** Nitrile gloves (double) ✓ **Body:** Disposable gown (preferred) that ties in back ✓ **Inhalation**: Respiratory protection as determined by risk assessment; *contact EHS for respiratory protection program assistance* ☐ **Eye:** Safety goggles for splash or other eye hazard ☐ **Body:** Lab coat ☐ **Other PPE, Specify**:
☐	☐	Manipulation of infectious materials classified as Risk Group 3 and requiring BSL-2+ containment	• Biological agents that pose a serious or lethal potential for infection by injection, skin exposure, ingestion, or inhalation	✓ **Eye:** Safety glasses for splash or other eye hazard ✓ **Hands:** Nitrile gloves (double) ✓ **Body:** Full disposable coverall suit (preferred) ✓ **Foot:** Shoe cover or dedicated shoe ✓ **Inhalation**: Respiratory protection as determined by risk assessment; *contact EHS for respiratory protection program assistance* ☐ **Eye:** Safety goggles for splash or other eye hazard ☐ **Other PPE, Specify**:

2.2 BIOHAZARDOUS AGENT PROTECTION – BIOSAFETY LEVEL 1, 2, 3 (Page 3 of 4)

Task Performed Yes	Task Performed No	Task Description (Modify wording to fit your needs)	Potential Hazards	PPE For Lab-Specific Tasks Follow Appropriate BSL Practices
☐	☐	Work with live animals: General safety concerns	• Animal bites • Exposure to animal allergens	☐ **Animal bites:** Restraints or bite-resistant gloves ☐ **Animal allergen:** Voluntary use of N95 respirator or PAPR. F*or allergens, contact EHS for respiratory protection program assistance.* ☐ **Specific Pathogen Free (SPF) Area:** Hair bonnet, gown, shoe covers, gloves ☐ **Other PPE, Specify**:
☐	☐	Work with live animals: Animal Biosafety Level 1 (ABSL-1)	• Exposure to infectious material	✓ **Hands:** Nitrile or vinyl gloves for broken skin ✓ **Body:** Lab coat OR ✓ **Body:** Disposable gown ☐ **Eye:** Safety glasses for splash or other eye hazard ☐ **Eye:** Safety goggles for splash or other eye hazard ☐ **Other PPE, Specify**:
☐	☐	Work with live animals: Animal Biosafety Level 2 (ABSL-2)	• Exposure to infectious material	✓ **Eye:** Safety goggles for splash or other eye hazard ✓ **Hands:** Nitrile or vinyl gloves ✓ **Body:** Disposable gown ☐ **Foot:** Shoe covers ☐ **Other PPE, Specify**:
☐	☐	Work with live animals: Animal Biosafety Level 2+ (ABSL-2+)	• Exposure to infectious material	✓ **Eye:** Safety glasses for splash or other eye hazard ☐ **Eye:** Safety goggles for splash or other eye hazard ✓ **Hands:** Nitrile or vinyl gloves ✓ **Body:** Disposable gown (tie in the back) ✓ **Foot:** Shoe covers ☐ **Other PPE, Specify**:

2.2 BIOHAZARDOUS AGENT PROTECTION – BIOSAFETY LEVEL 1, 2, 3 (Page 4 of 4)

Task Performed Yes	Task Performed No	Task Description (Modify wording to fit your needs)	Potential Hazards	PPE For Lab-Specific Tasks Follow Appropriate BSL Practices
☐	☐	Work with live animals: Animal Biosafety Level 3 (ABSL-3).	• Exposure to infectious material • Exposure to infectious agent by airborne transmission	✓ **Eye:** Safety glasses for splash or other eye hazard ☐ **Eye:** Safety goggles for splash or other eye hazard ✓ **Hands:** Nitrile or vinyl gloves ☐ **Body:** Disposable gown ✓ **Foot:** Shoe covers ✓ **Inhalation:** Mandatory use of N95 respirator or PAPR, as determined by risk assessment. *For mandatory use, contact EHS for respiratory protection program assistance.* ✓ **Additional PPE, Specify:** A full body disposable coverall is appropriate in an animal facility.
☐	☐			
☐	☐			


3.0 RADIOACTIVE AGENT PROTECTION: IONIZING, ULTRAVIOLET, INFRARED

Task Performed Yes	Task Performed No	Task Performed in Lab (Modify wording to fit your needs)	Potential Hazards	PPE For Lab-Specific Tasks
☐	☐	Work with solid radioactive material or solid radioactive waste	• Cell damage • Potential spread of radioactive contamination	✓ **Eyes**: Safety glasses ✓ **Hands**: Disposable nitrile or other appropriate radioactive material impermeable gloves ✓ **Body:** Lab coat; long pants, long skirt, or equivalent leg covering (no shorts); lab footwear (Refer to Page 3) ✓ **Work on Sealed Source:** Minimum PPE is necessary when working with sealed radiation sources.
☐	☐	Work with liquid radioactive material (in corrosives, flammables, and aqueous liquids, including liquid radioactive waste) or radioactive powders	• Cell damage • Potential spread of radioactive contamination • Hazards presented by the specific chemical	✓ **Eyes:** Safety glasses ✓ **Hands:** Disposable nitrile or appropriate chemical resistant gloves compatible with work with radioactive materials ✓ **Body:** Lab coat; long pants, long skirt, or equivalent leg covering (no shorts); lab footwear (Refer to Page 3)
☐	☐	Work with ultraviolet radiation	• Eye damage • Skin burns	✓ **Eye:** UV face shield and/or goggles ✓ **Hand:** Nitrile gloves if hand exposure is possible ✓ **Body:** Lab coat
☐	☐	Work with infrared-emitting equipment (e.g., glass blowing)	• Eye damage	✓ **Eye:** Appropriate polycarbonate infrared filter glasses ✓ **Body:** Flame resistant lab coat
☐	☐			
☐	☐			

4.0 LASER PROTECTION

Task Performed Yes No	Task Performed in Lab (Modify wording to fit your needs)	Potential Hazards	PPE For Lab-Specific Tasks
	OPEN BEAM		
☐ ☐	Perform beam alignment or laser experiment; repair or maintenance that requires working with an open laser beam, and/or defeating the interlock(s) on any Class 3B or Class 4 laser system	• Eye damage • Skin damage	✓ **Eye:** Appropriate laser safety goggles/glasses with optical density based on individual beam parameters; *contact EHS to determine appropriate optical density.* ✓ **Body:** Lab coat; long pants, long skirt, or equivalent leg covering (no shorts); lab footwear (Refer to Page 3)
☐ ☐	Use an open beam Class 3R laser beam with magnifying optics (including eyeglasses)	• Eye damage	✓ **Eye:** Appropriate laser safety goggles/glasses with optical density based on individual beam parameters; *contact EHS to determine appropriate optical density.*
☐ ☐	Work with a Class 3B open beam laser system with the potential for producing direct or specular (mirror-like) reflections	• Eye damage	✓ **Eye:** Appropriate laser safety goggles/glasses with optical density based on individual beam parameters; *contact EHS to determine appropriate optical density.*
☐ ☐	Handle dye laser materials, such as powdered dyes, chemicals, and solvents	• Cell damage • Fire • Explosion	✓ **Eyes:** Safety glasses ✓ **Hands:** Chemical resistant gloves ✓ **Body:** Flame resistant lab coat or coveralls
☐ ☐	Maintain and repair power sources for Class 3B and Class 4 laser systems	• Electrocution • Fire • Explosion	✓ **Eye:** Safety glasses ✓ **Hands:** Insulated gloves ✓ **Body:** Flame resistant lab coat

5.0 NANOMATERIAL PROTECTION

Task Performed Yes No	Task Performed in Lab (Modify wording to fit your needs)	Potential Hazards	PPE For Lab-Specific Tasks
☐ ☐	Work with bound or wet nanomaterials	• Inhalation • Skin damage • Eye damage • Chemical exposure	✓ **Eyes:** Safety glasses ✓ **Face**: Face shield as splash or splatter may occur ✓ **Hands**: Disposable nitrile or other appropriate chemical resistant gloves ✓ **Hands**: Routinely replace gloves to minimize exposure and hand contamination ✓ **Body:** Lab coat; long pants, long skirt, or equivalent leg covering (no shorts); lab footwear (Refer to Page 3) ✓ **Inhalation:** Half face respirator with P100 cartridge if working with aerosolizing nanomaterials outside of a vented work enclosure; must *contact EHS for respiratory protection program enrollment*. ☐ **Other PPE, Specify**:
☐ ☐	Work with unbound or dry engineered nanomaterials	• Inhalation • Skin damage • Eye damage • Chemical exposure	For unbound or dry material: ✓ **Eyes:** Safety glasses ✓ **Face**: Face shield as splash or splatter may occur ✓ **Hands**: Disposable nitrile or other appropriate chemical resistant gloves ✓ **Hands**: Routinely replace gloves to minimize exposure and hand contamination ✓ **Body:** Lab coat made of non-woven fabric and elastic at the wrists; long pants, long skirt, or equivalent leg covering (no shorts); lab footwear (Refer to Page 3) ✓ **Inhalation:** Half face respirator with P100 cartridge if working with aerosolizing nanomaterials outside of a vented work enclosure; **must** *contact EHS for respiratory protection program enrollment*. ✓ **Removal of PPE:** Give special attention to the technique used to remove and dispose of contaminated PPE to avoid skin contact. ☐ **Other PPE, Specify**:
☐ ☐			


6.0 PHYSICAL HAZARD PROTECTION (Page 1 of 2)

Task Performed Yes	Task Performed No	Task Performed in Lab (Modify wording to fit your needs)	Potential Hazards	PPE For Lab-Specific Tasks
☐	☐	Work with cryogenic liquids	• Skin damage • Eye damage	✓ **Eyes**: Safety glasses ✓ **Face**: Face shield ✓ **Hands**: Cryogenic, low temperature insulated gloves ✓ **Body:** Lab coat; long pants, long skirt, or equivalent leg covering (no shorts); lab footwear (Refer to Page 3) ☐ **Body:** Cryogenic apron
☐	☐	Remove freezer cryo vials from liquid nitrogen	• Vials may explode upon rapid warming • Cuts to face/neck and frostbite to hands	✓ **Eyes**: Safety glasses ✓ **Face**: Face shield ✓ **Hands**: Cryogenic, temperature, thermal insulated gloves ✓ **Body:** Lab coat; long pants, long skirt, or equivalent leg covering (no shorts); lab footwear (Refer to Page 3) ☐ **Body:** Cryogenic apron
☐	☐	Work with very cold equipment or dry ice	• Frostbite • Hypothermia	✓ **Eyes**: Safety glasses ✓ **Body:** Lab coat; long pants, long skirt, or equivalent leg covering (no shorts); lab footwear (Refer to Page 3 ✓ **Hands**: Cryogenic low temperature insulated gloves
☐	☐	Work with hot liquids, heating equipment, and/or open flames (autoclave, Bunsen burner, water bath, oil bath)	• Burns resulting in skin or eye damage	✓ **Eyes:** Safety glasses ✓ **Hands:** Inner disposable nitrile or appropriate chemical resistant gloves ✓ **Hands:** Outer thermal insulated gloves ✓ **Body:** Lab coat; long pants, long skirt, or equivalent leg covering (no shorts); lab footwear (Refer to Page 3) ✓ **Eyes:** Safety goggles for work with hot liquids ✓ **Face**: Face shield as splash or splatter may occur ✓ **Hands:** Autoclave gloves, impermeable insulated gloves for liquids and steam
☐	☐	Wash glassware	• Lacerations if glass breaks • Splash from cleaning agents	✓ **Eyes**: Safety glasses ✓ **Hands**: Nitrile or appropriate chemical resistant gloves ✓ **Body:** Lab coat; long pants, skirt, or equivalent leg covering (no shorts); lab footwear (Refer to Page 3) ☐ **Face**: Face shield ☐ **Hands:** Cut resistant gloves if glass breaks


6.0 PHYSICAL HAZARD PROTECTION (Page 2 of 2)

Task Performed Yes	Task Performed No	Task Performed in Lab (Modify wording to fit your needs)	Potential Hazards	PPE For Lab-Specific Tasks
☐	☐	Work with loud equipment, noises, sounds, alarms, etc.	• Potential ear damage and hearing loss	✓ **Hearing:** Earplugs or ear muffs, as necessary; *contact EHS for noise exposure assessment.*
☐	☐	Work with an apparatus with contents under pressure or vacuum _____ (mm of Hg, psi, or torr)	• Skin damage • Eye damage	✓ **Eyes**: Safety glasses ✓ **Hands**: If chemicals are used, nitrile or other appropriate chemical-resistant gloves ✓ **Body:** Lab coat; Long pants, skirt, or equivalent leg covering (no shorts); lab footwear (Refer to Page 3) ☐ **Face**: Face shield ☐ **Eyes and/or Face**: For high risk activities - Safety goggles and face shield ☐ **Body:** If chemicals are used, chemical-resistant apron ☐ **Other PPE, Specify**
☐	☐	Work with sharps or broken glass	• Cuts	✓ **For Cuts**: Use tongs for broken glass and a designated sharps container for contaminated wastes ✓ **For Cuts**: Cut resistant outer glove (Kevlar) with nitrile inner gloves
☐	☐	Work with sharps and/or empty a syringe used with chemicals	• Exposure to aerosols from the syringe	✓ **For Aerosols:** Safety glasses and a mask. Respiratory protection; *contact EHS for respiratory protection program assistance* ✓ **Hands**: Nitrile or appropriate chemical resistant gloves ☐ **Other PPE, Specify:**
☐	☐	Work with compressed gases inside environmental chambers	• Asphyxiation • Toxic gas exposure	✓ Employee is not allowed to enter and work inside an oxygen-deficient or hazardous chamber.
☐	☐	Maintain and repair electrically powered equipment	• Electrocution	✓ **Eyes**: Safety glasses ✓ **Hands**: Insulated gloves ✓ **Body:** Coveralls
☐	☐			

Section 3: Certify the Hazard Assessment

Please certify that the hazard assessment for the laboratory has been completed by filling out and signing this page.

CERTIFICATION OF THE LABORATORY HAZARD ASSESSMENT AND PPE SELECTION

Principal Investigator's (PI) Name (Print Name):	Department/Unit:	
Building(s):	Room(s):	
Lab Manager's Name:	Lab Manager's Phone:	
Completed by (Print Name):	Signature:	Date
Signature of PI:		Date

Section 4: PPE Training Documentation

Laboratory safety training must be conducted by the Principal Investigator, Lab Manager, or their designee. Training will identify and discuss potentially hazardous tasks performed in the lab and selection and use of lab-specific PPE to protect the laboratory worker or researcher. The training content, instructor, and student attendees must be documented. To provide adequate training, the PI, Lab Manager, or their designee will provide the following:

1. Identify all applicable safety training courses needed for each staff member and ensure that each staff member has these courses.
2. The PI, lab manager, or their designee will review the completed Lab PPE Hazard Assessment Guide with the employee. It describes the operations in the lab where employees need PPE for protection against exposure to hazards. In this step, the hazard assessment is used as a training tool. While discussing lab operations and the associated hazards with lab staff, the manager will address the following:
    - How the lab obtains PPE
    - What types of PPE are used in the lab and for which tasks
    - Where and how the PPE is stored and maintained
    - How to inspect and what to look for to confirm PPE is in good condition before putting it on. If not, place the PPE.
    - How to put on, wear, adjust for proper fit, and remove PPE
    - How to properly use the PPE
    - How to properly decontaminate and clean reusable PPE, and how to properly dispose of single-use PPE
    - Discuss any limitations of the PPE
    - General PPE safety practices, including not wearing PPE outside of lab hazard areas (e.g., hallways and eating areas).
3. Each trained lab staff member will sign the training documentation to acknowledge that they have reviewed and been trained on the Laboratory PPE Assessment Guide.

Conduct refresher training whenever the hazard assessment and/or PPE selected for use is updated.

Laboratory PPE Hazard Assessment Guide Training Acknowledgement:

Principal Investigator: _____ Department/Unit: _____

Building: _____ Room: _____

Trainer: _____ Trainer Job Title: _____

I have read, asked questions, and understand the PPE requirements for the activity/materials described for my work.

Date	Name of Person Trained	Job Title	Employee or Student ID Number	Signature

24.18 Appendix R: Methylene Chloride Workplace Chemical Protection Program

Dartmouth College

DARTMOUTH

Table of Contents

Section 1 – Scope

This Workplace Chemical Protection Program (WCPP) applies to all Dartmouth College personnel—including faculty, staff, students, and contractors – who may use or be potentially exposed to methylene chloride (also known as dichloromethane or DCM) during laboratory research or teaching activities.

The program encompasses all departments and laboratories where methylene chloride is used or stored, including academic laboratories in the sciences and engineering, shops and maker spaces, and support operations involving solvent-based processes such as solvent welding. It also covers any ancillary spaces (e.g., storage, waste accumulation areas) where methylene chloride is handled or present.

This WCPP has been developed to **ensure compliance** with:

- The **EPA Methylene Chloride Final Rule** under the **Toxic Substances Control Act (TSCA)** (40 CFR Part 751) which mandates implementation of strict exposure control programs and expanded safety requirements for continued laboratory and research use of methylene chloride
- The **OSHA Methylene Chloride Standard** (**29 CFR 1910.1052**) outlines permissible exposure limits, engineering control requirements, medical surveillance, and worker training obligations.

This program applies to any workplace condition where methylene chloride is used, stored, or disposed of, and where exposure could occur via inhalation or skin contact. Temporary, infrequent, or small-quantity uses are not exempt and must still adhere to the requirements outlined herein.

Section 2 – Purpose

The Environmental Protection Agency (EPA), under the Toxic Substances Control Act (TSCA), has determined that methylene chloride, also known as dichloromethane (DCM), poses an unreasonable risk of injury to health because cumulative exposures to DCM can cause cancer and damage to the liver and kidneys. Acute exposures to high concentrations of DCM vapor in poorly-ventilated spaces have caused central nervous system harm, up to and including unconsciousness and death through respiratory paralysis.

The EPA has identified a limited number of applications that may continue. A Workplace Chemical Protection Program is required for those entities that continue using DCM under these allowable uses. Dartmouth College has implemented the following requirements to satisfy this obligation.

Section 3 – Definitions

As-needed monitoring - Exposure measurements taken when there is a change of use.

DCM – Dichloromethane, also called MC, methylene chloride, CH_2CL_2—clear and colorless liquid with a chloroform-like odor (pleasant and sweet). Readily evaporates and is much heavier than air.

De minimis - The threshold concentration for which the regulatory restrictions are not required. For DCM, this concentration is 0.01% by weight.

Exposure Control Plan (ECP) - This documents actions taken to mitigate occupational exposures and comply with the WCPP at the lab, department, or institute level.

Owners/operators - Anyone who owns, leases, operates, controls, or supervises a workplace. This includes Dartmouth College and each PI, instructor, lab manager, or supervisor who oversees a location where DCM is used or a person who uses DCM. Dartmouth College is responsible for writing and updating this WCPP. PIs, instructors, and supervisors are responsible for implementing this WCPP and approving and enforcing any Exposure Control Plans applicable to their work area.

Periodic monitoring - Depending on the results of the initial and/or repeat monitoring, the frequency of gathering new monitoring data ranges from 3 months to 5 years.

Potentially exposed person - Any person who may be exposed to a chemical or mixture in a workplace due to a condition of use of that chemical substance or mixture. This applies regardless of whether a person is a chemical user or an employee. Potentially exposed persons are responsible for complying with the provisions of this Program.

Prohibited uses - the EPA has established exposure limits for DCM for some conditions of use, including "use as a laboratory chemical." Nearly all other commercial and industrial uses, such as use as a solvent or paint remover, are prohibited. EPA has a complete list of prohibited uses in its Guide to Complying with the 2024 Methylene Chloride Regulation.

Regulated area - An area demarcated where airborne concentrations exceed, or there is a reasonable possibility they may exceed, the Existing Chemical Exposure Limit (ECEL) of 2 ppm or the EPA Short Term Exposure Limit (STEL) of 16 ppm.

Retailer - An entity that distributes or makes available products to consumers.

Time-Weighted Average (TWA) - The airborne exposure averaged with time (e.g., 8-hour or 15-minute).

Workplace Chemical Protection Program (WCPP) - A written program to protect potentially exposed persons in the workplace who are engaged in conditions of use that are not prohibited.

Section 4 – Roles and Responsibilities

4.1 Environmental Health and Safety (EHS)

- Guide the elimination of DCM.
- Coordinate with the Industrial Hygienist or consultant for quantitative and qualitative assessments of employee exposure to DCM.
    - Exercise surveillance over health and safety issues regarding testing and monitoring.
    - In coordination with the employees' department, notify affected employees within 15 working days of receiving laboratory analysis results.
- Suggest minimizing DCM exposure levels, such as suitable work protocols, engineering controls, and personal protective equipment (PPE).
- Conduct reviews of engineering controls and work practices in locations where DCM is utilized.
- Develop, conduct, and/or provide through third-party Methylene Chloride Training to all those individuals potentially exposed to DCM.
- Maintain training records.
- Annually review the WCPP.

4.2 Occupational Medicine

- Provide medical surveillance and screenings for DCM users as outlined in this Program.
- Keep medical records for faculty and staff exposed to DCM per the guidelines specified in this Program.

4.4 Dick's House

- Provide medical surveillance and screenings for students as outlined in this Program.
- Keep medical records for students exposed to DCM per the guidelines specified in this Program.

4.4 Principal Investigators and Lab Managers

Have primary responsibility for managing and enforcing the WCPP in their areas. Those departments using methylene chloride in authorized activities covered in the Program shall:

- Identify areas where DCM is used and inform EHS for exposure assessment.
- Ensure individuals handling or exposed to DCM are informed of the associated hazards and employ appropriate safety measures.
- Notify EHS about any modifications in DCM usage, work methods, or controls that might affect exposure levels.

- Adhere to the Chemical Hygiene Program for laboratories for storing and labeling materials containing DCM.

4.5 Users of DCM

- Adhere to the procedures outlined in this Program.
- Use the designated Personal Protective Equipment (PPE).
- Attend and participate in relevant safety training sessions.
- Notify EHS about any modifications in DCM usage, work methods, or controls that might affect exposure levels.
- Notify PI, lab manager, and/or EHS if any DCM exposures exist.

Section 5 – Exposure Control Plan (ECP)

5.1 Centralized ECP for Laboratory Use

This Exposure Control Plan (ECP) covers safety practices to be followed for using DCM as a laboratory chemical at Dartmouth College. Any deviation from this Plan requires approval in writing from the Chemical Hygiene Officer. The use of DCM is subject to pre-approval by the Principal Investigator (PI) and/or Supervisor responsible for the laboratory in which it will be used. DO NOT USE DCM UNTIL YOU HAVE OBTAINED THE NECESSARY PRE-APPROVAL.

5.1.2 Elimination

The EPA regulates methylene chloride because, under the Toxic Substances Control Act (TSCA), it determined that the chemical presents an "unreasonable risk of injury to health". This determination is due to significant risks of cancer, liver damage, and neurotoxicity (like headaches and dizziness) from short and long-term exposure through inhalation and skin contact. Therefore, EHS will address this unreasonable risk by eliminating DCM for all activities unless it's included in the conditions of use and an exposure control plan has been established.

5.1.3 Substitution

The following resources may be considered for substituting DCM for a suitable alternative:

- EPA – Appendices: An Alternatives Assessment for Use of Methylene Chloride; Proposed Regulation of Methylene Chloride under TSCA Section 6(a)
- Green Chemistry Teaching and Learning Community – Methylene Chloride (DCM) Replacements
- ACS Green Chemistry Institute – Tools for Innovation in Chemistry

5.1.4 Engineering Controls

- C**hemical fume hoods** should be used for all open handling of DCM.
- Install **local exhaust ventilation (LEV)** for enclosed processes or equipment like rotary evaporators or solvent welders.
- Ensure ventilation systems are **inspected and certified** annually.
- Never work with DCM in unventilated or poorly ventilated spaces.

5.1.5 Administrative Controls

- All occupants of laboratories that use DCM shall review this WCPP and ECP before entry, sign that they have received the information they contain, and agree to abide by the training provided to them.
- Limit the quantity of DCM used to the smallest amount necessary for the task.
- Seal containers with **parafilm or vapor-tight caps** when not in use.
- Use **secondary containment** for all DCM containers.
- Keep waste containers **sealed and properly labeled**.
- Avoid skin contact—use tools for transfer and pouring.
- The storage of DCM must comply with requirements for particularly hazardous substances.
- Stop all use of DCM if any malfunction of the local exhaust ventilation device indicated above is suspected.
- Any PPE suspected of coming in contact with DCM must be changed immediately.

5.1.6 Personal Protective Equipment (PPE)

- Minimum PPE:
    - Closed-toe shoes and clothing covering your legs
    - Lab coat
    - Safety glasses
    - **Two pairs** of 5 mil NEOPRENE gloves
        - DCM readily penetrates nitrile gloves in <10 minutes (check glove manufacturer's glove guide for best estimate on breakthrough time)
- Changes gloves immediately if splashed
- If there is a risk of a splash, working with volumes greater than 300 mL, or submersion, wear splash goggles, face shield, chemically resistant apron, and chemical-resistant sleeves.
- For expected glove contact with DCM, cleaning DCM spills, or handling volumes greater than 300 mL, wear a pair of Silver Shield gloves over one pair of nitrile gloves.
    - Due to the quick breakthrough time of nitrile gloves with DCM contact, it is NOT recommended to use only nitrile gloves in these circumstances.
- Wash your hands whenever changing gloves

5.2 Centralized ECP for Solvent Welding of Acrylic and Polycarbonate

This Exposure Control Plan (ECP) covers safety practices to be followed for the use of a bonding agent that contains DCM for solvent welding at Dartmouth College. Any deviation from this Plan requires approval in writing from the Chemical Hygiene Officer. Using a bonding agent containing DCM is subject to pre-approval by the Principal Investigator (PI) and/or Supervisor responsible for overseeing your work. DO NOT USE THE BONDING AGENT UNTIL YOU HAVE OBTAINED THE NECESSARY PRE-APPROVAL.

5.2.1 Engineering Controls

- **Local Exhaust Ventilation (LEV):**
  - Required at all DCM solvent welding workstations
  - Must be verified annually by a third-party and maintained at manufacturer-recommended capture velocity
- **Chemical Fume Hoods (CFH):**
  - Preferred for small-scale solvent welding
  - Sashes must remain below the marked working height during operation
- **Enclosures or Downdraft Tables:**
  - May be used where available and appropriate

5.2.2 Work Practice Controls

- Conduct all solvent welding inside an LEV or CFH
- Keep DCM containers closed when not in use
- Label and store all DCM products per GHS requirements
- Use minimal quantities needed for each task
- Never eat, drink, or store food near solvent welding areas
- Dispose of rags and wipes in closed hazardous waste containers
- Clean all surfaces after work with compatible solvents

5.2.3 Personal Protective Equipment (PPE)

- Minimum PPE:
  - Closed-toe shoes and clothing covering your legs
  - Lab coat
  - Safety glasses
  - **Two pairs** of 5 mil NEOPRENE gloves
    - DCM readily penetrates nitrile gloves in <10 minutes (check glove manufacturer's glove guide for best estimate on breakthrough time)
- Changes gloves immediately if splashed
- If there is a risk of a splash, working with volumes greater than 300 mL, or submersion, wear splash goggles, face shield, chemically resistant apron, and chemical-resistant sleeves.
- For expected glove contact with DCM, cleaning DCM spills, or handling volumes greater than 300 mL, wear a pair of Silver Shield gloves over one pair of nitrile gloves.
  - Due to the quick breakthrough time of nitrile gloves with DCM contact, it is NOT recommended to use only nitrile gloves in these circumstances.
- Wash your hands whenever changing gloves

5.3 Approved Processes at Dartmouth College

DCM is allowed under this Program as a laboratory chemical under approved applications and in waste operations to dispose of materials generated through other approved uses.

These uses cannot be eliminated because of DCM's unique chemical properties, and it is essential to ensure that results from ongoing experiments can be compared with previously obtained experimental results. According to EPA regulation, all uses not explicitly permitted under this Program shall be eliminated. Note that all approved uses shall be used within a certified chemical fume hood or local exhaust ventilation system unless otherwise noted:

Approved applications:

- Calibration and Standards
    - Instrument calibration
    - Analytical Standard
- Chemical Analysis and Sample Preparation
    - Nuclear Magnetic Resonance (NMR) Spectroscopy
    - UV-Vis Spectroscopy
    - Infrared (IR) Spectroscopy
- Chemical Synthesis and Reactions
    - Synthesis
    - Reagent
- Chromatography
    - High Performance Liquid Chromatography (HPLC)
    - Gas Chromatography
    - Column chromatography – manual system (flash or gravity)
    - Thin-layer chromatography
- Cleaning, Degreasing, or Dissolving – **ONLY within a certified chemical fume hood**
    - Glassware cleaning, washing, and degreasing
    - Part washing
    - Adhesive removal
- Dispensing and Transferring - **ONLY within a certified chemical fume hood**
    - Dispensing from a container with a solvent pump
    - Pouring from a container
    - Transferring DCM-containing liquid (including waste) to another container
    - Solvent purification/drying systems
- Extraction and Purification
    - Column chromatography – automated system (combi flash)
    - Extraction solvent
    - Natural product extractions
    - Recrystallization
    - Solvent purification, drying, or degassing system
- Instrument Maintenance
    - Cleaning Instrument (optics, sample lines, extrusion tips)
    - Column regeneration (e.g., HPLC)
- Other Uses

    - Polymer and resin processing (polymerization, solvent, resin dissolution)
- Rotary Evaporation System
    - Using a rotary evaporation system
- Solvent Welding

Section 6 – Exposure Limits

Under this program, long-term exposures to DCM will be kept below two ppm (8-hour TWA) and short-term exposures below 16 ppm (15-minute TWA) wherever possible. Additional monitoring will be implemented whenever long-term exposures exceed one ppm. Regulated Areas will be established for any work areas where long-term exposures may exceed two ppm (8-hour TWA) or where tasks are performed that may result in short-term exposures exceeding 16 ppm (15-minute TWA).

6.1 Monitoring Requirements

Initial monitoring for DCM is required to establish a baseline for DCM users and to inform the development of the Exposure Control Plan (ECP). Initial monitoring results, such as periodic monitoring, will be used to determine the frequency of compliance activities. Monitoring must be taken when and where operating conditions are best representative of each potentially exposed person's highest likely full shift, and 15-minute exposures occur.

6.1.1 Exemptions to Initial Monitoring

Two conditions can exempt an employer from conducting initial monitoring for DCM.

1. If objective data generated during the last 5 years demonstrates DCM is not released in the workplace environment at or above the ECEL action level and EPA STEL, with initial monitoring conducted within 5 years of that data.
2. If exposure to DCM is less than 30 days per year, with two conditions:
    a. Direct reading measurements must be taken in the environment to ensure levels are below the ECEL action level and EPA STEL.
    b. Appropriate controls must be implemented to ensure levels are below the ECEL and EPA STEL.

6.1.2 Initial and Periodic Monitoring

The results of initial monitoring will determine how frequently periodic monitoring must occur. Periodic monitoring can range from every 3 months, every 6 months, or every 5 years, depending on the following conditions:

Determine monitoring frequency based on initial monitoring results.

DCM Concentration (exposure monitoring results)			**Re--monitoring frequency**
8-hr TWA (ECEL)		**15-min TWA (STEL)**	
< 1 ppm	and	≤ 16 ppm	ECEL and EPA STEL periodic monitoring at least once every 5 years
< 1 ppm	or	> 16 ppm	ECEL monitoring at least once every 5 years AND EPA STEL periodic monitoring required every 3 months
> 1 ppm & ≤ 2 ppm	or	< 16 ppm	ECEL monitoring every 6 months
> 1 ppm & ≤ 2 ppm	or	> 16 ppm	ECEL periodic monitoring every 6 months AND EPA STEL periodic monitoring every 3 months
> 2 ppm	or	> or ≤ 16 ppm	ECEL periodic monitoring every 3 months AND EPA STEL periodic monitoring every 3 months

6.1.3 Changes in Conditions

The frequency of periodic monitoring will change depending on whether exposure conditions have changed.

Criteria	Action
Exposure reduced to at or below ECEL (but Above Action Level). ● Two consecutive samples taken at least 7 days apart show an 8-hour TWA exposure to DCM has decreased from above the ECEL to between 1 ppm and 2 ppm.	Adjust periodic monitoring frequency from every 3 months to every 6 months.
Exposure reduced below the ECEL Action Level. Two consecutive samples taken at least 7 days apart show DCM exposure has decreased. ● 8-hour TWA: Below 1 ppm (Action Level). ● 15-minute exposure: At or below 16 ppm (EPA STEL).	Adjust periodic monitoring frequency from every 6 months to every 5 years.

6.1.4 Suspension of Periodic Monitoring

Based on the criteria below, monitoring may be suspended if work with DCM is suspended.

Criteria	Action
Conditions Requiring 3-Month Interval Monitoring Not Performed: Processes or tasks included in the finalized Workplace Chemical Protection Program (WCPP) that require 3-month interval monitoring do not occur during the required period.	Periodic monitoring may be suspended. Maintain documentation confirming that the processes or tasks were not performed. Resume monitoring when the conditions of DCM use specified in the WCPP are restarted.
Conditions Requiring 6-Month Interval Monitoring Not Performed: Processes or tasks specified in the finalized WCPP that necessitate 6-month interval monitoring do not occur during the required period.	Periodic monitoring may be suspended. Maintain documentation confirming that the processes or tasks were not performed. Resume monitoring when the conditions of DCM use specified in the WCPP are restarted.

6.2 Sampling Requirements

The following sampling guidelines must be followed for every potentially exposed person.

1. Sampling Requirements:
    a. Sampling must be conducted for every potentially exposed person or a representative sample representing all exposed persons.
    b. Sampling must be taken when and where the operating conditions represent full shift exposures.
    c. All potentially exposed persons must be allowed to observe exposure monitoring.
    d. Samples must be taken at the personal breathing zone.
    e. Notify the monitored person of the monitoring results and potentially exposed persons (e.g., similar exposure group) within 15 working days after receipt of the results.
2. Sampling Report:
    a. Provide the ECEL, action level, EPA STEL, and significance.
    b. Provide the quantity, location, and manner of DCM use during monitoring.
    c. Provide the monitoring results.
    d. Indicate whether the concentration exceeds the ECEL, action level, and EPA STEL.
    e. Describe actions taken to reduce exposure to below exposure limits.
    f. Describe the respiratory protection measures if needed.
    g. List any identified releases of DCM during monitoring.

6.3 Regulated Areas

A regulated area must be established wherever airborne concentrations of DCM exceed, or could reasonably be expected to exceed, the ECEL of 2 ppm or the STEL of 16 ppm based on monitoring. EHS must approve the boundaries of each regulated area established under this Program.

6.3.1 Establishing Regulated Areas

Regulated areas must be established and clearly demarcated by signage indicating the use of DCM. Signage alerts potentially exposed persons of the area's boundaries and minimizes the number of exposed persons.

The exact wording will be tailored for each area, and may be in multiple languages as needed. An example of wording is the following.

Methylene Chloride Warning

- Authorized Personnel Only
- Airborne Concentrations may exceed:
  - ECEL: 2 ppm
  - STEL: 16 ppm

Avoid Exposure

- Follow Safety Protocols
- Respiratory Protection Required When Methylene Chloride is in Use

6.3.2 Access Control

Only authorized personnel may enter a regulated area. These personnel must receive DCM-specific training, including hazard communication, safe handling practices, emergency procedures, and proper use of dermal PPE and respiratory protection before entering the regulated area.

6.3.3 Respiratory Protection

A NIOSH-approved supplied-air respirator (SAR) or self-contained breathing apparatus (SCBA) is required to enter a regulated area. Additional details regarding medical evaluation, fit testing, and training are included in **Dartmouth College**'s Respiratory Protection Program.

Section 7 – Training and Information

The EPA rule includes requirements for training and references the OSHA Methylene Chloride Standard training requirements. Both EPA and OSHA reference general training requirements (e.g., nature of training required, frequency, *etc*.) and task-specific training. As such, training may be provided from a centralized, institutional level and/or at the lab-specific level by PIs, instructors, and supervisors who oversee the assignment of tasks in the lab.

7.1 Centralized Dichloromethane Training

The institutional training program for DCM at **Dartmouth College** will be developed and updated by EHS. The program shall cover these requirements:

1. Training shall be consistent with OSHA's Methylene Chloride Standard 1910.1052(I)(1) through (6), including completing training before initial job assignment.
2. Must be done in a comprehensive manner that is understandable to potentially exposed persons.

3. Shall cover hazards associated with DCM as required by the OSHA Hazard Communication Standard 1910.1200(b)(3)(iii) or site Chemical Hygiene Plan (some might use a lab manual instead).
    a. Dermal protection must cover glove selection (type and material), use, expected duration of glove effectiveness, actions to take when glove integrity is compromised, storage, procedure for glove removal, disposal, and chemical hazards.
    b. Inhalation protection training must occur annually if respiratory protection is required. It must cover medical requirements, fit testing procedures, hazards, use of respirator, donning/doffing of respirator, limitations, maintenance, and storage.
    c. Personal Protective Equipment training should cover selection, use, inspections, and replacement schedules.
4. Training must be repeated to maintain the knowledge of safe use and handling.
5. Employees for whom exposure monitoring results exceed the EPA action level or EPA STEL shall be re-trained to ensure that each employee understands the principles of safe use and handling of DCM.
6. When workplace changes, such as modifying tasks or procedures or new procedures, which can reasonably be expected to increase the exposure level, the employer shall update the training to ensure that each affected employee has the requisite proficiency.

7.2 Lab/Shop-Specific Dichloromethane Training

Each PI, instructor, and/or supervisor who oversees the assignment of tasks requiring the use of DCM in the lab shall implement and document hands-on training for lab personnel, covering:

1. Task- or activity-specific PPE is required, as well as the location of the PPE.
2. Exposure controls are required during tasks with DCM and training on using those controls (e.g., appropriate fume hood sash level).
3. The PI, instructor, or supervisor shall ensure that only individuals trained on DCM safety can perform DCM tasks.

If tasks are modified or new tasks are initiated, the PI, instructor, or supervisor shall notify EHS, as additional DCM monitoring may be required.

Section 8 – Recordkeeping

Compliance records must be retained for a period of five years. Owners and operators, including each PI, instructor, or supervisor who oversees a location where DCM is used or a person who uses DCM, are required to participate in generating and maintaining these records, as they are crucial in proving adherence to the restrictions set forth by the EPA. It is acknowledged that many of these records and documentation are already maintained by Dartmouth College and by individual research groups associated with overlapping programs such as Medical Surveillance, Training, and Chemical Hygiene program elements:

1. **Exposure Control Records:** Their generator will maintain these records as specified below.
    a. Lab-specific Exposure Control Plans will be maintained by the PI, instructor, or supervisor.
    b. Implementation records, including inspections, evaluations, and exposure control updates, as well as confirmation that affected persons are properly implementing exposure controls, will be maintained by EHS.
    c. Documentation of personal protective equipment being used as part of the program will be maintained by EHS and/or PI, instructor, or supervisor.
    d. EHS will maintain training records for centralized DCM training.
    e. EHS and/or PI, instructor, or supervisor will maintain lab-specific training records.
    f. Maintenance, shutdown, or malfunction documentation for facility exposure controls that cause air concentrations to exceed the ECEL or STEL will be maintained by the PI, instructor, or supervisor. Each PI, instructor, or supervisor who oversees a location where DCM is used or a person who uses DCM is responsible for notifying EHS immediately when such events are suspected to have occurred.
2. **Exposure Monitoring Records:** Monitoring records will be maintained by EHS for employees who may be potentially exposed, including:
    a. All measurements made to determine conditions affecting monitoring results, including copies of the notifications to the potentially exposed persons
    b. The identities of all potentially exposed persons whose exposure was not measured and whose exposure is intended to be represented by the monitoring
    c. Description of analytical methods
    d. Information on air monitoring equipment, including calibration dates, limits of detection, and malfunctions

e. Objective data is used to forgo initial exposure monitoring, including: the use being evaluated, the source of the data, the measurement methods and results, and any other relevant information.

Section 9 – References

- Ansell Chemical Glove Resistance Guide
- A Guide to Complying with the 2024 Methylene Chloride Regulation
- EPA Fact Sheet: Methylene Chloride or Dichloromethane
- FACT SHEET: 2024 Final Risk Management Rule for Methylene Chloride under TSCA
- Methylene Chloride Hazards for Bathtub Refinishers
- Preliminary Information on Manufacturing, Processing, Distribution, Use, and Disposal: Methylene Chloride
- Risk Evaluation for Methylene Chloride

24.19 Appendix S: Guideline for Hydrogen Use in the Laboratory

Dartmouth College
Environmental Health & Safety

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Guideline for Hydrogen Use in the Laboratory

Introduction

This document provides a guideline for identifying the safety requirements when using flammable hydrogen gas, and/or flammable mixtures in the laboratory. The information presented in this overview is intended to provide general guidance regarding the hazards associated with hydrogen gas. It is not intended to be a specific written safety procedure for your lab. Specific written procedures are the responsibility of the Principal Investigator. Contact Dartmouth Environmental Health and Safety at ehs@dartmouth.edu to notify us of potential new operations using hydrogen and to conduct an assessment of the proposed use. Many requirements will depend on the frequency of use and the amount of gas.

Hazards

Hydrogen is a known flammable gas. At atmospheric pressure, the Lower Explosive Limit (LEL) of hydrogen is 4% in air, and the Upper Explosive Limit (UEL) is 75% in air.
Hydrogen is a colorless, odorless, tasteless, flammable, nontoxic gas that is flammable over a wide range of concentrations. Some of the unique hydrogen properties that contribute to potential hazards (flammability and explosivity) are:

- Hydrogen has very low ignition energy.
- Hydrogen burns with a nonluminous flame, which can be invisible under bright light.
- Due to its small molecular size, Hydrogen can easily pass through porous materials and has the ability to be absorbed by some containment materials. This can eventually result in loss of ductility or embrittlement (this reduces the performance of some containment and piping materials such as carbon steel). Loss of ductility/embrittlement is accelerated at elevated temperatures.

The use of hydrogen gas in labs must follow the guidance of the Occupational Safety and Health Administration (OSHA) 1910.1450, the National Fire Protection Association (NFPA 55), and the Compressed Gas Association.

Requirements

- Create a standard operating procedure (SOP) for hydrogen use in the laboratory. Keep a copy readily accessible for lab use and submit a copy to EHS for review.
- Proper ventilation is required. This can be done through a chemical fume hood or a ventilated gas cabinet. Consult Engineering or Science Facilities on the building infrastructure to ensure the ventilation can handle an uncontrolled release of the cylinder.
- Used specifically designed regulators for hydrogen. Never attempt to repair a regulator or force connections that do not readily fit together. Avoid cracking hydrogen cylinder valves to remove dust or dirt from fittings, as this practice (though acceptable for other gases) could result in self-ignition.
- Before moving Hydrogen gas cylinders from their secured location, replace regulators with protective valve caps. Never roll, drop, or lift cylinders by their protective caps.
- Keep away from all possible ignition sources **by a minimum of 5 feet**. (e.g., Heat, Open flames, Sparks, or electric discharge).

  Considerations:

  - Supply proper bonding and isolated grounding (especially with chemical fume hoods).
  - Install explosion-proof equipment as needed (light fixture and switches, depending on the fume hood manufacturer; there are possible upgrades).
  - Anti-spark mats are required if the floor is an insulator and static buildup is possible.
  - Purchase spark-proof tools if necessary.
- For large gas cylinders and high frequency of use, equipment is recommended to use a flash arrestor.
- Check for leaks; Hydrogen is the lightest known gas. It may leak out of systems that are air-tight for other gases. Leak check system with soapy water; never use a flame.
- Use of flammable gas detection alarm systems is recommended; place alarms in close vicinity to areas of anticipated leakage. Alarms will be triggered if a specified concentration of Hydrogen gas is exceeded, providing early warning for possible leaks. Ensure that alarms / flammable gas detection systems are calibrated regularly as per the manufacturer's recommendations.
- Use appropriate personal protective equipment (PPE).

Storage

- Store only where the temperature will not exceed 125°F (52°C).
- Separate hydrogen cylinders from oxygen, chlorine, and other oxidizers by at least 20 ft. (6.1 m), or use a barricade of noncombustible material. This barricade should be at least 5 ft. (1.53 m) high and have a fire resistance rating of at least ½ hour.
- Always secure cylinders upright to keep them from falling or being knocked over. Install the valve protection cap, if provided, firmly in place by hand when the cylinder is not in use.
- Post "No Smoking or Open Flames" signs in storage and use areas. There must be no sources of ignition. All electrical equipment in storage areas must be explosion-proof. Storage areas must meet national electrical codes for hazardous areas.
- Determine the limits of hydrogen cylinders/total cubic feet storage of gas per fire control area. The total quantity of hydrogen gas is limited based on location within the building, the methods of storage (e.g., gas cabinet), and the design of the building's fire suppression and protection systems. Consult EHS and Engineering for allowable limits. In general, labs must limit the number/amount of cylinders to the minimum needed, and use just-in-time ordering.
- All cylinders must be secured by at least one strap, at two-thirds the height of the cylinder.

Emergency Response

The PIs should train individuals using hydrogen in labs to recognize different mechanisms by which hydrogen setups can leak, how accumulation can occur, and the emergency procedures when there is a suspected or known hydrogen gas leak.

Know who to contact - (911, EHS, and the Principal Investigator of the laboratory)

If a leak is detected:

1. Evacuate the immediate area of all occupants.
2. Immediately shut off the hydrogen source if safe to do so. Increase indoor ventilation with emergency explosion-proof exhaust fans (if available), opening fume hoods fully, opening windows (if operable), or use of emergency room exhaust.
3. Notify the PI immediately.
4. Execute the lab emergency procedures for hydrogen leaks immediately; this includes calling 911, notifying the PI, and other required emergency contacts. The emergency procedures need to be detailed in the lab's hydrogen handling SOP.