UCONN

CHEMICAL HYGIENE PLAN

Environmental Health and Safety
University of Connecticut
3102 Horsebarn Hill Road, U-4097
Storrs, CT 06269-4097
Phone: (860) 486-3613
ehs@uconn.edu

Chemical Hygiene Plan	
Last Reviewed Date:	07-01-2023
Last Revised Date:	07-25-2024
Effective Date:	1991
Applies To:	Employees, students, and others working in UConn laboratories with hazardous chemicals
Contact:	**EHS Chemical Health and Safety Manager**

Table of Contents

Chemical Hygiene Plan

I. Purpose

The University of Connecticut seeks to promote and maintain all programs that support the safety, health, and well-being of University employees, students, and visitors. The Chemical Hygiene Plan (CHP) was developed to protect the health and safety of personnel working in University laboratories with hazardous and other regulated chemicals. It incorporates the requirements of the Occupational Safety and Health Administration (OSHA) standard **29 CFR 1910.1450**, Occupational Exposure to Hazardous Chemicals in Laboratories, more commonly referred to as the OSHA Laboratory Standard.

II. Scope and Applicability

The CHP applies to individuals who use, store, manage, or dispose of hazardous or other regulated chemicals from laboratories at the University of Connecticut's main and regional campuses, except UConn Health. For the purposes of this plan, **laboratories** are defined as work areas where small quantities of hazardous chemicals are used on a non-production basis. In laboratories, reactions, transfers, and handling of chemicals are designed to be safely conducted by one person. It excludes workplaces whose function is to produce commercial quantities of materials. In addition to the requirements of the CHP, work in laboratories involving biological or radiological materials must comply with UConn's **Biological Safety Manual** and **Radiation Safety Manual**.

The CHP provides a general overview of standard operating procedures, work practices, controls, and personal protective equipment used to protect personnel from the health and physical hazards present in laboratories. It is the responsibility of all individuals working in laboratories to comply with the guidelines of the CHP. In addition, lab personnel must follow the safety manuals, standard operating procedures, and work practices required by departments, principal investigators, and laboratory managers to address procedures and hazards specific to their laboratories.

III. Enforcement

The University of Connecticut is committed to providing a healthful and safe environment for all activities under its jurisdiction and complying with all applicable federal, state, and local safety regulations and standards. Department heads, principal investigators, laboratory managers, lab workers, and other authorized individuals all share the responsibility for minimizing personnel exposure to laboratory hazards and maintaining compliance with the CHP. Failure to comply with this plan may result in disciplinary measures in accordance with University Laws and By-Laws, **General Rules of Conduct for All University Employees**, applicable collective bargaining agreements, and the **University of Connecticut Student Code**.

IV. Definitions

- **Active Lab Area**- laboratory areas where chemicals are used or stored.

- **Chemical Hygiene Plan** (CHP)- a written program developed and implemented by the University which sets forth procedures, equipment, personal protective equipment, and work practices that can protect lab personnel from the health hazards presented by hazardous chemicals used in that particular workplace.

- **Hazardous chemical**- any chemical which is classified as a physical hazard, a health hazard, a simple asphyxiant, combustible dust, pyrophoric gas, or hazard not otherwise classified.

- **Health Hazard**- means a chemical that is classified as posing one of the following hazardous effects: acute toxicity (any route of exposure); skin corrosion or irritation; serious eye damage or eye irritation; respiratory or skin sensitization; germ cell mutagenicity; carcinogenicity; reproductive toxicity; specific target organ toxicity (single or repeated exposure); or aspiration hazard.

- **Lab Personnel**- department heads, principal investigators, laboratory managers, lab workers, and other individuals assigned by UConn to perform specific duties in laboratories where hazardous chemicals are used or stored. This does not include maintenance, custodial, or other workers not actively engaged in laboratory activities.

- **Permissible Exposure Limit (PEL)** - a regulatory limit set by OSHA based on the amount or concentration of a substance in the air. In some cases, it may also contain a skin designation. Most PELs are based on an 8-hour time weighted average (TWA) exposure to which it is believed most workers may be exposed to for a working lifetime without developing serious illness. PELs are enforced as a legal standard.

- **Physical Hazard**- a chemical that is classified as posing one of the following hazardous effects: explosive; flammable (gases, aerosols, liquids, or solids); oxidizer (liquid, solid, or gas); self-reactive; pyrophoric (gas, liquid, or solid); self-heating; organic peroxide; corrosive to metal; gas under pressure; in contact with water emits flammable gas; or combustible dust.

- **Threshold Limit Value (TLV)** - the time-weighted average (TWA) concentration for a conventional 8-hour workday and a 40-hour workweek, to which it is believed that nearly all workers may be repeatedly exposed, day after day, for a working lifetime without adverse effect. The TLV is a consensus standard issued by the American Conference of Governmental Industrial Hygienists (ACGIH).

V. Roles and Responsibilities

Individuals overseeing or working in laboratories where hazardous chemicals are used or stored are responsible for following the guidelines listed in the CHP. This plan does not apply to undergraduates or other students enrolled in laboratory courses in teaching labs where hazardous chemicals may be used or stored. The responsibilities of each position are outlined below:

A. Vice President for Research

- Provides institutional leadership and assumes ultimate responsibility to ensure compliance with the Chemical Hygiene Plan.
- Supplies the University Chemical Hygiene Officer with the support necessary to implement and maintain the requirements of the Chemical Hygiene Plan.
- Updates the President of the University on EHS policies, programs, and relevant issues regarding laboratory safety.

B. University Chemical Hygiene Officer (CHO)

- Reviews and updates the Chemical Hygiene Plan.

- Works with departments, principal investigators, laboratory managers, and lab workers to develop and implement chemical hygiene policies, programs, laboratory-specific standard operating procedures, and safe work practices.
- Provides technical assistance to lab personnel regarding adherence to the Chemical Hygiene Plan.
- Manages the University laboratory training, inspection, chemical inventory, and fume hood testing programs.
- Assists lab personnel in the selection of appropriate engineering controls, administrative controls, and personal protective equipment for hazards encountered in laboratories.
- Works with departments, lab personnel, and the Chemical Hygiene Committee to continually improve the chemical hygiene program.
- May appoint a Deputy Chemical Hygiene Officer (DCHO) and delegate duties to the DCHO in accordance with the Chemical Hygiene Plan. The DCHO has the authority to independently act on behalf of the CHO to implement the Chemical Hygiene Plan and fulfill these roles and responsibilities.

C. Department Head

- Directs lab personnel within their department to comply with the guidelines of the Chemical Hygiene Plan.
- Instructs lab personnel within their department to receive Initial Lab Safety and Chemical Waste Management training and annual retraining through EHS.
- Works to maintain an up-to-date list of lab personnel within their department.
- Works with principal investigators or laboratory managers, within their department, found to be in violation of the Chemical Hygiene Plan or the Health and Safety Policy to ensure timely corrective action.
- Reviews accident reports and works with principal investigators, laboratory managers, lab personnel, and EHS to make appropriate changes to laboratory standard operating procedures to prevent future incidents from occurring.

D. Principal Investigator (PI)

- Follows the guidelines of the Chemical Hygiene Plan and ensures compliance with all EHS policies and programs applicable to their labs.
- Ensures that their lab personnel, including the PI, complete Initial Lab Safety and Chemical Waste Management training provided by EHS prior to working in or

overseeing work done in the lab. A refresher course must be completed annually by the PI and their lab personnel, either online or in-person.

- Maintains an accurate, up-to-date chemical inventory for each laboratory.
- Reviews and updates the lab's **Workplace Hazard Assessment Form(s)**, as needed.
- Provides training to lab personnel that addresses the hazards, **controls**, work practices, personal protective equipment (PPE), and emergency procedures specific to the lab.
- Maintains and makes available lab-specific training **documentation** for lab personnel, including the contents of training and a list of personnel receiving the training.
- Ensures compliance with the University's **Working Alone Policy**.
- Ensures that minors (individuals under 18 years old) will always be supervised by qualified laboratory personnel.
- Provides appropriate personal protective equipment to personnel in their lab(s) for the health hazards, physical hazards, and equipment identified in the **Workplace Hazard Assessment**.
- Reviews and approves protocols and procedures of lab personnel for potential safety and/or technical issues prior to active research.
- Develops and provides training and **lab-specific standard operating procedures** (LSOPs) for lab personnel engaged in research with particularly hazardous chemicals.
- Ensures that lab personnel properly collect, label, and manage wastes.
- Minimizes or eliminates actual or potential hazards that could lead to accidents, injuries, or property damage.
- Ensures that labs remain clean, orderly, and in a sanitary condition.
- Ensures safe operation of laboratory equipment through proper installation, inspection, maintenance, and repair.
- Reports all lab-related accidents/emergencies to UCFD (911) and injuries to **Human Resources.** Serious injuries (i.e., death, in-patient hospitalization, amputation, or loss of an eye) must be reported to EHS immediately to allow for compliance with OSHA reporting time requirements. Near miss incidents (i.e., incidents that did not result in injury, illness, or damage, but had the potential to do so given a slight shift in circumstances) should also be documented and reported to EHS for review.
- Contacts **Facilities Operations** or EHS when safety showers, eyewash stations, fume hoods, or other safety-related equipment are not working properly.
- Provides oversight of laboratory operations to ensure compliance with the University Chemical Hygiene Plan, **Laboratory Chemical Inventory Program**, **Laboratory Inspection Program**, and **Chemical Waste Disposal Manual**.

- May designate an individual working in their lab(s) to collaborate with the PI to enact laboratory-specific safety policies and procedures. Designation of such an individual does not absolve the PI of the responsibilities listed in this section. The PI is ultimately responsible for ensuring health and safety in the lab(s).

E. Laboratory Manager

- Oversees a shared laboratory/equipment space.
- Follows the guidelines of the Chemical Hygiene Plan and ensures compliance with all EHS policies and programs applicable to the lab(s) they oversee.
- Ensures all individuals assigned to the laboratory, including the Laboratory Manager, complete either Initial Lab Safety and Chemical Waste Management or refresher training annually through HuskySMS.
- Maintains an accurate chemical inventory for each laboratory.
- Informs laboratory users of the actual and potential hazards of chemicals, equipment, and operations of the laboratory.
- Provides appropriate personal protective equipment to personnel in their lab(s) for the health hazards, physical hazards, and equipment identified in the **Workplace Hazard Assessment**.
- Ensures wastes are properly collected, labeled, stored, and managed.
- Minimizes or eliminates actual or potential hazards that could lead to accidents, injuries, or property damage.
- Reports all lab-related accidents to UCFD (911) and injuries to **Human Resources.** Serious injuries (i.e., death, in-patient hospitalization, amputation, or loss of an eye) must be reported to EHS immediately to allow for compliance with OSHA reporting time requirements. Near miss incidents (i.e., incidents that did not result in injury, illness, or damage but had the potential to do so given a slight shift in circumstances) should also be documented and reported to EHS for review.
- Ensures that the lab(s) remains clean, orderly, and in a sanitary condition.
- Manages safe operation of laboratory equipment through proper installation, inspection, maintenance, and repair.
- Ensures authorized lab personnel are properly trained for use of laboratory equipment.
- Contacts **Facilities Operations** or EHS when safety showers, eyewash stations, fume hoods, or other safety-related equipment are not working properly.

F. Lab Worker

- Reviews and follows policies, procedures, and work practices outlined in the Chemical Hygiene Plan and lab-specific procedures.
- Attends Initial Lab Safety and Chemical Waste Management training prior to working in a lab.
- Stays current with Lab Safety and Chemical Waste Management training by attending in-person or online refresher training annually.
- Uses engineering, administrative, and work practice controls to minimize exposure to hazards present in the lab.
- Wears appropriate personal protective equipment as specified in the **Workplace Hazard Assessment Form**, Safety Data Sheets (SDSs), or other applicable documentation.
- Receives approval from the principal investigator or laboratory manager prior to conducting research involving hazardous chemicals.
- Notifies and consults with the principal investigator or laboratory manager prior to making changes to existing, reviewed procedures.
- Properly collects, handles, labels, stores, and manages hazardous chemicals and wastes.
- Ensures that lab(s) remain clean, orderly, and in a sanitary condition.
- Reports unsafe conditions and near misses to the principal investigator or laboratory manager and EHS.
- Adheres to all University, Departmental, and laboratory-specific safety policies, procedures, and directives.

G. Chemical Hygiene Committee

- Reviews and provides input for the Chemical Hygiene Plan and standard operating procedures for the use of hazardous chemicals.
- Reviews and provides input into the **Laboratory Chemical Inventory Program**.
- Reviews reports of chemical spills and other emergency laboratory situations and provides input on any mechanisms to improve safety and emergency response.
- Reviews and provides input regarding the content and scheduling of training programs for laboratory personnel.

H. Environmental Health and Safety

- Reviews, edits, and evaluates the Chemical Hygiene Plan annually and as needed.

- Establishes chemical hygiene policies and procedures to protect lab personnel and the environment.
- Conducts Laboratory Safety and Chemical Waste Management training.
- Provides technical guidance and consultation to the University community regarding work practices, procedures, controls, and personal protective equipment to ensure safe use of hazardous materials in labs.
- Performs fume hood evaluations.
- Inspects laboratories as outlined in the **Laboratory Inspection Program**.
- Conducts and maintains chemical inventories of laboratories as outlined in the **Laboratory Chemical Inventory Program**.
- Provides services and consultation related to **hazardous waste management** and disposal.
- Investigates accidents involving hazardous chemicals.
- Conducts exposure monitoring, as necessary.

I. Minors

- Individuals under 18 years old are not allowed in laboratories that contain health or physical hazards unless they are University of Connecticut students or registered participants in a University-sanctioned project or program.
- Individuals under 18 years old must always be supervised by lab personnel while working in laboratories.
- Activities involving minors, who are not enrolled or accepted for enrollment in credit-granting courses at the University or who are not employees of the University, must be sponsored by a unit within the University, be registered with the University's Minor Protection Coordinator, and meet University standards described in the **Policy for the Protection of Minors and Reporting of Child Abuse and Neglect**. For more information, please visit the **Minor Protection** website.

VI. Training and Information

The OSHA Laboratory Standard requires that training be provided to all employees working in laboratories at the time of initial assignment to a work area where hazardous chemicals are present and prior to assignments involving new exposure situations. The CHP applies this standard to all individuals working in laboratories at UConn, except for undergraduate students attending class in non-research laboratories (See note below). It is the responsibility of all lab personnel to attend and stay current with Laboratory Safety and Chemical Waste Management Training provided by EHS and any job-specific training provided by departments, principal investigators, laboratory managers, or other qualified individuals.

Note: Undergraduate students enrolled in laboratory courses in teaching labs receive training through their instructor which is documented through the Student Administration System.

A. Initial Safety Training

All individuals working in labs, including principal investigators, laboratory managers, lab workers, and other personnel must attend the Initial Laboratory Safety and Chemical Waste Management Training provided by EHS prior to working in laboratories. The initial training is offered in both in-person and online formats and covers:

- The contents and location of the OSHA Laboratory Standard;
- The location and details of the Chemical Hygiene Plan;
- The permissible exposure limits for OSHA regulated substances or recommended exposure limits;
- Signs and symptoms associated with exposures to hazardous chemicals;
- The location and availability of known reference material on the hazards, safe handling, storage, and disposal of hazardous chemicals;
- Methods and observations that may be used to detect the presence or release of a hazardous chemical;
- The physical and health hazards of chemicals in the work area; and
- Appropriate work practices, emergency procedures, and personal protective equipment to be used to protect individuals from hazards in laboratories.

B. Annual Refresher Training

Refresher training provided by EHS must be completed every year by principal investigators, laboratory managers, lab workers, and other individuals working in labs. The training is required to ensure that all individuals working in labs are up to date with current federal and state regulations and University policies regarding safety. The refresher training course is offered through EHS in both in-person and online formats.

C. Laboratory-Specific Training

In addition to training provided by EHS, laboratory-specific training must be provided by departments, principal investigators, or laboratory managers on the specific hazards of chemicals, equipment, or operations unique to each laboratory. Examples of laboratory-specific training include, but are not limited to:

- Use of cryogenic liquids;
- Safety protocols for use of equipment that present health and/or physical hazards to lab personnel (e.g., impact, cuts/penetration, harmful dusts/vapors, noise, etc.);
- Procedures using **highly reactive** or explosive chemicals (e.g., aqua regia, piranha solutions, pyrophoric, water-reactive, etc.); and
- Emergency procedures.

Laboratory-specific training must take place prior to involvement with the chemical, equipment, or operation. **Documentation** of the training, including the content, training date, and signatures of both the trainee and trainer, is recommended.

VII. Emergency and First Aid Procedures

Emergencies are incidents that pose an actual or potential threat to people and/or the environment. They include events such as, but not limited to, equipment failure, explosions, fires, spills, rupture of containers, or failure of control equipment that results in an uncontrolled release into the laboratory. The UConn Fire Department (UCFD) is the first responder at the Storrs and Depot campuses and must be contacted immediately after an emergency occurs. Lab personnel working at regional campuses must contact local fire departments (i.e., 911 or 8-911 [Avery Point Campus Landline]). No individual working in a laboratory is allowed to use a fire extinguisher without appropriate training. All emergencies must be reported to the principal investigator or laboratory manager and EHS. The following procedure must be followed if an emergency occurs:

Emergency Procedure	
1.	**RELOCATE** everyone in the immediate work area to a safe location.
2.	**ALERT**- Dial 911. Follow the directions of the dispatcher. The person that dials 911 must meet UCFD upon arrival to provide further information about the emergency.
3.	**CONFINE**- If it can be done safely, close doors to confine the area where the emergency occurred and post an "**Emergency Hangtag**" on the door(s) to prevent reentry by other personnel.
4.	**EVACUATE** the building through the nearest exit. Do not run. Do not use elevators.
5.	**REPORT** to your designated meeting site.
6.	**REENTER** once emergency personnel have cleared the area.

Note: Additional emergency response procedures for non-chemical threats (e.g., power outages, bomb threats, suspicious packages, shelter-in-place, etc.) are available for review in the **Emergency Hazard Guide** provided by the **Office of Emergency Management**.

A. Chemical Spills

Chemical spills refer to the release of chemicals, wastes, oils, or other potentially dangerous materials into the air, water, or workplace. Spills may include incidents where a person is impaired, injured, or contaminated. Chemical spills must not be cleaned up without the assistance of trained emergency responders (i.e., UCFD, the local Fire Department, or other emergency response vendor). Emergency responders will assess the risk from a spill and consider the:

- Risk of fire/explosion,
- Potential overexposure to airborne contaminants,
- Onset of dangerous reactions,
- Contact hazards with corrosive and/or toxic chemicals, and
- Threat to the environment.

Lab personnel involved in hazardous chemical spills must follow the **emergency procedure** outlined above.

B. Incidental Releases

Incidental releases are small spills that can be safely dealt with by laboratory personnel. Incidental releases must present little to no risk of exposure to individuals or the environment and can be safely controlled at the time of release. If an incidental release occurs in a laboratory, the following steps must be followed:

Procedure for Incidental Releases	
1.	Evacuate everyone in the lab and post an "**Emergency Hangtag**" on the door(s) to prevent reentry by other lab personnel.
2.	Contact the PI or Laboratory Manager prior to cleaning up any small spill. Dial 911 if the PI/Laboratory Manager is not available and follow the **emergency procedure**.
3.	Ensure the risk of exposure is minimal with the PI/Laboratory Manager. If a danger or risk of exposure exists, follow the **emergency procedure**.
4.	Avoid contact with contaminated areas. If the spill is in a non-ventilated area, relocate, dial 911, and follow the **emergency procedure**.
5.	If safe, turn off ignition sources and compressed gases. If not, evacuate the lab, call 911, and follow the **emergency procedure**.
6.	Put on appropriate personal protective equipment indicated in the safety data sheet. Work with another person to clean up the spill. Do not clean up a spill alone.
7.	Use the appropriate spill kit to control the source and confine the spill to a small area.
8.	Place spill debris in an appropriate container, tightly seal or close container, and properly label the waste.
9.	Place the waste in the **satellite accumulation area** and contact EHS for a waste pickup.

10.	Report the spill to EHS.
11.	Restock supplies used to clean up the spill.

C. Safety Showers and Eyewash Stations

Properly functioning eyewash stations and safety showers are required to be present for immediate emergency use within 10 seconds walking time of labs where corrosive materials are used or stored. The water temperature in both eyewash stations and safety showers must range between 60°F (16°C) and 100°F (38°C). Eyewashes and safety showers must be located on the same level as the hazard and the path of travel must be free of obstructions. The ANSI standard Z358.1 should be used as a guideline for the proper design, certification, performance, installation, use, and maintenance of eyewash stations and safety showers. Drench hose units may supplement but may not be used in place of eyewashes and safety showers.

Lab personnel are responsible for identifying locations of eyewash stations, safety showers, and other emergency equipment prior to research. Lab personnel are required to test eyewash stations weekly to ensure proper function. Safety showers are inspected annually by a contracted vendor through Facilities Operations. If a safety shower has not been tested within the last year or an eyewash station or shower is not working properly, principal investigators, laboratory managers, or other supervisory personnel must initiate a work order with Facilities Operations to assess and/or repair the equipment.

D. First Aid Procedures

Lab personnel are responsible for identifying locations of eyewash stations, safety showers, first aid kits, fire alarms, and other emergency equipment prior to research. The following procedure must be followed when an emergency results in exposure to the eyes with a hazardous chemical.

First Aid Procedure - Eye Exposure to a Hazardous Chemical	
1.	Forcibly hold both eyes open under an emergency eyewash to ensure an effective wash behind both eyelids.

2.	If contact lenses are being worn, remove the contacts while flushing.
3.	Dial 911 or have someone else from the lab dial 911.
4.	Continue flushing the eyes underneath the eyewash until emergency personnel arrive.
5.	Report the injury to your principal investigator and/or laboratory manager and EHS.

The following procedure must be followed when an emergency results in exposure to the eyes with a nonhazardous solid.

First Aid Procedure - Eye Exposure to Nonhazardous Solid	
1.	If eyes are exposed to glass, metal, wood, or other types of particulates, do not flush eyes under an emergency eyewash.
2	Close or cover the eye(s), dial 911, and have emergency personnel evaluate the eye(s) prior to flushing.
3.	Report the injury to your principal investigator and/or laboratory manager and EHS.

The following procedure must be followed when an emergency results in chemical exposure to the skin.

First Aid Procedure - Skin Exposure to a Hazardous Chemical	
1.	Wash affected area(s) with tepid water from an emergency safety shower, if indicated in the safety data sheet. Take care not to break skin.
2.	Remove or cut off contaminated clothing while rinsing. Do not pull contaminated clothing over the head.
3.	Dial 911 or have someone else from the lab dial 911.
4.	Keep flushing affected area(s) with water from the safety shower until emergency personnel arrive.
5.	Report the injury to your principal investigator and/or laboratory manager and EHS.

The following procedure must be followed when an emergency results in an exposure through inhalation of chemical vapors, fumes, or smoke.

First Aid Procedure - Inhalation of Chemical Vapors, Fumes, or Smoke	
1.	If an exposed individual is unconscious or if there is a possibility of oxygen depletion, toxic vapors, or an explosive atmosphere, do NOT enter the lab. Dial 911.
2.	If the exposed individual is conscious, move the person to fresh, uncontaminated air. Dial 911.
3.	Report the injury to your principal investigator and/or laboratory manager and EHS.

The following procedure must be followed when an emergency results in ingestion of a hazardous chemical.

First Aid Procedure - Chemical Ingestion	
1.	If safe to do so, move the affected individual to an uncontaminated area.
2.	Dial 911 or have someone else from the lab dial 911.
3.	Do not induce vomiting or drink water or other liquids unless instructed to do so by emergency personnel.
4.	Report the injury to your principal investigator and/or laboratory manager and EHS.

The following procedure must be followed when an emergency results in exposure to a cryogenic liquid.

First Aid Procedure - Exposure to Cryogenic Liquids	
1.	If a person’s skin contacts a cryogen, place the affected area in a warm water bath (not above 40°C/104°F). Never use hot or cold water or dry heat. Thawing of the affected area(s) must be done gradually.

2.	If a burn from a cryogen occurs, do not rub the burned area. Rubbing can result in further tissue damage.
3.	Dial 911 and seek medical attention as soon as possible for all cryogenic injuries.
4.	Report the injury to your principal investigator and/or laboratory manager and EHS.

VIII. Safety Documentation

Safety documentation is required in each laboratory to assure compliance with regulations and University policies. Principal investigators or laboratory managers are required to update forms and documentation as changes to laboratory personnel, chemicals, or personal protective equipment occur. The following safety documentation must be present in all laboratories:

A. Chemical Hygiene Plan

Every laboratory is required to have an up-to-date copy of the Chemical Hygiene Plan (CHP) in the lab. Access to hard or electronic copies of the document is acceptable. Electronic copies must be kept on a computer that is readily accessible to all researchers. Each individual working in the lab is required to complete a **CHP Signature Confirmation**, confirming adherence to the CHP. In addition to the University CHP, departments, principal investigators, and/or laboratory managers can develop laboratory-specific safety manuals to inform lab personnel of the hazards and procedures specific to the department or laboratory.

B. Chemical Inventory

1. Lab-Specific Inventory

Every chemical, including compressed gas cylinders, brought into a laboratory must be added to a chemical inventory. The principal investigator and/or laboratory manager is responsible for maintaining an accurate chemical inventory. At a minimum, the chemical inventory must contain:

- Name of the chemical;

- Location of the chemical in the lab (e.g., flammable storage cabinet); and
- Approximate amount of the chemical (i.e., the size of the container).

Chemicals relocated or removed from the lab (e.g., empty, expired, off-specification, waste, etc.) must be deleted from the inventory to ensure accuracy. The chemical inventory can be printed out and stored in the laboratory or maintained on a computer that is accessible to all lab personnel.

2. Laboratory Chemical Inventory Program

The goal of the **Laboratory Chemical Inventory Program** is to create and maintain an accurate, campus-wide inventory of laboratory chemicals at the Storrs and Depot campuses. This program excludes the Chemistry Building at Storrs, which maintains its own **chemical inventory program**. EHS uses the systems for federal reporting by tracking laboratory chemicals from the point of delivery to final disposal. Lab personnel must follow the steps for ordering chemicals outlined in each program to ensure chemicals are barcoded by Central Warehouse or the Chemistry Department prior to use. Lab personnel at the Storrs and Depot campuses are required to:

- Follow the steps for ordering chemicals through HuskyBuy or Procurement Cards to ensure barcodes are generated to inventory incoming chemicals;
- Verify that chemicals are delivered to the correct location(s);
- Contact EHS or the Chemistry Department if barcoded materials are relocated to another location; and
- Dispose of barcodes from their online chemical inventories when original containers are empty or are submitted to EHS as wastes for disposal.

Additional responsibilities and procedures, with the exception of those working in the Chemistry Building, are outlined in the **Laboratory Chemical Inventory Program.** Lab personnel working at the Storrs and Depot campuses are responsible for compliance with this program.

C. Safety Data Sheets (SDSs)

Safety data sheets (SDSs) are printed or electronic documents that provide health and safety-related information on chemicals. Manufacturers or importers of chemicals are required to obtain or develop an SDS for each hazardous chemical they produce or import. Principal investigators or laboratory managers are responsible for ensuring that

SDSs are available for every chemical in the laboratory and readily accessible to lab personnel. Either printed or electronic copies of safety data sheets are acceptable. If safety data sheets are stored on a computer, they must be on a computer that is accessible to everyone in the lab. The format of SDSs, including section numbers, headings, and descriptions are in the table below:

Safety Data Sheet Format		
Section	**Section Heading**	**Description**
1.	Identification	Product identifier; manufacturer or distributor name, address, phone number; emergency phone number; recommended use; restrictions on use
2.	Hazard(s) identification	All hazards regarding the chemical; required label elements
3.	Composition/ information on ingredients	Information on chemical ingredients; trade secret claims
4.	First-aid measures	Important symptoms/effects, acute, delayed; required treatment
5.	Fire-fighting measures	Suitable extinguishing techniques, equipment; chemical hazards from fire
6.	Accidental release measures	Emergency procedures; protective equipment; proper methods of containment and cleanup
7.	Handling and storage	Lists precautions for safe handling and storage, including incompatibilities

8.	Exposure controls/personal protection	Includes OSHA's Permissible Exposure Limits (PELs); Threshold Limit Values (TLVs); appropriate engineering controls; personal protective equipment (PPE)
9.	Physical and chemical properties	Lists the chemical's characteristics
10.	Stability and reactivity	Chemical stability and possibility of hazardous reactions
11.	Toxicological information	Routes of exposure; related symptoms, acute and chronic effects; numerical measures of toxicity
12.	Ecological information	Non-mandatory—Information on the environmental impact of the chemical
13.	Disposal considerations	Non-mandatory—Guidance on proper disposal practices, recycling, or reclamation
14.	Transport information	Non-mandatory—Guidance on classification for shipping and transportation
15.	Regulatory information	Non-mandatory—Identifies any safety, health and environmental regulations not covered elsewhere in the SDS
16.	Other information	Includes the date of preparation or last revision

Lab personnel are responsible for understanding the contents of safety data sheets to ensure proper chemical handling, storage, and disposal. Safety data sheets can be obtained through the website located on the UConn Laboratory Safety Information Card, the EHS website, manufacturer's websites, or other reliable sources.

D. Workplace Hazard Assessment Form

Every lab is required to complete a **Workplace Hazard Assessment Form** (WHA). The WHA form was designed to help UConn supervisory personnel choose appropriate personal protective equipment (PPE) for their workers. A copy of the WHA form must be sent to EHS, and another copy must be present in the lab. The form is required to be updated whenever operations in the lab change or warrant the use of new personal protective equipment. Both **instructions** for completing the form and the **form** itself can be reviewed and completed on the EHS website.

E. Safety Information Cards

Every laboratory is required to complete and post the **UConn Emergency Information Card** on the exterior door of the lab. Emergency personnel use the card to contact the principal investigator and/or laboratory manager if an accident occurs in the lab. The card must be updated whenever changes to lab personnel occur. A copy of the card is located below:

UCONN EMERGENCY INFORMATION CARD	
Principal Investigator/Laboratory Manager	**Lab Number**
Name: ____________________	____________
24 Hour Phone Number: ____________________	
KEY PERSONNEL	**Phone**
Names: ____________________	____________
____________________	____________
EMERGENCY NUMBER	**Phone**
Ambulance/Fire /Police /Spills	911
Environmental Health and Safety | 860-486-3613 | ehs@uconn.edu	

Every laboratory is also required to complete and post a **Laboratory Safety Information Card** on the interior door of the lab. This card is used to identify the location(s) of safety-related documentation (e.g., chemical inventory, safety data sheets, workplace hazard assessment, etc.) required in each lab. A copy of the card is located below:

LABORATORY SAFETY INFORMATION CARD
Principal Investigator/Laboratory Manager Name: ______________________________
The Chemical Hygiene Plan location:
https://media.ehs.uconn.edu/Chemical/ChemicalHygienePlan.pdf or______________
Safety Data Sheets location: ______________________________
Chemical Inventory location: ______________________________
Workplace Hazard Assessment location: ______________________
Environmental Health and Safety | 860-486-3613 | ehs@uconn.edu

IX. Chemical Management

The OSHA Laboratory Standard applies to chemicals that exhibit health and physical hazards. Each type of hazardous chemical has been assigned a hazard class(es), pictogram(s) and hazard category(s) by manufacturers or importers based on scientifically validated methods, tests, and evidence. The health and/or physical hazard classes for each chemical are listed in the safety data sheet. Lab personnel are responsible for recognition and control of chemicals that pose health and physical hazards in their research.

Pictograms are required on original container labels and safety data sheets to alert users of the chemical hazards to which they may be exposed. Each pictogram represents a distinct hazard(s) identified by a symbol on a white background framed within a red border. The pictogram(s) is determined by chemical manufacturers and importers. Chemicals can have one or multiple pictograms.

The hazard category refers to the division of criteria within each hazard class (e.g., Flammable Liquids are divided into four hazard categories numbered from Category 1-4).

These categories compare hazard severity within a specific hazard class (e.g., a Category 1 flammable liquid is considered a more severe hazard than a Category 4 based on lower flashpoints and boiling points). Most categories are classified based on a number (e.g., 1, 2, 3, etc.) and in some cases, a subcategory letter (e.g., 1A, 1B, 1C, etc.). Categories are ranked in severity by descending order (i.e., Category 1 or 1A is considered a more severe than Category 2 or 1B). Lab personnel must be familiar with the hazard category for each chemical in use to accurately assess the risks involved.

A. Health Hazard Classes

The definitions, pictograms, and categories of each type of health hazard defined by OSHA are listed below:

Health Hazards		
Health Hazard Class Definition	**Pictogram(s)**	**Categories**
Acute toxicity refers to those adverse effects occurring following oral or dermal administration of a single dose of a substance, multiple doses given within 24 hours, or an inhalation exposure of 4 hours.	 	1,2,3,4
Aspiration means the entry of a liquid or solid chemical directly through the oral or nasal cavity, or indirectly from vomiting, into the trachea and lower respiratory system.		1
Carcinogen means a substance or a mixture of substances that induce cancer or increase its incidence.		1A,1B,2
Eye irritation is the production of changes in the eye following the application of test substance to the anterior surface of the eye that are fully reversible within 21 days of application.		2A

Mutation is defined as a permanent change in the amount or structure of the genetic material in a cell.		1A,1B,2
Reproductive toxicity includes adverse effects on sexual function and fertility in adult males and/or females, as well as adverse effects on development of the offspring.		1A,1B,2
Respiratory sensitizer means a chemical that will lead to hypersensitivity of the airways following inhalation of the chemical.		1A,1B
Serious eye damage is the production of tissue damage in the eye, or serious physical decay of vision, following application of a test substance to the anterior surface of the eye, which is not fully reversible within 21 days of application.		1
Skin corrosion is the production of irreversible damage to the skin; namely, visible necrosis through the epidermis and into the dermis, following the application of a test substance for up to 4 hours.		1A,1B,1C
Skin irritation is the production of reversible damage to the skin following the application of a test substance for up to 4 hours.		2
Skin sensitizer means a chemical that will lead to an allergic response following skin contact.		1A,1B
Specific target organ toxicity- single exposure (STOT-SE) means specific, nonlethal target organ toxicity arising from a single exposure to a chemical.		1,2,3

Specific target organ toxicity- repeated exposure (STOT-RE) means specific target organ toxicity arising from repeated exposure to a substance or mixture.		1,2

*Table derived from OSHA 1910.1200 App A.

B. Physical Hazard Classes

The definitions, pictograms, and categories of each type of physical hazard defined by OSHA are listed below:

Physical Hazards		
Physical Hazard Class Definition	**Pictogram(s)**	**Categories**
Chemicals that, in contact with water, emit flammable gases are solid or liquid chemicals that, by interaction with water, are liable to become spontaneously flammable or to give off flammable gases in dangerous quantities.		1,2,3
A chemical that is **corrosive to metals** means a chemical which by chemical action will materially damage, or even destroy, metals.		1
Explosives are solid or liquid chemicals that are capable of self-reaction to produce gas at such a temperature, pressure, and speed as to cause damage to the surroundings.		1.1, 1.2, 1.3, 1.4, 1.5, 1.6
Flammable gas means a gas having a flammable range with air at 20°C (68°F) and a standard pressure of 101.3 kPa (14.7 psi).		1,2
Flammable liquid means a liquid having a flash point of not more than 93°C (199.4°F).		1, 2, 3, 4

Flammable solid means a solid that is a readily combustible solid, or that may cause or contribute to fire through friction.		1,2
Gases under pressure are gases that are contained in a receptacle at a pressure of 200 kPa (29 psi) (gauge) or more, or that are liquefied or liquefied and refrigerated.		Compressed gases, liquefied gases, dissolved gases, refrigerated liquefied gases
Organic peroxide means a liquid or solid organic chemical that contains the bivalent -O-O- structure and as such is considered a derivative of hydrogen peroxide, where one or both hydrogen atoms have been replaced by organic radicals.	 	A, B, C, D, E, F, G
Oxidizing liquid means a liquid that, while in itself is not necessarily combustible, may cause or contribute to the combustion of other material, generally by yielding oxygen.		1,2,3
Oxidizing solid means a solid that, while in itself is not necessarily combustible, may cause or contribute to the combustion of other material, generally by yielding oxygen.		1,2,3
Pyrophoric liquid means a liquid that, even in small quantities, is liable to ignite within five minutes after coming into contact with air.		1
Pyrophoric solid means a solid that, even in small quantities, is liable to ignite within five minutes after coming into contact with air.		1

Self-reactive chemicals are thermally unstable liquid or solid chemicals liable to undergo a strongly exothermic decomposition even without participation of oxygen (air).		A, B, C, D, E, F, G
Self-heating chemicals are a solid or liquid chemicals, other than a pyrophoric liquid or solid, which, by reaction with air and without energy supply, is liable to self-heat; this chemical differs from a pyrophoric liquid or solid in that it will ignite only when in large amounts (kilograms) and after long periods of time (hours or days).		1,2

* Table derived from OSHA 1910.1200 App B.

C. Chemical Labeling

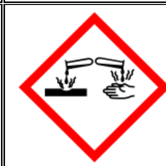
All chemicals and samples used or created in laboratories must be properly labeled. All new chemicals brought into labs must be labeled with a product identifier, signal word, hazard statement(s), precautionary statement(s), pictogram(s), and the name, address, and telephone number of the chemical manufacturer, importer, or other responsible party. Existing chemicals present in labs prior to December 2015, must be labeled with, at a minimum, a chemical name.

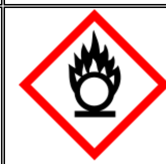
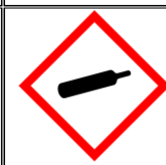
1. Original Containers

Original chemical bottles must have labels that are written in English (other languages may also be included, if necessary), legible, and prominently displayed on the container. Lab personnel are responsible for ensuring that labels on incoming containers of hazardous chemicals are not removed or defaced. Existing chemical labels that have become illegible must be relabeled to identify contents.

2. Secondary Containers

Secondary containers (e.g., beakers, flasks, jars, spray bottles, etc.) holding chemicals or samples must be properly labeled with the chemical name(s) and hazard class(es). The full name(s) of the hazard class(es) (e.g., flammable, corrosive, reproductive toxicant, etc.) can be written out on the secondary container or the corresponding OSHA GHS pictogram can be affixed to the container. A list of approved OSHA GHS pictograms for both health and physical hazards is outlined below:

Health Hazards		
Hazard Symbol	**Pictogram**	**Examples**
Exclamation Mark		Irritant (eye and skin) Skin sensitizer Acute toxicity (harmful) Narcotic effects Respiratory tract irritant Hazardous to ozone layer (non-mandatory)
Corrosion		Skin corrosion/burns Eye damage Corrosive to metals
Skull and Crossbones		Acute toxicity (Fatal or toxic)
Health Hazard (Silhouette of a person with a starburst on the chest)		Carcinogen Mutagenicity Reproductive toxicity Respiratory sensitizer Target organ toxicity Aspiration toxicity
Physical Hazards		
Hazard Symbol	**Pictogram**	**Examples**

Exploding Bomb		Explosive Self-reactive Organic peroxide
Flame		Flammable Pyrophoric Self-heating Emits flammable gas Self-reactive Organic peroxide
Flame Over Circle		Oxidizer
Gas Cylinder		Gases under pressure

D. Chemical Segregation and Storage

Chemicals must be stored according to compatibility and hazard class. Incompatible chemicals stored in the same storage device can react with other chemicals and degrade labels, containers, and cabinets. Lab personnel are required to review safety data sheets (SDSs) to obtain proper storage, stability, and compatibility guidelines. Incompatible chemicals must not be stored alphabetically or in proximity to one another. At a minimum, chemicals must be segregated into the following hazard classes:

Chemical Segregation and Storage			
Hazard Class	**Storage**	**Examples**	**Incompatibles**
Corrosive Acids-Inorganic	Store in corrosives cabinet, or on protected shelving and in secondary containment. Secondary containment must be used when	Hydrochloric acid, Sulfuric acid, Phosphoric acid, *Nitric acid	Flammable liquids, flammable solids, bases, oxidizers, organic acids,

	storing acids on bare metal. *Oxidizing acids must be stored in a separate, compatible secondary containment bin.		cyanides, sulfides
Corrosive Acids-Organic	Store in corrosives cabinet, or on protected shelving and in secondary containment Secondary containment must be used when storing acids on bare metal. *If stored together, organic acids must be separated from flammable chemicals using a secondary containment bin.	Acetic acid, Trichloroacetic acid, Formic acid	Flammables, bases and oxidizers, inorganic acids, cyanides, sulfides
Corrosive Bases-Inorganic	Store in a corrosives cabinet, or on protected shelving away from acids.	Ammonium hydroxide, Potassium hydroxide, Sodium hydroxide	Flammable liquids, acids, oxidizers, organic bases
Corrosive Bases-Organic	Store in a corrosive cabinet and separate from acids and inorganic bases.	Hydroxylamine, Tetramethylethylene diamine, Triethylamine	Oxidizers, hypochlorites, inorganic bases
Explosives	Store in a secure location away from other chemicals, store in areas away from shock or friction.	Trinitrophenol, Picric acid, Diazoisobutylnitrile	Consult SDS and/or EHS
	Store on lab benches or shelves with other stock chemicals.	Sodium chloride, Potassium phosphate, agar	Consult SDS and/or EHS

General Stock Chemicals			
Flammable Liquids	Store in an approved flammable storage cabinet or flammable explosion-proof refrigerator. *Peroxide-forming chemicals must be dated upon delivery and after opening.	Ethanol, Methanol, Acetone, Xylene, Toluene, Diethyl ether, *Tetrahydrofuran	Oxidizers, reactives, acids, bases
Flammable Solids	Store in cool, dry area away from oxidizers and corrosives.	Carbon, Charcoal, Paraformaldehyde	Acids, bases, oxidizers
Oxidizers	Store in secondary containment with non-combustibles or inorganic materials.	Perchlorates, Permanganates, Nitrates	Flammables, combustibles, organic materials
Pyrophoric Liquids and Solids	Store in a flammable storage cabinet, flammable rated refrigerator/freezer, glovebox, or desiccator. Consult the SDS for the most appropriate storage location.	Grignard reagents, Metal alkyls and aryls (e.g., tert-butyllithium), Metal carbonyls (e.g., lithium carbonyl), Finely divided metal powders (e.g., cobalt, iron, zinc, lithium)	Avoid areas with combustible materials, heat/flames, oxidizers, and water sources.
Toxics	Store in a ventilated, dry, cool area, as recommended by the manufacturer.	Cyanides, Heavy metal compounds (e.g., cadmium, mercury)	Flammable liquids, acids, bases, reactives, oxidizers. Consult EHS for assistance.

Water-Reactive	Store in a cool, dry location. Protect from sources of water. Label area for water-reactive storage.	Sodium, Lithium, Potassium metals, Sodium borohydride	Aqueous solutions, oxidizers, water sources Consult SDS for specific information.

*Safety data sheets must be consulted for specific manufacturer storage and compatibility guidelines.

Each hazard class should be stored in a separate cabinet or location in the lab. If separate cabinets are not available, chemicals of different hazard classes, in limited cases, can be segregated by placing them on separate shelves in separate secondary containment bins within the same cabinet.

The following chemical storage requirements must be followed in laboratories:

- Flammable chemicals should be stored in an approved flammable storage cabinet or refrigerator.
- No more than 10 gallons of flammable liquids can be stored outside of a rated flammable storage cabinet.
- Tightly seal containers to minimize the vapor release.
- Corrosive liquids must be stored below eye level (i.e., approximately 5 feet or below).
- Limited quantities of hazardous chemicals should be stored on benches, floors, or in fume hoods.
- If storage of hazardous chemicals on floors must occur, secondary containment is required.
- Secondary containment bins are recommended to retain materials if the primary container breaks or leaks.
- Acutely toxic chemicals must be stored in dedicated cabinets.
- Chemical shelving must be firmly secured to walls.
- Chemicals must not be stored on top of cabinets.
- Chemicals must be stored away from heat and direct sunlight.
- Off-specification, expired, and other chemicals with no useful purpose in the lab should be disposed of through EHS.

E. Chemical Transport

Chemicals will be delivered directly to laboratories or central delivery areas. When chemicals must be transported to other locations within or outside of the building, individuals must ensure that the following measures are taken during transport.

- Prior to moving large quantities of hazardous chemicals (e.g., relocating to another building), contact EHS to ensure compliance with federal, state, and local laws.
- Contact EHS prior to transporting unstable or explosive chemicals.
- Secondary containment must be used during transport.
- The secondary containment must be large enough to contain the contents of the bottle(s) being transported in the event of breakage.
- Secondary containers must be leak and break resistant.
- Ensure chemicals are tightly sealed prior to transport.
- Chemicals must not be left unattended during transport.
- Sturdy carts with secondary containment must be used for transporting multiple, heavy, or large containers.
- Avoid transporting chemicals on stairs. Use elevators (preferably a freight elevator) when moving chemicals between floors.
- Wear appropriate personal protective equipment (PPE).
- Avoid high-traffic areas.

Note: **EHS** must be contacted when chemicals are relocated from their original assigned location to another location within or outside of the building to maintain compliance with the **Laboratory Chemical Inventory Program**.

X. Standard Operating Procedures

All individuals working in UConn laboratories must follow the standard lab procedures listed in the CHP. Additional lab-specific policies or work practices required by the PI or Laboratory Manager must also be followed by lab personnel. Lab-specific policies and practices must be at least as stringent as the guidelines in the CHP.

A. General Requirements

- Avoid working alone in laboratories. Review the **Working Alone Policy** to understand responsibilities and disciplinary actions for violation of the policy.

- Do not allow unauthorized individuals in laboratories. Access is limited to University lab personnel and visitors with legitimate reasons for being in such a laboratory.
- Do not allow pets in laboratories, with limited exceptions for police dogs and service animals (e.g., guide dogs) as permitted by the **Animals on Campus** policy. The only live vertebrate animals allowed in laboratories are those approved by the **Institutional Animal Care and Use Committee (IACUC)** for use in teaching and research.
- Review the safety data sheet(s) for all applicable chemicals prior to use.
- Substitute a hazardous chemical with a safer alternative or reduce the quantities of hazardous chemicals being used whenever possible.
- Review the CHP and laboratory-specific standard operating procedures.
- Identify the locations and understand how to use emergency equipment.
- Do not use fire extinguishers without annual training provided through UCFD.
- Learn and follow emergency procedures, including evacuation routes.
- Wear personal protective equipment (PPE) as specified in the Workplace Hazard Assessment Form, safety data sheets, or equipment specifications.
- Wear, at a minimum, ANSI Z87.1-certified eyewear, clothing that covers the legs, and closed-toed footwear in active lab areas. Corrective eyeglasses must be used in conjunction with ANSI Z87.1-certified eyewear unless the eyeglasses are ANSI Z87.1 certified and have been approved for use by the PI/Laboratory Manager.
- Inspect equipment and personal protective equipment (PPE) for damage prior to use. Replace or repair damaged equipment or PPE.
- Use a properly functioning chemical fume hood or other local ventilation when working with hazardous chemicals.
- Label all secondary containers (e.g., a beaker, flask, vial, jar, etc.) containing hazardous chemicals and samples with the chemical name(s) and hazard class(s).
- Use all chemicals and equipment for their intended purpose.
- Keep a stocked first aid kit for emergency use.
- Use trays under equipment to contain spills or the overflow of liquids.
- Report accidents, spills, or other emergencies to the principal investigator or laboratory manager and EHS.

B. Personal Hygiene

- Do not eat, drink, smoke, chew gum, or apply cosmetics in **active lab areas**.
- Do not store food, beverages, tobacco, or cosmetic products in active lab areas.
- Never touch a hazardous chemical without appropriate hand protection.
- Never attempt to smell, inhale, or taste a hazardous chemical.

- Do not reuse disposable gloves.
- Do not use mouth suction to pipet. Use a pipet bulb or similar device.
- Secure loose-fitting jewelry.
- Tie back and secure long hair.
- Wear the specific lab attire documented in the **WHA form**. EHS recommends lab coats for all research involving hazardous chemicals.
- Do not wear lab coats, gloves, and other personal protective equipment outside of active lab areas.
- Wash hands thoroughly with soap and water before and after handling chemicals, and prior to exiting the lab.
- Wash affected areas promptly whenever a chemical comes in contact with the skin.
- Remove and manage contaminated clothing and gloves before leaving the laboratory.
- Launder contaminated clothing and other reusable personal protective equipment through an approved vendor. Never take contaminated clothing home for cleaning.
- Decontaminate materials and equipment prior to reuse.

C. Housekeeping

- Keep fire alarms, fire extinguishers, electrical panels, disconnect switches, first aid kits, safety showers, eyewash stations, and other safety-related equipment unobstructed and appropriately marked.
- Ensure aisles, hallways, and stairs remain clear of chemicals and equipment.
- Keep lab benches, floors, shelving, and equipment clean, orderly, and in a sanitary condition.
- Clear lab benches of additional chemicals, materials, and equipment that are not necessary to perform current research.
- Clean and/or decontaminate lab benches and equipment at the end of each experiment and each workday.
- Keep laboratory doors closed to minimize the spread of chemical vapors, pathogens, or smoke in case of an emergency.
- Store materials, including chemicals, wastes, equipment, cords, and other objects in a manner that does not create a hazard for workers (e.g., a trip hazard).
- Limit the storage of flammable and combustible materials (e.g., rags, paper, cardboard, etc.).
- Order only the amounts of chemicals that will be used in the near future. Excessive chemical storage increases the risk of worker exposures and severe accidents.

- Inspect and maintain lab equipment regularly and/or as specified by the manufacturer. Repair damaged equipment prior to reuse.
- Keep floors clean, dry, and free of obstructions that could pose a slip, trip, or fall hazard.
- Trap or filter vacuum equipment.
- Place chemicals in assigned storage areas at the end of each day.
- Contact emergency personnel to clean up **spills** immediately.
- Ensure belts, pulleys, fans, and other moving parts are appropriately guarded.
- Never allow **space heaters** in laboratories.
- Label and manage **hazardous wastes**.
- Dispose of **sharps** in approved sharps containers provided by EHS.

D. Electrical Safety

1. Electrical Panels

- Identify the locations of electrical panels and disconnect switches so that power can be quickly shut down in the event of an emergency.
- Keep disconnect switches unobstructed.
- Maintain a 3-foot clearance in front of electrical panels to permit safe operation and maintenance.
- Ensure electrical boxes with conductors, receptacles, and switches have covers in place and show no signs of damage.

2. Electrical Cords

- Ensure electrical cords are not frayed, twisted, worn, abraded, corroded, or used with exposed wires or missing ground pins.
- Ensure electrical cords are sized in accordance with the load that the cord will carry and the environment to which they are exposed.
- Use extension cords only on a temporary basis.
- Do not use extension cords as a substitution for fixed receptacle outlets.
- Use multi-tap power strips only with computer or electronic equipment that normally does not draw excessive amperage per the ratings on the unit.
- Never connect extension cords and/or power strips together (i.e., daisy-chaining).

- Do not run electrical cords through doors, walls, partitions, under rugs, or above drop ceilings. They must not be tied in knots, draped overhead, or attached to building structures.
- Ensure all electrical cords are grounded (do not remove ground prongs).
- Never overload electrical circuits.

3. Electrical Equipment

- Keep electrical equipment away from wet or damp locations, unless specifically rated for use under such conditions.
- Ensure live parts are effectively insulated or physically guarded.
- Enclose all power supplies to prevent contact with power circuits.
- Use a ground fault circuit interrupter when using electrical devices in or near wet environments. In some cases, it may be necessary to install ground fault circuit interrupting devices in the circuits being utilized.
- Keep flammable and corrosive materials away from electrical equipment unless the equipment is rated for such environments by the manufacturer.
- Minimize condensation that may enter electrical equipment placed in cold rooms or refrigerators.
- Ensure repairs and maintenance of electrical equipment are conducted by a qualified person as defined in the **UConn Electrical Safety Program**.

E. Research Approval

Laboratory personnel must obtain approval from their principal investigator prior to:

- Performing new or unfamiliar procedures.
- Using highly reactive or toxic chemicals (e.g., pyrophoric chemicals, hydrofluoric acid, etc.).
- Performing highly hazardous procedures (e.g., potential for violent reaction, generation of a toxic gas, etc.).
- **Working alone** in an immediately hazardous environment.

Laboratory personnel must obtain further approval to proceed with existing laboratory procedures from their principal investigator when:

- A change in quantity and/or volume or substitution of the chemicals in the procedure is planned. Principal investigators must determine the quantity/volume for which further approval is required.
- A change in the agreed-upon experimental set-up is planned.
- Signs of a failure in safety design or equipment are observed.
- **Signs or symptoms** of a chemical exposure are observed.
- Unexpected and/or potentially dangerous experimental results occur (e.g., fire, uncontrolled buildup of heat and/or pressure, etc.).

The principal investigator and EHS are available to assist laboratory personnel in reviewing hazards associated with any procedure, equipment, or chemical to be used in the laboratory to ensure that appropriate safety procedures and safeguards are established.

F. Laboratory Inspections

EHS conducts laboratory safety inspections through **HuskySMS**. EHS prioritizes inspections for laboratories using highly reactive, toxic, or potentially explosive substances. The EHS inspection procedure is outlined below:

1. EHS will email the principal investigator or laboratory manager prior to each inspection. The principal investigator or laboratory manager can either schedule a date and time for the inspection or EHS will show up unannounced.

2. EHS will inspect the laboratory.

3. EHS will create an inspection report and send it by email through HuskySMS to the principal investigator or laboratory manager within seven business days.

4. The principal investigator or laboratory manager must immediately address violations that pose an immediate threat to the health and safety of laboratory personnel. EHS will notify the principal investigator or laboratory manager of severe violations separately through email.

5. The principal investigator, laboratory manager, or compliance liaison must address each violation and respond to EHS through HuskySMS within 21 days of

receipt of the inspection report. Laboratory personnel must provide a separate corrective action in HuskySMS for each violation.

6. Laboratories identified with unsafe conditions will be re-inspected by EHS. Re-inspections may be either announced or unannounced. If progress is unsatisfactory, a second inspection report will be sent to the principal investigator/laboratory manager and the department head.

In addition to EHS inspections, laboratory personnel should conduct self-inspections regularly to confirm compliance and identify safety-related issues. Inspection checklists are available in the **Laboratory Inspection Program** to help facilitate the inspection process.

G. Laboratory Security

Lab personnel must take measures to ensure labs remain secure to prevent theft, sabotage, or vandalism. The following measures must be taken to ensure labs remain secure:

- Keep laboratory doors closed and locked when unoccupied.
- Ensure doors to cold rooms, dark rooms, common areas, and storage rooms with hazardous chemicals remain locked when unoccupied.
- Keep an accurate inventory for all chemicals in each lab.
- Provide additional security, such as a locked cabinet, for highly toxic or reactive chemicals.
- Dispose of hazardous chemicals no longer being used through EHS.
- Do not allow unauthorized individuals to enter labs.
- Report thefts, vandalism, or other suspicious activities to **UCPD** immediately.

In addition to the general precautions listed above, applicable labs must also comply with the specific security requirements involving biological select agents and toxins, radioactive isotopes, research animals, and controlled substances.

H. Exposure Monitoring

Personal and/or environmental exposure monitoring may be necessary when lab personnel exhibit **signs or symptoms** of a chemical exposure or perform experiments using hazardous chemicals without adequate ventilation. Principal investigators, laboratory managers, and laboratory personnel are responsible for contacting EHS when laboratory activities have or could lead to an actual or potential overexposure. In such cases, EHS will perform an exposure assessment and may conduct specific quantitative exposure monitoring. Monitoring results will be sent to the PI and all affected individuals. The results of the monitoring will be kept on file at EHS.

XI. Controlling Workplace Hazards

Efforts must be made to control hazardous or potentially hazardous conditions in laboratories. The hierarchy of controls is a system that lists hazard controls in descending order from the most effective to the least. The hierarchy of controls is listed below:

Procedures must be followed in laboratories to control both the hazard and worker exposure to the hazard. The primary methods for controlling exposure to respiratory hazards in the workplace must be through elimination, substitution with less toxic materials, or through engineering controls such as ventilation or enclosure of an operation. If such controls are not feasible or cannot alone reduce exposures to acceptable levels, appropriate administrative controls and/or personal protective equipment must be used, preferably in conjunction with engineering controls, to minimize worker exposure to hazards.

A. Engineering Controls

Engineering controls seek to control hazards at their source by designing the work environment or the job itself to eliminate or reduce exposure to hazards. Examples of engineering controls include:

- Purchasing equipment that provides a barrier between the hazard(s) and the individual(s);
- Redesigning existing equipment to reduce hazards;
- Changing a process to minimize contaminant release;
- Using barriers, shields, or enclosures to isolate a hazard or a person; and
- Using local exhaust ventilation.

1. Fume Hoods

Fume hoods are the most important engineering control used in labs to protect workers from exposure to hazardous chemicals. All procedures or operations that generate irritating and/or hazardous air contaminants should be conducted inside a fume hood. EHS inspects all constant velocity and variable air volume fume hoods to ensure proper flow rates. The parameters used to assess proper flow rates are listed in the table below.

Fume Hood Face Velocities		
Hood Sticker	**Flow Rate (linear feet per minute)**	**Recommended Action**
Green	80-120	SAFE TO USE
Yellow	60-79 or 121-150	USE CAUTION
Red	<60 or >150	DO NOT USE

EHS initiates work orders through **Facilities Operations** for all fume hoods that receive yellow or red stickers. Facilities Operations will contact EHS to recheck the hoods once repairs have been completed. Lab personnel must not use red-tagged fume hoods until EHS re-inspects and assures proper function. Yellow-tagged fume hoods may be used under certain conditions, as allowed by the principal investigator or laboratory manager, and/or EHS.

The following work practices, at a minimum, must be followed while working in fume hoods:

Fume Hood Work Practices	
1.	Keep all apparatus and chemicals at least 6 inches back from the front face of the hood.
2.	Do not store chemicals or apparatus in the hood. Keep only those chemicals and materials necessary for the current procedure.
3.	Keep the hood sash lowered as much as possible. Never exceed 18 inches. For hoods with horizontal sash panels, at least one panel should be positioned between the user's body and the work in the hood (i.e., arms wrapped around the sliding horizontal panel).
4.	Do not use the hood to volatilize chemicals or wastes (i.e., allow chemicals to evaporate).
5.	Keep the slots in the hood baffles free of obstruction.
6.	Never use electrical outlets inside the hood. Run all equipment cords to outlets outside of the hood.
7.	Elevate large equipment (e.g., a centrifuge) at least two inches off the base of the hood interior.
8.	Ensure fume hoods remain working when chemicals are present in the hood.
9.	Keep the hood sash closed when not in use.
10.	Learn and follow lab-specific procedures in the event of a fume hood failure.
11.	Never work in a fume hood that is not running properly. Seal and remove chemicals from hood, close the sash, and contact **EHS**.

Caution: Using perchloric acid in a standard fume hood can lead to accumulation of explosive perchlorate salts in the ductwork. Prior to using heated or concentrated perchloric acid in a chemical fume hood, contact EHS for approval.

2. Gloveboxes

Gloveboxes are enclosed compartments with tight-closing doors or air locks and armholes with impervious gloves sealed into the box. They can be under either positive or negative pressure and are designed to provide a separate atmosphere for hazardous materials that are sensitive to air, water vapor, or other air contaminants. Depending on the material in use, exposure to air contaminants can lead to rapid degradation or a violent reaction.

The principal investigator or laboratory manager must ensure that all personnel are trained prior to working in the glovebox. Training should be documented.
The principal investigator or laboratory manager is responsible for ensuring the glovebox, vacuum pump and associated cords, lines, gauges, gloves, solvent scrubbers, and/or other associated equipment have been installed properly and are used as specified by the manufacturer.

The following work practices must be followed while working in gloveboxes:

- Inspect the gloves, windows, vacuum pump, lines, and connections for signs of damage or deterioration (e.g., holes, discoloration, etc.) prior to each use.
- Maintain the glovebox as specified by the manufacturer, including routine maintenance and service contracts.
- Wear nitrile gloves inside the glovebox gloves to extend the life of the glovebox gloves and avoid cross-contamination.
- Ensure back-up procedures are in place for a loss of power or an absence of required compressed gases.

3. Other Sources of Ventilation

In addition to fume hoods and gloveboxes, other forms of ventilation that may be present in labs include biosafety cabinets, canopy hoods, clean benches, downdraft tables, ductless fume hoods, elephant trunks, slot hoods, toxic gas cabinets, and other devices. Local exhaust ventilation (LEV) refers to systems designed to enclose or capture and remove contaminated air at the source. Other sources of ventilation may only be designed to protect samples or products from contamination. Types and descriptions of other sources of ventilation are indicated in the table below:

Additional Ventilated Devices in Laboratories	
Type	**Description**
Biosafety Cabinets	Biosafety cabinets use one or more HEPA filters to deliver clean, nearly particulate free air to a work surface. Biosafety cabinets (BSC) are designed to protect the product, the worker, and the environment from contamination. BSCs must be certified annually to ensure the unit's ability to perform its intended function.
Canopy Hoods	Canopy hoods are one or two-sided overhead hoods primarily used to capture heated air or vapor from ovens or autoclaves. Canopy hoods must not be used to capture hazardous chemicals since most are positioned too high to effectively capture hazardous vapors and draw contaminants through workers' breathing zones.
Clean Benches	A clean bench is a device that draws air from the lab through a HEPA filter and vents the filtered air downwards onto a work surface to keep the materials nearly free from particulate contamination. Clean benches only protect the product from contamination. These devices are not to be used with hazardous materials as they provide no personal protection.
Downdraft Tables	Downdraft hoods or necropsy tables are specially designed work areas with ventilation slots on the sides of the work area. They are used primarily for animal perfusions and dissections. Downdraft hoods are designed to be used with chemicals with vapor densities that are heavier than air.
Ductless Fume Hoods	Ductless fume hoods use a fan to draw air into a chamber, through one or more filters, and back into the laboratory. EHS does not recommend the use of ductless fume hoods in labs due to unpredictable filter change-out schedules and low face velocities, which increase turbulence and the risk of recirculating hazardous materials back into the laboratory.

Elephant Trunks	An elephant trunk, or snorkel, is a piece of flexible duct or hose that is connected to an exhaust duct. They are primarily used to capture discharges from gas chromatographs, pipe nipples, and pieces of tubing. To capture contaminants effectively, the trunk must be positioned close to the point source (e.g., typically one-half a diameter of the hood from the end of the hose), or it will be susceptible to inefficient capture.
Slot Hoods	Slot hoods are local exhaust ventilation hoods specially designed to capture contaminants generated according to a specific rate, distance from the hood, and release velocity for specific ambient airflow. They are application-specific (e.g., dark rooms) and must be designed by a qualified engineer to ensure proper function and capture velocity.
Toxic Gas Cabinets	Gas cabinets are fully enclosed, noncombustible cabinets connected to an exhaust system that are used to provide an isolated environment for highly toxic compressed gas cylinders in storage or in use. Highly toxic or odorous gases should be used and stored in gas cabinets to prevent contamination of the laboratory, in the event of a leak or rupture.

The following guidelines must be adhered to while working with biosafety cabinets, canopy hoods, clean benches, downdraft tables, ductless fume hoods, elephant trunks, slot hoods, toxic gas cabinets, and other sources of ventilation.

- The department, principal investigator or laboratory manager is responsible for ensuring that the local exhaust and/or other ventilated devices have been installed as specified by the manufacturer.
- All lab personnel working with the ventilated device must have appropriate training. Training should be documented.
- Inspect the equipment prior to each use.
- Maintain the equipment as indicated by the manufacturer, including routine maintenance and service contracts.
- Wear appropriate personal protective equipment as indicated in the Workplace Hazard Assessment Form, safety data sheets, and/or manufacturer equipment specifications.

- Ensure proper backup measures are in place for a loss of power or other equipment failure.

B. Administrative Controls

Administrative controls are policies, work practices, and procedures designed to limit personnel exposure to workplace hazards. Administrative controls are often used in conjunction with engineering controls and personal protective equipment. Examples of administrative controls include:

- Training and education;
- Policies to limit risk of exposure;
- Standard operating procedures;
- Housekeeping;
- Routine maintenance of equipment; and
- Signs and labels.

In addition to the guidelines in the CHP, the principal investigator and/or laboratory manager may implement administrative controls specific to their labs. Lab-specific training and other lab-specific policies and procedures must be conveyed to lab personnel prior to research in the labs.

1. Working Alone in Labs

The **Working Alone Policy** applies to undergraduates, graduate students, and post-doctoral scholars performing academic or research related work. The policy was developed to minimize the risk of severe injury while working alone with materials, equipment, or in areas that could result in severe injury or an immediate life-threatening hazard. Department heads, principal investigators, laboratory managers, lab workers, and others responsible for assigning work to students must evaluate whether an immediately hazardous environment, as defined in the policy, exists in the lab and whether working alone is permitted.

2. Lab-Specific Standard Operating Procedures (LSOPs)

Lab-specific standard operating procedures (LSOPs) are detailed documents that describe the steps and appropriate safety controls that must be followed prior to performing a given experimental procedure. While the CHP provides a general overview of safe work practices with regards to laboratory safety, principal investigators, laboratory managers, and other lab personnel are responsible for developing LSOPs for procedures involving hazardous chemicals and/or processes that fall outside the guidelines of the CHP. LSOPs must provide enough detail so that individuals with limited experience can safely conduct the procedure or process. Specific attention must be paid to chemicals with high degrees of acute toxicity, reactivity (e.g., explosives, pyrophorics, etc.) and other chemicals which can cause severe harm upon single or repeated exposure. Each LSOP must include, at a minimum, the following elements:

Lab-Specific Standard Operating Procedure Format	
Section	**Section Title**
1.	List of Chemicals
2.	Administrative Controls
3.	Engineering Controls
4.	Work Practices
5.	Personal Protective Equipment
6	Storage
7.	Spills and Accident Procedures
8.	First Aid Procedures
9.	Hazardous Waste Management
10.	Decontamination Procedures
11.	Specific Procedures
12.	Lab Personnel Approval

EHS has developed LSOPs for hydrofluoric acid (HF), pyrophoric chemicals, aqua regia solutions, and piranha solutions. Principal investigators and laboratory managers using these materials are responsible for completing the LSOP, signing a copy, ensuring that lab personnel review and sign the LSOP, and modifying the LSOP if procedures change. Every individual working with hydrofluoric acid (HF), pyrophoric chemicals, aqua regia solutions, and piranha solutions are required to review, follow, and sign a copy of the LSOP. The required LSOPs must be readily available in the lab.

Note: Principal investigators or laboratory managers must develop lab-specific procedures for other chemicals, processes, or operations not covered by the standard operating procedures in the CHP. A blank **LSOP template** and **Standard Operating Procedure Worksheet** are available through EHS. LSOPs may be developed without using these templates but must include all the sections (e.g., engineering controls, personal protective equipment, etc.) noted in the templates.

C. Personal Protective Equipment

When engineering or administrative controls are not feasible or do not provide sufficient protection from hazards, principal investigators and/or laboratory managers are responsible for providing appropriate personal protective equipment (PPE) to lab personnel and ensuring its proper maintenance and use. PPE for the eyes, face, hands, head, body, and feet must be of safe design and construction for the work to be performed and be used and maintained in a sanitary and reliable condition. A **Workplace Hazard Assessment** must be performed to determine the appropriate PPE to be worn in each lab or for specific work activities.

Personal protective equipment must provide a level of protection greater than the minimum required to protect individuals from the hazards identified in the lab. Careful consideration must be given to fit and comfort. PPE that fits poorly will not provide adequate protection. PPE that fits well and is comfortable to wear will encourage further use. Multiple sizes and/or types of PPE may need to be purchased to accommodate all lab personnel. If several distinct types of PPE are worn together, they must be compatible.

PPE must conform to the American National Standards Institute (ANSI)/International Safety Equipment Association (ISEA) or American Society for Testing and Materials (ASTM) requirements that have been incorporated into the OSHA regulations, as follows:

Personal Protective Equipment Standards			
PPE	**OSHA Standard**	**ANSI/ISEA/ASTM Standards**	**Examples**
Eye and Face Protection	**29 CFR 1910.133**	ANSI/ISEA Z87.1	Safety glasses/ goggles/face shields Impact goggles Surgical masks Filter lenses
Head Protection	**29 CFR 1910.135**	ANSI/ISEA Z89.1	Hard hats Helmets Bump caps
Hand Protection	**29 CFR 1910.138**	ANSI/ISEA 105	Abrasion, cut, or puncture-resistant gloves Chemical-resistant gloves Heat-resistant gloves Cold-resistant gloves for working with cryogens
Foot Protection	**29 CFR 1910.136**	ASTM F2413	Closed-toed footwear Puncture-resistant safety shoes Slip-resistant footwear Foot covers and guards
Body Protection	**29 CFR 1910.132**	Not Applicable	Coveralls Lab coats Aprons, vests, or sleeves Heat-resistant clothing

The minimum personal protective equipment that must be worn in labs where hazardous chemicals are used or stored are ANSI Z87.1-certified eyewear, clothing that covers the legs, and closed-toed footwear (i.e., sandals, flip-flops, clogs, or other footwear that expose the front, top, side or back of the feet are not allowed). Lab coats are recommended for all work involving hazardous chemicals. Chemical splash goggles with indirect ventilation or no ventilation are recommended when handling hazardous chemicals, nonhazardous liquids over 60°C (140°F), and chemicals whose ability to cause damage or injury to the eyes is unknown.

Principal investigators or laboratory managers must determine, through the Workplace Hazard Assessment, when face shields that protect the chin, neck, and ears must be worn by lab personnel (e.g., increased risk of splashing, flying particles, etc.). Face shields must be used in conjunction with safety goggles or glasses. Additional PPE, as indicated on the lab Workplace Hazard Assessment Form, must also be worn by lab personnel.

1. Glove Selection

Prior to engaging in work with hazardous chemicals, principal investigators, laboratory managers, and lab personnel must ensure that the gloves being worn are compatible with the substances being handled. The hazards of the chemical, duration of use, temperature, pH, and other properties of the chemical as well as the permeation rate, breakthrough time, and degradation rate of the glove must all be considered. No single type of glove will provide adequate protection against all chemicals. Safety data sheets (SDSs) and the manufacturer's chemical-resistance glove guide must be consulted to ensure proper selection. Laboratory personnel may consult with EHS for assistance in determining which gloves provide the best protection against specific hazards. The following glove guide gives a general overview of the most common types of chemical-resistant gloves and the types of hazards they can guard against:

Chemical Resistant Gloves			
Type	**Advantages**	**Disadvantages**	**Use Against**
Butyl Rubber	Extended contact time possible	Poor versus hydrocarbons, chlorinated solvents	Polar organics (e.g., glycol ethers, ketones, esters)
Natural rubber/latex	Good physical properties, dexterity	Incidental contact only, poor vs. oils, organics, hard to detect puncture holes, can trigger latex allergies	Bases, alcohols, dilute water solutions, fair vs. aldehydes, ketones.

Neoprene	Extended contact time possible, medium chemical resistance, medium physical properties	Poor versus halogenated and aromatic hydrocarbons	Acids, bases, alcohols, fuels, peroxides, hydrocarbons, and phenols
Nitrile	Excellent physical properties, dexterity	Incidental contact only, poor vs. benzene, methylene chloride, trichloroethylene, many ketones	Oils, greases, petroleum products and some acids and bases, fair vs. toluene
Polyvinyl alcohol (PVA)	Resists a broad range of organics, good physical properties, specific-use glove	Cannot be used with water or water-based solutions, poor vs. light alcohols (e.g., methanol, ethanol)	Aliphatics, aromatics, chlorinated solvents, ketones (except acetone), esters, ethers
Polyvinyl chloride (PVC)	Good abrasion resistance, medium chemical resistance, specific-use glove	Plasticizers can be stripped making gloves rigid, poor vs. most organic solvents	Acids, fats, and petroleum hydrocarbons
Fluoro-elastomer (Viton)	Extended contact possible, organic solvents, good resistance to cuts and abrasions	Poor physical properties, poor vs. some ketones, esters, amines	Aromatics, chlorinated solvents, also aliphatics and alcohols
Norfoil	Extended contact possible, excellent chemical resistance	Poor fit, easily punctures, poor grip, stiff	Most hazardous chemicals

2. Respirators

The primary method for controlling exposure to respiratory hazards in the workplace must be through engineering controls such as ventilation, enclosure of an operation, or substitution with less toxic materials. However, when lab personnel may be exposed above recognized exposure limits, respirators must be used if:

- Engineering controls are not feasible;
- Engineering controls alone cannot reduce exposures to acceptable levels; or
- Respirators are used as an interim measure while engineering controls are in the process of being implemented.

Principal investigators, laboratory managers, and lab personnel planning to wear respirators must comply with all requirements outlined in the **UConn Respirator Program**.

a. Required Use of Respirators

Lab personnel required to use respirators, including filtering facepiece respirators (e.g., dust masks), must be trained in their proper use, inspection, and maintenance, and must receive a medical evaluation and fit test prior to use. The principal investigator and/or laboratory manager must ensure that lab personnel receive training through EHS as follows:

- Initially - prior to being assigned a respirator;
- Annually;
- If retraining appears necessary because changes in the workplace or the type of respirator render the previous training obsolete;
- Inadequacies in an individual's knowledge or use of the respirator indicate that the individual has not retained the necessary understanding or skill; and
- Any other situation arises in which retraining appears necessary to ensure safe respirator use.

b. Voluntary Use of Dust Masks

On occasion, individuals may desire to use dust masks voluntarily in labs, though conditions do not exist that mandate their use. In such cases, medical evaluations and fit testing are not required and the employer may provide dust masks at the request of the individual or permit them to use their own if:

- The use of the dust mask is not required by the principal investigator and/or laboratory manager;
- The dust mask is used for comfort purposes only and not to protect the health of the worker;
- The principal investigator or laboratory manager determines that such dust mask use will not in itself create a hazard; and
- Selection, maintenance, and training requirements are met.

When dust masks will be used voluntarily, principal investigators or laboratory managers must ensure that:

- Lab personnel receive **Respiratory Protection - Voluntary Use of Dust Masks (HuskySMS)** training; and
- The respirator maintenance and care provisions of the UConn **Respirator Program** are followed.

If lab personnel plan to wear other types of respirators voluntarily, principal investigators or laboratory managers must ensure they are medically evaluated, trained, and fit-tested annually. Principal investigators, laboratory managers, and lab personnel planning to wear respirators must comply with all requirements outlined in the **UConn Respirator Program**.

XII. Waste Management

A. Hazardous Waste

Hazardous wastes include discarded solids, liquids, or gases with properties that are dangerous or potentially harmful to human health or the environment. Hazardous wastes include those chemicals that are listed as a hazardous waste or exhibit characteristics (i.e., ignitability, corrosivity, reactivity, or toxicity) of a hazardous waste as defined by the **Environmental Protection Agency** (EPA). All listed and characteristic hazardous wastes are identified by waste codes. The waste list and descriptions of each type are listed in the table below:

Listed Hazardous Wastes	
Hazardous Waste List	**Description**
F-list (Non-specific source wastes)	The F-list consists of 28 different wastes, including certain spent solvents, metal finishing wastes, dioxin-containing wastes, chemical manufacturing wastes, wood preserving wastes, petroleum refinery wastewater treatment sludges, and hazardous waste landfill leachate.
K-list (Source-specific wastes)	The K-list consists of over 100 wastes from specific industrial processes (e.g., wood preserving, petroleum refining, primary and secondary metals manufacturing; and the manufacturing of industrial chemicals, inks, pigments, pesticides, explosives, and veterinary pharmaceuticals).
P-list (Discarded commercial chemical products-acute)	This P-list consists of about 200 different commercial chemical products that are defined as acutely hazardous and toxic. Wastes that fall under this listing include only those products that contain the listed constituent as the sole active ingredient. These wastes include virgin materials that are being discarded, as well as container residues and spill residues.
U-list (Discarded commercial chemical products-non-acute)	The U-list consists of several hundred different commercial chemical products. Wastes that fall under this listing include only those products that contain the listed constituent as the sole active ingredient. These wastes include old or off-specification virgin materials that are being discarded, as well as container residues and spill residues of these materials.

*Table derived from **40 CFR Part 261 Subpart D.**

Hazardous wastes that are not identified on the F, K, P or U-lists must still be managed in labs as hazardous waste if they exhibit any of the four characteristics listed below:

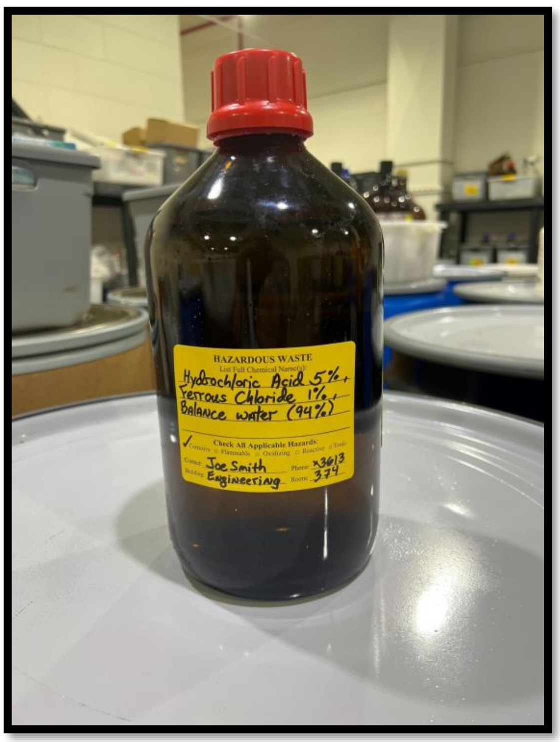
Characteristic Hazardous Wastes	
Characteristic	**Description**
Ignitability (D001)	A waste is **ignitable** if it is: (1) a liquid and has a flash point below 60° C (140° F); (2) a flammable solid; (3) an ignitable compressed gas; or (4) classified by the U.S. Department of Transportation as an oxidizer.
Corrosivity (D002)	A waste is **corrosive** if it: (1) is aqueous (i.e., water-based) and has a pH of 2.0 or lower (i.e., a strong acid) or 12.5 or more (i.e., a strong alkali/base); or (2) can corrode steel at a rate of greater than 0.250 inches per year.
Reactivity (D003)	**Reactive wastes** include wastes that are: (1) unstable and readily undergo violent change without detonating; (2) react violently with water; (3) form potentially explosive mixtures with water; (4) generate toxic gases, vapors or fumes when mixed with water; (5) release toxic cyanide or sulfide gases when exposed to pH conditions between 2 and 12.5; (6) capable of detonation or explosive reactions if it subjected to a strong initiating source or if heated under confinement; (7) capable of detonation or explosive decomposition or reaction at standard temperature and pressure; or (8) are forbidden explosives.
Toxicity (D004-D043)	A waste is **toxic** if it contains any of 40 different hazardous constituents at a concentration equal to or greater than a certain threshold amount. These 40 constituents include 8 metals, 6 pesticides, 2 herbicides, 10 volatile organic compounds (VOCs), and 14 semi-volatile organic compounds (SVOCs).

*Table derived from **40 CFR Part 261 Subpart C.**

No listed (i.e., F, K, P, or U-listed wastes) or characteristic hazardous wastes are allowed to be disposed of down drains, treated to render them non-hazardous, or volatilized into the air. In addition, abandoned chemicals, **unknown chemicals**, or chemicals in deteriorating containers must also be managed as hazardous waste. The principal investigator or laboratory manager is responsible for assuring that the procedures outlined in the **University Chemical Waste Disposal Manual** are followed by their lab workers.

B. Hazardous Waste Management in the Laboratory

- Package all hazardous wastes in sturdy containers that are compatible with the waste (e.g., do not store acid wastes in metal containers). Never use empty household or food grade containers to store hazardous waste.
- Mark containers with hazardous waste stickers or tags and full chemical names from the moment waste is added (i.e., DO NOT USE CHEMICAL FORMULAS OR ABBREVIATIONS).
- Ensure hazardous wastes with more than one chemical list the approximate percentage of each chemical product (include the percentage of water if applicable) and add up to 100%. Examples of compliant hazardous waste labels are pictured below:



- Keep containers closed with a tight-fitting cap or lid (e.g., no corks, rubber stoppers or open funnels), unless waste is being directly added to the container.
- Place containers that continually generate hazardous wastes (e.g., high-performance liquid chromatography wastes) in secondary containment, and ensure all tubes and hoses are closed as much as possible to minimize potential release.
- Never mix incompatible wastes in the same container.
- Never add waste to an unlabeled waste container.

- Never store incompatible wastes in the same secondary containment bin.
- Store all hazardous wastes at or near a “Satellite Accumulation Area” sign.
- Never exceed 55 gallons of non-acute waste per waste stream or 1 quart of acutely hazardous waste in a satellite accumulation area.

C. Hazardous Waste Disposal Procedures

- Ensure hazardous waste stickers or tags, full chemical names, and approximate percentages (if applicable) are legible and prominently displayed on each container.
- Check all the applicable hazard classes and complete the contact information on the hazardous waste sticker or tag.
- Submit a **Chemical Waste Pickup Form** when waste containers are almost full.
- Verify submission of the pick-up through a confirmation email to the email address listed on the form.
- EHS normally picks up hazardous waste on Mondays, Wednesdays, and Fridays.

Note: EHS will not remove hazardous wastes that have chemical abbreviations, illegible names, no percentages (if applicable), inadequate contact information, or fail to use hazardous waste stickers or tags.

D. Aerosol Cans

Waste aerosol cans commonly contain hazardous chemicals (e.g., pesticides, solvents, etc.) and/or hazardous propellants (e.g., isobutane, propane, etc.) and cannot be disposed of in the regular trash. Lab personnel must manage full, partially full, and empty aerosol cans as hazardous waste and dispose of them through EHS. The steps to manage aerosol cans are outlined below:

Waste Aerosol Cans Management	
Steps	**Procedure**
1.	Label a box or bag with a hazardous waste sticker or tag with the words “Used Aerosol Cans.”
2.	Place full, partially full, and empty aerosol cans in the labeled box or bag.
3.	Submit a **Chemical Waste Pickup Form** when waste aerosol cans require disposal.

4.	EHS will remove the waste during the next regularly scheduled pick-up.

EHS will manage and dispose of the waste aerosol cans, residual solvents, and propellants in compliance with state and federal regulations.

E. Gel Stain Waste

Electrophoresis gel stains contain dyes, reagents and other chemicals designed to detect samples on electrophoresis gels. Some gel stains, such as ethidium bromide, are toxic and capable of causing harm and genetic defects upon exposure. Although ethidium bromide and other gel stains are not regulated by the EPA as hazardous wastes, specific work practices must be followed to ensure proper disposal through EHS. The management and disposal practices for gel stain wastes are listed below:

Gel Stain Waste Management	
Solid Waste	
1.	Place stained gels (e.g., ethidium bromide, SYBR Safe, etc.) or contaminated solid debris in an open head 5 gallon pail available through EHS.
2.	Place a green "Connecticut Regulated Waste" sticker on the pail and label the sticker with the name of the gel stain (e.g., ethidium bromide).
3.	Close the container when not directly adding waste to the container.
4.	Submit a **Chemical Waste Pickup Form** when the container is almost full.
Liquid Waste	
1.	Place gel stain liquids in a sturdy, non-leaking container.
2.	Place a green "Connecticut Regulated Waste" sticker on the container and label the sticker with the name of the stain (e.g., ethidium bromide).
3.	Close the container when not directly adding waste to the container.

4.	Submit a **Chemical Waste Pickup Form** when the container is almost full.

Do not use biohazard or autoclave bags to store ethidium bromide or other gel wastes. All gel stain waste must be managed, collected, and disposed of through EHS as chemical waste.

F. Universal Waste Management and Disposal

Universal wastes refer to common items such as thermometers, batteries, and fluorescent lamps that contain mercury and/or other toxic metals. These wastes are generated in a wide variety of settings, including laboratories. At UConn, the following materials must be managed as universal wastes:

Universal Wastes Management		
Category	**Management**	**Disposal**
Lamps (e.g., linear fluorescent, HID/HPS, U and Circlines, Biax and Compact/PL's, etc.)	1. Place the lamp(s) in a closed container immediately after it is removed from service. 2. Label the container with a "Universal Waste" sticker. 3. Mark the checkbox on the label for "Universal Waste-Lamp(s)." 4. Write the "Accumulation Start Date."	Submit a work order through **Facilities Operations** for removal once containers are full or near the one year accumulation time limit.
Batteries, Automotive (lead-acid vehicle batteries)	1. Tape the terminals. 2. Label the battery with a "Universal Waste" sticker. 3. Mark the checkbox on the label for "Universal Waste Battery(ies)." 4. Write the "Accumulation Start Date."	Contact **UConn Motor Pool** for disposal.

Batteries, Non-Automotive (e.g., lead-acid, nickel-cadmium, silver oxide, lithium, mercury, magnesium, etc.)	1. Place used batteries in individual plastic bags or tape the terminals. 2. Label the bag or battery with a "Universal Waste" sticker. 3. Mark the checkbox on the label for "Universal Waste Battery(ies)." 4. Write the "Accumulation Start Date."	Submit a chemical waste pick-up request through **EHS**.
Mercury-Containing Thermostats or Other Mercury-Containing Equipment	1. Place the mercury containing device(s) in a container with a tight-fitting cap or lid. 2. Label the container with a "Universal Waste" sticker. 3. Mark the checkbox on the label for "Waste-Mercury Thermostat(s)." 4. Write the "Accumulation Start Date."	Submit a chemical waste pick-up request through **EHS**.
Used Electronic Equipment (e.g., computers, monitors, radios, copiers, etc.)	1. Contact **Surplus Operations**. 2. Surplus Operations will remove the used electronic and determine when it becomes a solid waste. Once the waste determination is made, Surplus will: a. Label the device with a "Universal Waste" sticker.	Surplus Operations will contact an e-waste recycler to remove the used electronics within one year.

	b. Mark the checkbox for "Universal Waste- Used Electronics." c. Write the "Accumulation Start Date."	
Pesticides	1. Label waste pesticides with a "Hazardous Waste" sticker or tag and full chemical names. 2. Keep the cap or lid of the waste container closed, unless actively adding waste. 3. Store pesticide wastes with compatible chemicals in a secure location at or near a "Satellite Accumulation Area" sign.	Submit a chemical waste pick-up request through **EHS**. EHS will determine whether the pesticide waste meets the criteria to be managed as a universal waste.

G. Other Waste Management

In addition to hazardous chemical wastes, other materials generated in labs must also be effectively managed. Lab personnel are required to follow all applicable guidelines in the **Chemical Waste Disposal Manual**.

1. Empty Chemical Container Management

Lab personnel must update their lab-specific inventory or their inventory associated with the **Laboratory Chemical Inventory Program** when original chemical containers become empty. Empty chemical containers must be managed based on the chemical originally present in the container.

a. Acutely Hazardous Chemicals

Empty containers of **P-listed chemicals** must be properly labeled as hazardous waste and be discarded through EHS. Wastes that fall on the P-List include only those products that contain the listed constituent as the sole active ingredient. P-listed chemicals commonly found in labs may include:

Common P-Listed Chemicals in Laboratories		
Acrolein	Allyl alcohol	Arsenic compounds
Carbon disulfide	Cyanogen	2,4-dinitrophenol
Epinephrine	Inorganic cyanide salts	Nitrous and nitric oxides
Osmium tetroxide	Sodium azide	Vanadium pentoxide

Prior to disposal of any empty container, principal investigators, laboratory managers, and lab personnel must determine if the empty container is listed on the EPA's **P-List**.

b. Non-Acutely Hazardous Chemicals

All empty containers, not identified on the P-List, must meet the following criteria prior to disposal in the regular trash:

1. All waste has been removed using the practices commonly employed to remove materials from that type of container (e.g., pouring, pumping, aspirating, etc.); and
2. The empty container does not have a residual, noxious odor.

If both criteria are met, lab personnel must remove and dispose of the caps, cross out/deface the chemical name(s) on the label, and then dispose of the empty container in the regular trash, lab glass, or other suitable waste receptacle. If any criteria cannot be met, the container must be managed as **hazardous waste** and be disposed of through EHS.

2. Glass Waste

Lab personnel must dispose of intact or broken lab glass in puncture-resistant containers or boxes with inner liners to prevent cuts or lacerations to individuals handling the waste. Glass waste must never contain solid or liquid chemicals or be disposed of with regular trash. Empty, non-contaminated glass waste is not a regulated material and is disposed from laboratories by the custodial staff or other **Facilities Operations** personnel.

3. Sharps Waste

The Environmental Protection Agency (EPA) and Connecticut Department of Energy and Environmental Protection (DEEP) require sharps waste (e.g., needles, scalpel blades, hypodermic needles, syringes (with or without attached needles), and needles with attached tubing, regardless of contact with infectious agents, to be managed as "Regulated Medical Waste."

Other sharps that can puncture or tear autoclave bags including Pasteur pipettes, disposable pipettes, razor blades, blood vials, test tubes, pipette tips, broken plastic culture dishes, glass culture dishes, and other types of broken and unbroken glass waste (e.g., microscope slides and cover slips) that may have been in contact with infectious material must also be managed as sharps.

All sharps generated in labs must be disposed of in approved sharps containers provided by EHS. Sharps containers are available through submission of a **Biological Waste Pick-Up Form**.

Note: Sharps derived from injections with **P-Listed chemicals** (e.g., epinephrine) must be disposed of in black sharps containers provided by EHS upon request.

4. Gas Cylinder Returns/Disposal

Lab personnel using compressed gases are responsible for returning empty or unused cylinders to the onsite vendor or supplier. EHS does not manage the return or disposal of compressed gas cylinders. Prior to purchasing compressed gases, lab personnel must check with the supplier to ensure they will accept the return of empty or partially used cylinders. If the supplier will not accept the cylinders, the costs associated with returning or disposing of the cylinders may be charged to the department, principal investigator, or lab manager. Lab personnel may contact the **Purchasing Department** to review a current list of approved vendors for compressed gases at UConn.

5. **Biological Waste**

Procedures for the treatment and disposal of biological and regulated medical waste are outlined in the **Biological Waste Guide**. Principal investigators, laboratory managers, lab personnel, and others generating biological and/or regulated medical waste in UConn labs are responsible for compliance with the federal and state regulations and University requirements indicated in the guide.

The mixing of biological and hazardous chemical wastes should be avoided. If the mixing of biological materials with hazardous chemicals is required, the entire mixture must be managed as **hazardous waste**.

6. **Radiological Waste**

Lab personnel are required to gain authorization from the Radiation Safety Committee prior to using radioactive materials. Procedures for the authorized, proper disposal of radioactive waste, including thorium and uranium compounds, generated in UConn labs must be carried out as indicated in the **Radiation Safety Manual**. Principal investigators, laboratory managers, and lab personnel generating radioactive wastes in UConn labs are responsible for compliance with the federal and state regulations and University requirements indicated in the manual.

Mixed wastes that contain both hazardous waste and radioactive material are regulated by the Environmental Protection Agency (EPA) and the Nuclear Regulatory Commission (NRC). No mixed waste (i.e., regulated hazardous waste contaminated with radioactive material) shall be generated unless prior authorization is obtained through the Radiation Safety Committee in an approved radioactive materials usage permit. Principal investigators, laboratory managers, and lab personnel are responsible for contacting EHS prior to the generation of mixed waste containing hazardous chemicals and radioactive materials. Fees associated with the proper disposal of mixed waste may be charged to the department and/or principal investigator of the laboratory that generated the mixed waste.

H. Waste Minimization

The University is required under EPA regulations to reduce the volume of hazardous wastes generated. Minimizing wastes increases worker safety, protects the environment, and decreases disposal costs. Lab personnel must take measures to manage and reduce quantities of hazardous chemicals and wastes when feasible. Strategies to minimize waste are listed below:

Waste Minimization Practices	
Chemical Management	
1.	Maintain an accurate chemical inventory. Check the lab chemical inventory for existing chemicals prior to reordering. Update the inventory each time chemicals are received or disposed of.
2.	Order the minimum amount of a chemical required for an experiment or process. Avoid purchasing chemicals in bulk quantities at reduced costs if the additional quantity is unnecessary. Disposal costs may nullify discounts.
3.	Use the oldest chemicals first to prevent older chemicals from expiring or becoming off-specification.
4.	Reduce the scale of chemicals used in experiments or processes.
5.	Label each chemical and sample stored in secondary containers (i.e., beakers, flasks, vials, etc.) with the chemical name(s) and hazard class(es). Unknown chemicals are extremely costly to dispose of.
6.	Purchase equipment that uses non-hazardous chemicals or reduced quantities of hazardous chemicals.
7.	Use spent solvents capable of removing residues for initial rinsing(s) of glassware and new solvent for final rinse(s). Dispose of hazardous rinsate through EHS.
8.	Dispose of expired or off-specification chemicals, or chemicals and samples with no useful purpose in the lab, through EHS. Do not stockpile chemicals.
Substitution	
1.	Substitute ethanol for methanol, if feasible.
2.	Substitute non-mercury thermometers for mercury thermometers.
3.	Substitute citric acid-based solutions in histology for xylene, benzene, or toluene.
4.	Substitute ethanol for formaldehyde for tissue preservation.
5.	Substitute non-hazardous liquid scintillation cocktails for hazardous solvent-based cocktails.
6.	Substitute rechargeable alkaline batteries for nickel cadmium.

7.	Substitute non-hazardous chemicals for cleaning glassware for hazardous chemicals (e.g., chromic acid, hydrochloric acid, potassium hydroxide, etc.), if feasible.
Reduction of EPA Regulated Hazardous Chemicals	
1.	Avoid, minimize, or substitute reagents containing arsenic, barium, copper, cadmium, chromium, lead, mercury, nickel, osmium, selenium, silver, or zinc.
2.	Avoid, minimize, or substitute the following halogenated solvents; tetrachloroethylene, methylene chloride, trichloroethylene, 1,1,1-trichloroethane, chlorobenzene, 1,1,2- trichloro-1,2,2-trifluoroethane, ortho-dichlorobenzene, trichlorofluoromethane, and 1,1,2-trichloroethane.
3.	Avoid, minimize, or substitute the following non-halogenated solvents; xylene, acetone, ethyl acetate, ethyl benzene, ethyl ether, methyl isobutyl ketone, n-butyl alcohol, cyclohexanone, and methanol.
4.	Avoid, minimize, or substitute the following non-halogenated solvents; toluene, methyl ethyl ketone, carbon disulfide, isobutanol, pyridine, benzene, 2-ethoxyethanol, and 2-nitropropane.
5.	Avoid, minimize, or use chloroform solutions at concentrations less than 6mg/L. Chloroform volumes greater than or equal to 6mg/L are regulated by EPA.
Waste Management	
1.	Label hazardous waste containers with hazardous waste stickers/tags and full chemical names from the moment waste is added.
2.	Avoid mixing chemical, biological and/or radiological wastes. Contact EHS prior to generating mixed waste.
3.	Avoid mixing hazardous and non-hazardous chemical waste.
4.	Segregate non-halogenated waste from halogenated waste, if feasible.
5.	Segregate inorganic waste from organic waste, if feasible.
6.	Segregate cyanides, arsenic trioxide, osmium tetroxide, and other **P-Listed wastes** from other chemical wastes, if feasible.
7.	Separate waste containing heavy metals from organic solvent waste, if feasible.
8.	Do not mix uncontaminated pump oil with other hazardous wastes. Uncontaminated pump oil can be recycled.
9.	Avoid purchasing lecture bottles of compressed gases that cannot be returned to the manufacturer.

The University recycles batteries, fluorescent lamps, mercury-containing thermostats and other mercury-containing equipment, and used electronics with circuit boards. The appropriate management practices and disposal contacts for each waste type are listed in the **Storrs** and **regional campuses** waste stream guidance documents.

XIII. Toxicity and Exposure Limits

A. Toxic Chemicals

Chemicals used in laboratories have a wide range of physical, chemical, and toxicological properties that lead to adverse health effects in humans. The risks associated with their usage are dependent on both the level of exposure and the inherent toxicity of the chemical. The most critical factor that determines whether a substance is toxic to an individual is the relationship between the amount of the chemical reaching the target organ and the toxic effect it produces. In some cases, a single (acute) exposure may bring about negative health effects whereas other toxic effects may be revealed after repeated, long-term (chronic) exposures. Many toxic effects from chemicals are reversible (i.e., causing no permanent damage) whereas other exposures can lead to permanent damage and even death at a sufficient dose, duration, and/or frequency.

Exposure to chemicals in the laboratory occurs by four routes:

1. Inhalation into the respiratory tract;
2. Absorption through the skin via dermal contact;
3. Ingestion into the digestive tract; and
4. Injection directly into the bloodstream.

Lab personnel are responsible for reviewing safety data sheets for the chemicals being used to learn the proper response actions for each route of entry.

B. Exposure Limits

Exposure to toxic chemicals in laboratories can lead to negative health effects in susceptible individuals. As a result, the Occupational Safety and Health Administration (OSHA), American Conference of Governmental Industrial Hygienists (ACGIH), and National Institute for Occupational Safety and Health (NIOSH) have established exposure limits for chemicals to protect individuals from workplace hazards. OSHA's action levels and permissible exposure limits (PELs) are enforceable by law. Descriptions of exposure limits are listed below:

Exposure Limits		
Exposure Limit	**Description**	**Agency**
Action level	Action level means a concentration designated for a specific substance, calculated as an 8-hour time-weighted average, which initiates certain required activities such as exposure monitoring and medical surveillance.	OSHA
Immediately Dangerous To Life or Health (IDLH)	An IDLH condition is defined as a situation 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.	NIOSH
Permissible Exposure Limits (PELs)	PELs are regulatory limits based on the amount or concentration of a substance in the air. In some cases, they may also contain a skin designation. Most PELs are based on an 8-hour time weighted average (TWA) exposure to which it is believed most workers may be exposed to for a working lifetime without developing serious illness.	OSHA
Recommended Exposure Limits (RELs)	RELs are time-weighted average (TWA) concentrations for up to a 10-hour workday during a 40-hour workweek.	NIOSH
Threshold Limit Values (TLVs)	Threshold Limit Values (TLVs) are based on the TWA concentration for a conventional 8-hour workday and a 40-hour workweek, to which it is believed that nearly all workers may be repeatedly exposed, day after day, for a working lifetime without adverse effect.	ACGIH
Threshold Limit Value- Ceiling	TLV–C is the concentration that should not be exceeded during any part of the working	ACGIH

(TLV–C)	exposure. If instantaneous measurements are not available, sampling should be conducted for the minimum time period sufficient to detect exposures at or above the ceiling value.	
Short-Term Exposure Limit (STEL)	Short-Term Exposure Limit (STEL) is a 15-minute TWA exposure that should not be exceeded at any time during a workday, even if the 8-hour TWA is within the TLV–TWA. The STEL is the concentration to which it is believed that workers can be exposed continuously for a short period of time without suffering from 1) irritation, 2) chronic or irreversible tissue damage, 3) dose-rate-dependent toxic effects, or 4) narcosis of sufficient degree to increase the likelihood of accidental injury, impaired self-rescue, or materially reduced work efficiency.	ACGIH

OSHA requires that safety data sheets list not only the relevant OSHA PEL but also the TLV and any other exposure limit used or recommended by the chemical manufacturer, importer, or employer preparing the safety data sheet. Since only approximately five hundred PELs have been established, many chemicals used in laboratories do not have recognized exposure limits. In such cases, comparison of the chemical lacking an exposure limit to other chemicals with similar structures (e.g., hydrocarbons) or physical properties (e.g., volatile organic compounds) may be necessary. Lab workers must contact the principal investigator, laboratory manager, or **EHS** with questions or concerns regarding exposure limits for specific chemicals used in the lab.

C. Factors Affecting Toxicity

Toxicology is based on the relationship between a toxic reaction (the response) and the amount of toxicant received (the dose). The dose-response relationship is the basic concept for determining the relative level of harmfulness of a chemical. In a sufficient amount, even chemicals normally considered harmless can evoke a toxic response. Exposure to toxic chemicals is dependent on several factors listed in the table below:

Factors that Influence Chemical Toxicity	
Route of entry	Excretion
Physical condition	Combined effects of chemicals
Dose	Presence of other chemicals
Frequency	Stress
Ability to be absorbed	Sensitivity
Metabolism	Gender
Distribution within body	Individual variation

Lab personnel are responsible for using the **hierarchy of controls** to prevent exposure to toxic chemicals.

D. Signs and Symptoms of Chemical Exposures

Signs and symptoms of chemical exposures can occur after single or repeated exposures. Some individuals develop a sensitivity (i.e., an allergic reaction) in normal tissue after repeated exposure to certain chemicals (e.g., chromium, nickel, formaldehyde, isocyanates, etc.). The following table is a list of common signs and symptoms associated with chemical exposures:

Signs and Symptoms of Chemical Exposures		
Category	**System Affected**	**Symptoms**
Dermatological	Skin, Eyes	Abnormally dark or light skin, burning sensation, itching, rashes, redness, swelling
Gastrointestinal	Stomach, Intestines	Diarrhea, nausea, vomiting
Hematological	Blood	Anemia (fatigue, weakness)

Neurological	Brain, Spinal Cord	Confusion, coma, convulsions, coordination difficulty, depression, dizziness, headache, sweating
Renal	Kidney	Back pain, frequent or infrequent urination
Reproductive	Ovaries, Testes, Fetus	Infertility, miscarriage
Respiratory	Nose, Trachea, Lungs	Irritation, choking, coughing, runny nose, sneezing, tight chest

Lab personnel experiencing any signs or symptoms of chemical exposures must contact their principal investigator, laboratory manager, or EHS prior to conducting further research.

XIV. Chemical-Specific Procedures

A. Flammable Liquids

The Occupational Safety and Health Administration (OSHA) defines a flammable liquid as having a flash point of not more than 93°C (199.4°F). OSHA defines flash point as “the minimum temperature at which a liquid gives off vapor within a test vessel in sufficient concentration to form an ignitable mixture with air near the surface of the liquid.” In most cases, the relative hazard of a flammable liquid increases as the flashpoint decreases. Many common solvents (e.g., acetone, diethyl ether, toluene, etc.) have flash points well below room temperature, making proper use, storage, and disposal more critical. Flammable liquids and mixtures containing flammable liquids are assigned to one of four hazard categories, as indicated in safety data sheets (SDSs), based on their flash points and boiling points (See table below).

Flammable Liquid Categories		
Category	**Criteria**	**Hazard Statement**
1	Flash point < 23°C and initial boiling point ≤ 35°C (95°F)	Extremely flammable liquid and vapor
2	Flash point < 23°C and initial boiling point > 35°C (95°F)	Highly flammable liquid and vapor
3	Flash point ≥ 23°C and ≤ 60°C (140°F)	Flammable liquid and vapor
4	Flash point ≥ 60°C (140°F) and ≤ 93°C (200°F)	Combustible liquid

* Table derived from **OSHA 1910.1200 Appendix B**.

For a flammable liquid to ignite, three conditions must exist simultaneously:

1. The concentration of the vapor must be between the upper and lower flammable limits of the substance;
2. An oxidizer (usually the oxygen in air) must be present; and
3. A source of ignition must be present.

Taking measures to remove any of these conditions will prevent the start of a fire. Additional information on flammable liquids can be found in the **Flammable Liquids-Safe Work Practices** fact sheet.

1. Work Practices

- Work with flammable liquids in a properly functioning chemical fume hood, glovebox, or other source of local ventilation.
- Keep flammable liquid containers closed when not in use.
- Control all ignition sources in areas where flammable liquids are used.
- Never heat flammable substances using an open flame.
- Use oil baths, steam baths, water baths, heating mantles, or hot air baths. Do not distill flammable substances under reduced pressure.
- Make sure that metal surfaces or containers where flammable substances are being used are properly grounded, discharging static electricity.
- Identify the locations of fire alarms, pull stations, safety showers, and other emergency equipment.

2. Storage

- Store flammable liquids in rated flammable storage or explosion-proof cabinets when not in use.
- Avoid venting of flammable storage cabinets for fire protection purposes. Seal vent openings with bungs.
- Label flammable storage cabinets with, at a minimum, the word “Flammable."
- Never store paper, cardboard, or other combustible material in flammable storage cabinets.
- Keep flammable storage areas free of ignition sources (e.g., electrical outlets, open flames, hot surfaces, static electricity, etc.).
- Never store more than 10 gallons of flammable liquids outside of a rated flammable storage cabinet in the laboratory.
- Avoid storing flammable liquids on floors.
- Ensure safety cans are approved by a nationally recognized testing laboratory, have a flash-arresting screen, spring-closing lid, spout cover, and are designed to safely relieve internal pressure when subjected to fire exposure.
- Ensure flammable liquid quantities in laboratories comply with UConn Fire Department standards.
- Ensure flammable liquids required to be kept cold are stored in rated refrigerators designed for flammable or explosive storage (i.e., contain no ignition sources such as exposed electrical contacts).
- Store flammable liquids separately from strong oxidizers, corrosives, and other incompatible materials.
- Never store flammable liquids in a location that blocks any route of egress.

B. Corrosive Chemicals

Corrosive chemicals can cause immediate damage to the skin, eyes, tissues, and other parts of the body upon contact. Some chemicals may be corrosive to metals. Both acidic ($pH < 4$) and alkaline ($pH > 10$) solutions can cause chemical burns. Severity is dependent primarily upon the concentration of the chemical and the duration of contact. Exposure to corrosive chemicals can produce ulcers, bleeding, bloody scabs, skin discoloration, alopecia, scars, and other serious conditions. Below is a table of common corrosive hazard classes, storage methods, and examples of each class:

Corrosive Liquid Types and Storage Guidelines		
Type	**Storage**	**Examples**
Inorganic Acids	Store in corrosives cabinet or on protected shelving and in secondary containment away from organic acids and bases. Avoid storage on metal shelving.	Hydrochloric acid, Hydrofluoric acid, Phosphoric acid, and Sulfuric acid
Inorganic Bases	Store in corrosives cabinet away from acids and organic bases. Polyethylene secondary containment bins are recommended for storage of bases in cabinets.	Ammonium hydroxide, Potassium hydroxide, and Sodium hydroxide
Organic Acids	Store in corrosives cabinet, on protected shelving, or in secondary containment away from inorganic acids and bases. Avoid storage on metal shelving.	Acetic acid, Trichloroacetic acid, and Formic acid
Organic Bases	Store in a corrosive cabinet away from acids and inorganic bases. Polyethylene secondary containment bins are recommended for storage of bases in cabinets.	Hydroxylamine, Tetramethylethylene diamine, and Triethylamine
Oxidizing Acids	Store alone or in a separate secondary containment bin with compatible, inorganic acids.	Perchloric acid, Nitric acid, and Chromic acid

1. **Work Practices**

- Work with corrosive chemicals in a functional chemical fume hood, glovebox, or other source of local ventilation.

- Properly label secondary containers with the appropriate chemical name and hazard class.
- Work within 10 seconds of a properly functioning eyewash station and safety shower.
- Keep the corrosive chemical containers closed when not in use.
- Add acid in small quantities to the water to prevent spattering. Never add water to an acid.
- EHS recommends tight-fitting safety goggles, chemical-resistant gloves, lab coats, long pants, and closed toed footwear for all work with corrosive liquids.
- Research with hydrofluoric acid requires calcium gluconate gels or benzalkonium chloride in the immediate work area for emergency use. Expired calcium gluconate gels and/or benzalkonium chloride solutions must be replaced prior to research with hydrofluoric acid.

2. Storage

- Segregate inorganic acids from organic acids in separate cabinets or in separate secondary containment bins within the same cabinet.
- Store acids and bases in separate cabinets.
- Segregate acids from reactive metals (e.g., sodium, potassium, etc.), azides, and cyanides.
- Oxidizing acids, such as concentrated perchloric and nitric acids, must be stored in a separate cabinet or secondary containment bin, away from organic materials and other incompatible chemicals.

C. Particularly Hazardous Substances

The *OSHA Occupational Exposure to Hazardous Chemicals In Laboratories* standard requires that employees take additional safety precautions while working with particularly hazardous substances (PHSs) (i.e., carcinogens, reproductive toxins, and chemicals with a high degree of acute toxicity). These provisions include:

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

Lab personnel using carcinogens, reproductive toxins, and acutely toxic chemicals are responsible for complying with the OSHA standard. Principal investigators or laboratory managers are responsible for training, providing appropriate personal protective equipment (PPE), and approval of procedures using PHSs in their labs.

1. Identification of Particularly Hazardous Substances

a. Carcinogens are substances or a mixture of substances which cause cancer or increase its incidence. Carcinogenic chemicals are classified into one of three categories based on the strength of evidence in experimental studies. The categories are listed below:

- Category 1A- Known Human Carcinogens
- Category 1B- Presumed Human Carcinogens
- Category 2- Suspected Human Carcinogens

The category of carcinogenic substances can be identified through safety data sheets (SDSs). Carcinogenic chemicals listed as Category 1A, Category 1B, or Category 2 must be managed as particularly hazardous substances.

Carcinogenic chemicals listed in the following groups by OSHA, the National Toxicology Program, and International Agency for Research on Cancer Monographs can be used to identify carcinogenic chemicals to be managed as PHSs:

- **Occupational Safety and Health Administration**
- **National Toxicology Program** – Groups "Known To Be Human Carcinogens" and "Reasonably Anticipated To Be Human Carcinogens"
- **International Agency for Research on Cancer** – Groups 1, 2A, and 2B

b. Reproductive toxicity refers to substances or a mixture of substances that affect the reproductive capabilities including adverse effects on sexual function and fertility in adult males and/or females, as well as adverse effects on the development of the offspring. Reproductive toxicity is divided into three categories:

- Category 1A- Known human reproductive toxicant,
- Category 1B- Presumed human reproductive toxicant, and

- Category 2- Suspected human reproductive toxicant.

Category 1A, Category 1B, and Category 2 reproductive toxicants as well as reproductive toxins known to have effects on or via lactation, as indicated in safety data sheets (SDSs), must be managed as particularly hazardous substances.

c. Acute toxicity refers to substances producing adverse health effects following oral or dermal administration of a single dose of a substance, or multiple doses given within 24 hours, or an inhalation exposure of 4 hours. OSHA currently characterizes acutely toxic substances into categories based on toxicity by the oral, dermal, or inhalation routes. The categories are listed in the table below:

Acute Toxicity Hazard Categories				
Exposure Route	**Category 1**	**Category 2**	**Category 3**	**Category 4**
Oral (mg/kg bodyweight)	≤ 5	>5 and ≤ 50	>50 and ≤ 300	>300 and ≤ 2000
Dermal (mg/kg bodyweight)	≤ 50	>50 and ≤ 200	>200 and ≤ 1000	>1000 and ≤ 2000
Inhalation - Gases (ppmV)	≤ 100	>100 and ≤ 500	>500 and ≤ 2500	>2500 and ≤ 20000
Inhalation - Vapors (mg/l)	≤ 0.5	>0.5 and ≤ 2.0	>2.0 and ≤ 10.0	>10.0 and ≤ 20.0
Inhalation - Dusts/Mists (mg/l)	≤ 0.05	>0.05 and ≤ 0.5	>0.5 and ≤ 1.0	>1.0 and ≤ 5.0

*Table derived from **OSHA 1910.1200 App A**.

Individuals can identify the category of an acutely toxic substance through the safety data sheet (SDS). Acutely toxic chemicals listed as Category 1 or Category 2 must be managed as particularly hazardous substances. Procedures for Category 3 and Category 4 acutely toxic substances must be evaluated by the principal investigator.

2. Management of Particularly Hazardous Substances

In addition to the University **standard operating procedures** required for research with hazardous chemicals as outlined in the CHP, researchers working with PHSs also must follow the additional procedures listed below.

a. Establishment of a Designated Area in the Lab

PHSs must only be used and stored in designated areas. The designated area may be a fume hood, glovebox, an entire laboratory, or other suitable area recognized by authorized personnel working in the lab. Signs must be posted in designated areas where particularly hazardous substances are used. The sign(s) for individual or multiple hazards must state:

DANGER	DANGER	DANGER
CANCER HAZARD	**REPRODUCTIVE HAZARD**	**ACUTE TOXICANT**
Authorized Personnel Only	**Authorized Personnel Only**	**Authorized Personnel Only**

*The design of the sign(s) can be modified to suit the needs of the lab.

The designated area may be used for other research purposes if laboratory personnel comply with University standard operating procedures, training requirements, and emergency procedures.

b. Use of Containment Devices Such as Fume Hoods or Gloveboxes

Most research using PHSs should take place in a fume hood, glovebox, or other suitable containment device. If use of a suitable containment device is not feasible, EHS must be contacted to discuss alternative containment and/or safety protocols.

Fume hoods being used for research with PHSs should be running between 80-120 linear feet per minute, have a green sticker, and have been inspected by EHS within the last year. If the fume hood has a yellow or red sticker or has not been tested in the last year, contact **EHS**.

Gloveboxes can be used when protection from atmospheric moisture or oxygen is necessary, or when a fume hood does not provide adequate protection from exposure. Gloveboxes must be installed and maintained per manufacturer specifications to ensure proper function.

c. Procedures for Safe Removal of Contaminated Waste

All waste generated using PHSs must be managed as **hazardous waste**. Each waste container must:

- Be labeled with "Hazardous Waste" stickers or tags provided by EHS;
- Use full chemical names to describe the waste (i.e., no chemical abbreviations or symbols);
- List chemical contents as a percentage of the total volume;
- Be stored alone or with other compatible chemicals;
- Be stored in containers with tight-fitting caps or lids (i.e., containers must remain closed unless directly adding waste to the container); and
- Be stored at or near a satellite accumulation area sign.

Disposable personal protective equipment (e.g., chemical resistant gloves) and materials contaminated with PHSs must be managed as hazardous waste. **Chemical Waste Pick-Up Forms** must be submitted to EHS to ensure proper disposal of PHSs from labs. Review the **UConn Chemical Waste Disposal Manual** to ensure compliance with empty container management and other requirements that may be specific to PHS waste.

d. Decontamination Procedures

- All equipment, glassware, and materials used for research with PHSs must be properly decontaminated.
- Procedures must outline methods of decontamination for all equipment that comes in contact with PHSs.
- Manufacturer's instructions and specifications must be used to identify proper methods to decontaminate equipment.
- Decontamination of equipment should take place in fume hoods, if feasible.
- All work surfaces must be decontaminated at the end of the procedure or workday.

- Equipment contaminated with PHSs must never be removed from the lab without complete decontamination.

After decontamination procedures are completed, trained laboratory personnel must properly wash hands and any other body areas that have potentially contacted PHSs.

D. Highly Reactive and Explosive Chemicals

Hazardous chemicals in laboratories may be explosive or highly reactive. Others may become explosive when they contact incompatible materials (e.g., heat, fire, water, air, etc.) or are allowed to dry out, decompose, or encounter sources of friction or mechanical shock. Due to the high hazards associated with such compounds, appropriate procedures, control measures, personal protective equipment, and training are required. Failure to comply with safety measures can lead to explosions, fires, property damage, or serious injuries.

1. Classes of Highly Reactive and Explosive Chemicals

Many chemicals are classified as highly reactive or potentially explosive. A table of the hazard classes, pictograms, and examples of each class is listed below.

Classes of Highly Reactive and Explosive Chemicals		
Hazard Class	**Pictogram**	**Examples**
Chemicals that produce flammable gases when in contact with water		Alkali metals, calcium carbide, metal alkyls, Grignard reagents, sodium hydride, and zinc powders
Explosives		Benzoyl peroxide, dinitrophenol, lead azide, nitroglycerin, nitrocellulose, and picric acid (dry)

Organic peroxides		Butadiene (inhibited liquid monomer), diisopropyl ether, potassium metal, potassium amide, sodium amide, and vinylidene chloride
Pyrophoric liquids		tert-Butyllithium, diethylzinc, Grignard reagents, tributylphosphine, and trimethyl aluminum
Pyrophoric solids		Alkali metals, finely divided metals, metal hydrides, and white phosphorus
Self-Heating		Carbon (activated) potassium sulphide, anhydrous thiourea dioxide, and titanium disulphide
Self-Reactive		2,2'Azobisisobutyronitrile

2. Procedures for Highly Reactive and Explosive Chemicals

Due to the inherent risks involved with the use of explosive or highly reactive chemicals, measures must be taken to assess the risks and control hazards prior to engaging in active experimentation. Conducting "dry runs" of high hazard experiments is recommended to reinforce proper techniques, safety measures, and emergency procedures. The guidelines listed below must be followed when handling high hazard chemicals.

a. Administrative Controls

- Ensure safety training is provided by the principal investigator or other qualified person to all researchers working with highly reactive or potentially explosive chemicals. **Documentation** of the contents of the training, date of training and signatures of the trainer and trainee are required.
- Ensure proper licensing/permitting, oversight of students, security measures, and recordkeeping are maintained by the principal investigators for research with explosives. Contact EHS for more information.
- Develop lab-specific standard operating procedures (**LSOPs**) for high hazard chemicals.
- Use the minimum amount of chemical(s) needed to achieve the desired outcome.
- Avoid working alone with highly reactive or explosive chemicals.
- Never deviate from standard operating procedures unless previously discussed and agreed upon with the principal investigator.
- Alert other individuals working in the lab on what experiment is being conducted, the potential hazards, and when the experiment will be run.
- Restrict access to areas where high-scale reactions are taking place.

b. Engineering Controls

- Perform research involving highly reactive or explosive chemicals in a properly functioning fume hood, glovebox, or with another form of ventilation approved by the principal investigator or laboratory manager.
- Ensure the principal investigator or laboratory manager has approved properly rated safety shields, barricades, and/or guards, if required. Barriers should surround the hazardous area.
- Ensure reactions are shielded from each other and separated as far apart as possible, if more than one reaction is conducted simultaneously.
- Ensure equipment and materials are grounded to prevent static sparks from acting as ignition sources.

c. Work Practices

- Label all containers holding highly reactive or potentially explosive materials.
- Use non-sparking tools when stirring, cutting, or scraping potentially explosive compounds. Do not use metal or wooden devices.

- Ensure safety devices (e.g., high temperature controls, water overflow devices, etc.) are used to minimize potential incidents.
- Inspect chemicals known to become explosive when dry regularly (e.g., picric acid). Contact EHS if unstable chemicals stored in solvents have dried out.
- Label chemicals known to become explosive after a period of time (e.g., peroxide-forming chemicals) with the date the bottle was delivered to the lab and the date the bottle was first opened.
- Keep all sources of ignition away from reactive or explosive materials.
- Ensure a safety shower, eyewash station, and other safety equipment specific for the hazards involved are present in the laboratory.

d. Personal Protective Equipment

- Wear personal protective equipment as indicated in safety data sheets (SDSs) and the lab's **Workplace Hazard Assessment Form**.
- At a minimum, wear lab coats, appropriate gloves, clothing that covers the legs, closed-toed footwear, and ANSI Z87.1-certified eyewear when working with explosive or highly reactive chemicals.
- Ensure lab coats are appropriately sized, buttoned, and fit properly to cover as much skin as possible. Principal investigators or laboratory managers must determine if flame-resistant lab coats are required.
- Ensure face shields that protect the entire face and throat are worn, if required by the principal investigator or laboratory manager.
- Ensure leather and/or other suitable gloves (e.g., Nomex) are worn if lab personnel must reach behind a shielded area while a hazardous experiment is in progress or when handling high hazard chemicals, if required by the principal investigator or laboratory manager.

e. Storage

- Store in a designated storage area or cabinet with limited access.
- Purchase and maintain a proper magazine for the storage of explosives. Contact EHS for more information.
- Ensure additional storage precautions (e.g., a flammable storage refrigerator, a ventilated gas cabinet, etc.) required for certain compounds are available and maintained.
- Store away from incompatible materials and ignition sources such as open flames, hot surfaces, spark sources, and direct sunlight.

- Store in compatible secondary containment bins to contain highly reactive or explosive chemicals in the event of a leak or spill.
- Never store unlabeled chemicals.

E. Compressed Gas Cylinders

Compressed gases can pose serious hazards when mishandled. Damage to the valve or integrity of a cylinder can result in a large release of potential energy, transforming the cylinder into a potential rocket or fragmentation bomb. Safe management of cylinders requires both an understanding of the chemical hazards associated with each gas (e.g., corrosive, explosive, flammable, inert, oxidizing, toxic, or a combination of hazards) as well as an awareness of the other physical hazards resulting from the high pressures contained in each cylinder (e.g., asphyxiation, decompression, etc.). Safety data sheets (SDSs) must be reviewed prior to the handling, storage, or transport of any pressurized gas. In addition, training must be provided by principal investigators, laboratory managers, or a qualified vendor when new gases, or new equipment that uses compressed gases, are brought into laboratories.

1. Types of Gases under Pressure

The Occupational Safety and Health Administration (**29 CFR 1910.1200- Appendix B**) classifies gases under pressure based on pressure, temperature, and physical state. The four categories and criteria for gases under pressure are listed in the table below:

Types of Gases Under Pressure		
Category	**Criteria**	**Examples**
Compressed gas	A gas which, when under pressure, is entirely gaseous at -50°C (-58°F), including all gases with a critical temperature ≤ -50°C (-58°F)	Helium, Nitrogen, Oxygen, and Argon
Liquefied gas	A gas which, when under pressure, is partially liquid at temperatures above -50°C (-58°F). A distinction is made between:	Ammonia, Carbon dioxide, Propane

	▪ High pressure liquefied gas: a gas with a critical temperature between -50°C (-58°F) and +65°C (149°F); and ▪ Low pressure liquefied gas: a gas with a critical temperature above +65°C (149°F).	
Refrigerated liquefied gas	A gas which is made partially liquid because of its low temperature	Liquid Nitrogen
Dissolved gas	A gas which, when under pressure, is dissolved in a liquid phase solvent.	Acetylene

*Table derived from **OSHA 1910.1200 Appendix B**.

2. Work Practices

- Do not accept cylinders from manufacturers without appropriate labels. OSHA-compliant labels are required on each cylinder.
- Never write on cylinder labels. Labels are required to be free of markings for proper identification and safe transport.
- Ensure a cylinder cap or regulator valve is always in place.
- Secure each cylinder with a chain, strap, or cable to a wall or lab bench that can support the weight of the cylinder.
- Ensure cylinder restraints (e.g., chain, strap, etc.) are secured at least halfway up the body of the cylinder.
- Make sure cylinder restraints remain tight to restrict cylinder movement.
- Secure cylinders individually (i.e., one restraint per cylinder), unless cages, racks, or stands are designed to support multiple cylinders.
- Obtain gas cylinders in returnable canisters whenever feasible. Fees associated with the proper disposal of non-returnable canisters (e.g., lecture bottles) may be charged to the principal investigator or department.
- Order bottles with the lowest cylinder pressure possible for its intended purpose.
- Bond and ground all cylinders, lines, and equipment used with flammable compressed gases.
- Ensure electrical equipment used with flammable compressed gases (e.g., hydrogen) is designed by the manufacturer for use with flammable gases and approved by the principal investigator or laboratory manager.
- Never drag, roll, or slide cylinders.
- Ensure the regulator and cylinder remain accessible.

- Do not place cylinders where they may become part of an electric circuit.
- When discharging gas into a liquid, use a trap or suitable check valve to prevent liquid from returning to the cylinder or regulator.
- Ensure appropriate personal protective equipment is being worn for the specific gases being used.

3. Regulators, Piping and Fittings

- Use only the regulator designed for the specific gas being used.
- Ensure regulator valves remain closed when equipment is not in use.
- Ensure regulators, valves, hoses, and distribution lines are free of oil or grease and examined for leaks or other damage before each use.
- Make sure valves, piping, and fittings are rated for the pressures, temperatures, and gases being used.
- Do not force threads that do not fit.
- Avoid mixing different brands and types of tube fittings. Construction of parts is brand-specific, and they are usually not interchangeable.
- Never use parts with damaged or partly stripped threads.
- Never use oil or lubricants on equipment used with oxygen, unless specifically approved for the application (e.g., Krytox).
- Never use silver or copper piping for acetylene or ammonia.
- Never use cast iron piping for chlorine or hydrogen.
- Do not use tools to open a cylinder valve if it cannot be opened by hand. Contact the UConn contracted vendor or manufacturer and have cylinder replaced.

4. Tubing and Hoses

- Label all gas lines with the chemical name leading from a compressed gas supply.
- Ensure instrument connective tubing and hoses are rated and compatible for the gases being used.
- Inspect tubing frequently and replace when necessary.
- Do not use Tygon® or plastic tubing for most pressure work. These materials can fail under pressure or thermal stress.
- Never use Teflon™ tape on CGA (Compressed Gas Association) fittings (i.e., straight thread) if the seal is made by metal-to-metal contact. Use of Teflon™ tape causes the threads to spread and weaken, increasing the likelihood of leaks.

- Do not lay tubing/hoses connected to compressed gas cylinders across floors or aisles where they could create a trip or fall hazard.
- Avoid sharp bends of copper tubing. Copper tubing can crack with repeated bending.
- If using ammonia, never use brass, copper, or other incompatible tubing materials.
- Do not mix different brands and types of tubing. Parts are usually not interchangeable.
- Consult with the gas manufacturer if you are unsure about the specific connection for your cylinders.

5. Pressure-Relief Devices

- Properly size and configure pressure-relief devices and associated fittings (tubing, connectors, etc.) to provide a sufficient rate of pressure relief while preventing over-pressurization.
- Properly vent pressure-relief devices that may discharge toxic, corrosive, flammable, or otherwise hazardous or noxious materials.
- Do not install valves or other shutoff devices between pressure-relief devices and the equipment they are to protect.
- Do not install shutoff valves downstream of the relief device.
- Ensure that the relief vent is not blocked or restricted.
- Ensure tubing and piping downstream of pressure relief devices is at least the same diameter as the fitting on the vent side of the relief device.
- Ensure only qualified persons perform maintenance work on pressure-relief devices.

6. Storage and Disposal

- Store all cylinders upright.
- Store in cool, well-ventilated areas (e.g., no cold rooms) away from direct sunlight and sources of heat and ignition.
- Do not expose cylinders to temperatures exceeding 125°F.
- Never heat a cylinder to raise internal pressure.
- Segregate and store all cylinders based on hazard class.
- Keep the number of cylinders to a minimum.
- Do not store cylinders where heavy-moving objects may strike or fall on them.
- Store compressed gas cylinder away from exit routes.

- Restrict access by unauthorized personnel to cylinder storage areas.
- Do not store corrosives near gas cylinders. Corrosive vapors from mineral acids can deface markings and damage valves.
- Store oxidizing gases at least 20 feet away from flammable chemicals (e.g., hydrogen) or separate by a firewall at least 5 feet high with a fire resistance rating of 30 minutes.
- Store cylinders containing corrosive and toxic gases (e.g., arsine, ammonia, carbon monoxide, chlorine, ethylene oxide, fluorine, hydrogen sulfide, hydrogen cyanide, phosgene, silane, etc.) in locations with suitable exhaust (e.g., ventilated gas cabinet, fume hood, etc.).
- Separate and secure full and empty cylinders.
- When returning an empty cylinder, close the valve, secure the cylinder cap, label the cylinder "EMPTY" and contact the UConn contracted vendor or manufacturer to remove the cylinder from the lab.

7. Transport

- Wear protective eyewear, at a minimum, while transporting gas cylinders.
- Ensure cylinder caps remain in place (i.e., never transport a cylinder with a regulator in place).
- Transport one cylinder at a time.
- Move cylinders on an approved cart and secure with a strap or chain.
- Never drag cylinders or roll them on their sides.
- Contact the UConn contracted vendor to transport cylinders between buildings, or as needed.

F. Cryogenic Liquids

A cryogenic liquid is defined as a liquid with a boiling point below -90°C (-130°F) at 101.3 kPa (14.7 psi) absolute. Commonly used cryogenic liquids include liquid nitrogen, helium, and oxygen. Solid carbon dioxide (i.e., dry ice) is not a cryogen but can still be hazardous when not handled properly. Most cryogenic liquids are odorless, colorless, and tasteless when vaporized. When cryogenic liquids are exposed to the atmosphere, the cold boil-off gases condense the moisture in the air, creating a highly visible fog. Hazards associated with cryogenic liquids are listed in the table below:

Cryogenic Liquid Hazards	
Hazard	**Description**
Adhesion	Contact with tanks, piping, or equipment containing cryogenic liquids can cause skin to stick to the surface, tearing the skin during removal.
Asphyxiation	Cryogenic liquids can displace oxygen in the atmosphere due to large liquid-to-gas volume displacement ratios, typically about 700:1.
Explosion due to rapid expansion	Large liquid-to-gas ratios can lead to rapid pressure changes as cryogenic liquids vaporize. All cryogens can condense sufficient moisture from the air leading to freezing and blockage of the openings to storage vessels. Explosions can result from the build-up of trapped gases in the container.
Extreme cold and frostbite	Cryogenic liquids can freeze human tissue upon contact resulting in cold burns and frostbite.
Flammability	Liquid hydrogen has a wide flammability range, 4% to 74% in air, and requires a small amount of energy for ignition. To prevent formation of explosive mixtures in air, no ignition sources are allowed where liquid hydrogen is stored or handled. Any planned use of liquid hydrogen or other flammable cryogenic liquid must be reviewed by UCFD.
Oxygen-enriched air	Vaporization of liquid oxygen in an enclosed area can cause oxygen enrichment, which may cause or intensify a fire. Although oxygen does not burn, it will support combustion. Combustible materials (e.g., oil, grease, etc.) will become more likely to ignite, burn more vigorously, and may explode when exposed to oxygen-enriched materials. Any planned use of liquid oxygen must be reviewed by UCFD.

1. Work Practices

- Read the safety data sheet for each cryogenic liquid prior to use.
- Avoid eye or skin contact.

- Work in a well-ventilated location. Avoid closets, cold rooms, and other locations with little or no ventilation. A leak in such an area could cause an oxygen-deficient atmosphere.
- Consider ventilation monitors or oxygen deficient sensors and alarms. Check the monitors and alarms before and during cryogen use.
- Examine containers and pressure relief valves for defects or signs of damage prior to each use. Never use a container that has defects or damage. Contact a cryogenic vendor for assistance.
- Do not allow liquid oxygen or oxygen-enriched air to contact organic materials.
- Never touch uninsulated pipes or vessels containing cryogenic liquids.
- Carefully select working materials and equipment used with cryogenic liquids. Cryogenic liquids may alter the physical characteristics of many materials, making them brittle and leading to failure.
- Use non-metallic tongs or tongs with insulated handles to add or remove materials from cryogenic liquids.
- Verify there is pressure relief for any place where a pressure build-up could occur.
- Push (do not pull) Dewars with wheels if they need to be moved, unless otherwise instructed by the manufacturer. Pulling Dewars on wheels increases the risk of tipping.
- Do not ride on elevators when outside vendors are delivering cryogenic liquids.
- Schedule large Dewar fills during normal business hours when staff are available to assist. If after-hours access is needed, it is recommended that other lab personnel be nearby to assist.
- If Dewars must be moved, clear all obstacles from the pathway before transport. Contact the UConn contract vendor or manufacturer for assistance with moving cylinders if necessary.
- If a Dewar pressure relief valve fails and causes improper or frequent venting, leave the lab, post a warning sign on the door(s) to the lab to prevent access and dial 911.

2. Personal Protective Equipment (PPE)

- Wear ANSI Z87.1-certified safety goggles when working with cryogenic liquids. Safety glasses do not provide sufficient protection.
- Wear a face shield together with safety goggles when filling Dewars or transferring cryogenic liquids from one container to another.

- Wear appropriate gloves designed for cryogenic liquids; do not leave skin exposed. Gloves must be loose-fitting to allow for quick removal if a cryogen leaks or is spilled into them.
- Do not immerse gloves into cryogenic liquids. Most cryogenic gloves are designed for splash protection only.
- Do not wear metal jewelry or watches.
- Wear closed-toed footwear when handling cryogenic liquids. Leather will shed the spilled liquid better than canvas or other absorbent materials.
- Consider working in an apron made of leather or another non-absorbent material. Most clothing material will absorb spilled liquid cryogens, increasing the risk of skin exposure.
- Review the Workplace Hazard Assessment to identify the specific PPE required by the principal investigator or laboratory manager.

3. Storage

- Store cryogens in well-ventilated areas to prevent oxygen deficiency.
- Use only approved storage vessels that have pressure relief valves.
- Never adjust, block, or plug a pressure relief valve.
- Avoid contact with moisture during storage to prevent ice plugs in relief devices.
- Never store a cryogen in a sealed, airtight container at a temperature above the boiling point of the cryogen; the pressure resulting from the production of gaseous carbon dioxide or nitrogen may lead to an explosion.
- Periodically check container necks for ice plugs; core out ice plugs if present.
- Keep heat sources away from cryogenic liquids.
- Never store cryogens or dry ice in cold rooms due to the risk of asphyxiation.

G. Peroxide-Forming Chemicals

Peroxide-forming compounds can become more hazardous if not managed properly. Several commonly used solvents (e.g., diethyl ether, tetrahydrofuran, dioxane, etc.) can form explosive peroxides through a relatively slow oxidation process in the presence of heat, light, moisture, oxygen, or impurities. Since most peroxide-forming chemicals are packaged in atmospheres containing air, even unopened bottles can produce peroxides. Refrigeration does not eliminate peroxide formation and stabilizers only slow down formation.

Peroxide formation becomes evident when crystalline solids are observed in the liquid itself or around the bottle's cap. Some peroxide-forming chemicals produce solutions that appear cloudy. Once peroxides have formed, they can detonate when combined with other compounds or when disturbed by unusual heat, mechanical shock, impact, or friction. Visual inspection is the safest way to determine peroxide formation. If you suspect the presence of peroxides, contact EHS.

The following table lists common peroxide-forming chemicals present in laboratories. The lists of chemicals in the table below are not comprehensive. Safety data sheets (SDSs) must be reviewed to indicate whether chemicals being utilized in the laboratory can form explosive peroxides.

Peroxide-Forming Chemical Classes and Management		
Category 1. Severe Peroxide Hazard Without Storage		
Description:	Chemicals will form explosive levels of peroxides without becoming concentrated. A severe peroxide hazard will occur after prolonged storage, especially after exposure to air.	
Management:	Label these items with a date of receipt and date of opening. Test for peroxides monthly and discard after 3 months (even if unopened).	
Examples		
Butadiene (liquid monomer)	Isopropyl ether	Sodium amide
Chloroprene (liquid monomer)	Potassium amide	Tetrafluoroethylene (liquid monomer)
Divinyl acetylene	Potassium metal	Vinylidene chloride (liquid monomer)
Category 2. Peroxide Hazard Due to Concentration		
Description:	These chemicals become a peroxide hazard when they are concentrated through distillation or evaporation and can pose a serious explosion hazard.	
Management:	Label these items with a date of receipt and date of opening. Test for peroxides 6 months after opening (if	

	uninhibited) and dispose of within 12 months, unless peroxide testing confirms no peroxides are present.	
Examples		
Acetal	Diacetylene	2-Hexanol
Acetaldehyde	Dicyclopentadiene	Methylacetylene
Benzyl alcohol	Diethylene glycol dimethyl ether (diglyme)	Methyl cyclopentane
2-Butanol	Diethyl ether	Methyl-isobutyl ketone
Cumene	Diethylene glycol	2-Pentanol
2-Cyclohexen-1-ol	Dimethyl ether	1-Phenylethanol
Cyclohexene	Dioxanes	Tetrahydrofuran
Cyclooctene	Ethylene glycol dimethyl ether (glyme)	Tetrahydronaphthalene
Cyclopentene	4-Heptanol	Vinyl ethers
Category 3. Autopolymerize as a Result of Peroxide Accumulation		
Description:	These chemicals may explode when relatively small quantities of peroxides form. These chemicals normally have an inhibitor added by the manufacturer to prevent peroxide formation. Do not store inhibited chemicals in an inert atmosphere.	
Management:	Label these items with a date of receipt and date of opening. Dispose of inhibited chemicals after 12 months and uninhibited items within 24 hours of use.	
Examples		
Acrylic acid	Chlorotrifluoroethylene	Vinylacetylene
Acrylonitrile	Methyl methacrylate	Vinyl chloride
Butadiene	Styrene	Vinyl pyridine
Chloroprene	Vinyl acetate	Tetrafluoroethylene
Category 4. May Form Peroxides		
Description:	These chemicals are normally stable but may form peroxides under certain conditions.	

Management:	Review the safety data sheet to determine under which conditions peroxide formation is expected and manage accordingly. Consult EHS if crystals are present.	
Examples		
Acrolein	2-Ethylbutanol	1-Pentene
Benzyl ethyl ether	Ethyl vinyl ether	Phenoxyacetyl chloride
Benzyl methyl ether	n-Hexyl ether	Phenyl-o-propyl ether
Cyclooctene	Isoamyl ether	n-Propyl ether
p-Dibenzyloxybenzene	Isobutyl vinyl ether	Tetrahydropyran
Diethyl fumarate	b-Isopropoxypropionitrile	Triethylene glycol diacetate
Diethyl acetal	2-Methoxyethanol	1,3,3-Trimethoxypropene
Dimethoxymethane	3-Methoxyethyl acetate	1,1,2,3-Tetrachloro-1,3-butadiene
Di(1-propynl) ether	b-Methoxypropionitrile	4-Vinyl cyclohexene
2-Ethoxyethyl acetate	1-Octene	Vinylene carbonate

1. **Administrative Controls**

- Identify chemicals that form peroxides through safety data sheets.
- Solvents containing low levels of free radical scavengers such as butylated hydroxytoluene (BHT) should be used whenever the presence of the stabilizing species does not interfere with the intended application.
- Order only the quantities needed. Many uninhibited peroxide-forming chemicals (e.g., diethyl ether, tetrahydrofuran, etc.) used in labs must be tested or discarded after 12 months.
- Use older bottles before opening or ordering new ones.
- Store in tightly sealed, opaque containers when not in use. Protect peroxide-forming chemicals from air, heat, moisture, light, or impurities.
- Do not store liquid peroxides or solutions of peroxides at a temperature below the point where the peroxide freezes or precipitates. Peroxides in this form are shock and heat sensitive.

- Store away from incompatible materials such as strong oxidizing and reducing agents.
- If materials must be refrigerated, store in a flammable or explosion-proof refrigerator.
- Test for peroxides or discard bottles that have exceeded the manufacturer's expiration date. If the chemical has been tested, the test date must be written on the side of the bottle.

2. Work Practices

- Visually check for crystalline solids before each use.
- Label each bottle with the date received and the date the bottle was first opened.
- Never distill peroxide-forming solvents unless they have been tested and known to be free of peroxides. Peroxides concentrated in the residue can pose a serious explosion hazard.
- Peroxide test strips must be used to test for the presence of peroxides. Testing must NOT be conducted on peroxide-forming chemicals that are of unknown age or origin, if crystals or discolored solids are present, or if the liquid appears cloudy. Contact **EHS** for evaluation and disposal.
- Conduct procedures inside a chemical fume hood. The principal investigator must determine whether work behind a protective shield is also required.
- Reduce the sensitivity of peroxides to heat and shock by dilution with inert solvents.
- Avoid using solutions of peroxides in volatile solvents. Solvent evaporation must be controlled to avoid dangerous concentration of the peroxide.
- Do not allow peroxides to contact iron; compounds of iron, cobalt, or copper; metal oxide salts; acids, bases; or acetone.
- Do not handle peroxides with metal spatulas or magnetic stirring bars that could leach iron. Teflon™, ceramic, or wooden spatulas and stirring blades are recommended.
- Do not allow open flames or sources of heat, sparks, friction, grinding, or impact near peroxides.
- Do not return unused peroxide-forming chemicals to the original container.

H. Nanomaterials

Nanotechnology involves the engineering, manipulation, and control of particles with lengths in two or three dimensions from 1 to 100 nanometers (1 nanometer is 1 billionth of a meter). In this size range, particles begin to exhibit unique characteristics that influence chemical, physical, and biological behaviors. Research on a nanometer scale involves the production, design, and examination of materials with specific properties related to shape, size, surface area, porosity, and chemistry. Though current and future applications involving nanomaterials hold considerable potential, the health effects associated with exposure are not yet clearly understood.

Exposure to nanomaterials can occur through inhalation, absorption, injection, or ingestion. Toxicity will depend on the route of exposure and physical and chemical properties of the nanomaterial. Nanomaterials with known hazardous properties (e.g., carcinogens, mutagens, reproductive toxicants, sensitizers, reactive metals, etc.) as well as those that are photo-reactive, have highly charged surfaces, are highly acidic/basic, soluble, fibrous (i.e., possess a high aspect ratio), and/or have other hazardous properties require further assessment and control measures.

The table below provides a general overview of nanomaterial activities, exposure sources, and engineering controls. Principal investigators or laboratory managers must determine the appropriate engineering controls, work practices, and personal protective equipment necessary for the operations and nanomaterials specific to their labs.

Nanomaterial-Related Activities in Labs and Controls			
State	**Activity**	**Exposure Source**	**Controls**
Bound or fixed nanostructures (polymer matrix)	Mechanical grinding, alloying, etching, lithography, erosion, mechanical abrasion, grinding, sanding, drilling, heating, or cooling	Nanomaterials may be released during grinding, drilling, and sanding. Heating or cooling may damage the matrix, allowing release of nanomaterial.	Local exhaust ventilation, laboratory fume hood (with HEPA-filtered exhaust), HEPA-filtered exhausted enclosure (glovebox), biological safety cabinet class II type

			A1, A2, vented via thimble connection, or B1 or B2
Liquid suspension, liquid dispersion	Synthesis methods: chemical precipitation, chemical deposition, colloidal, electrodeposition crystallization, laser ablation (in liquid), pouring and mixing of liquids containing nanomaterials, sonication spraying/spray drying	Exposures may result from aerosols of nanoparticles during sonication or spraying, equipment cleaning and maintenance, spills, or product recovery (dry powders).	Laboratory fume hood (with HEPA-filtered exhaust) HEPA-filtered exhausted enclosure (glovebox) Biological safety cabinet class II type A1, A2, vented via thimble connection, or B1 or B2
Dry dispersible nanomaterials and agglomerates	Collection of material (after synthesis), material transfers, weighing of dry powders, mixing of dry powders	Exposures may occur during any dry powder handling activity or product recovery.	Laboratory chemical hood with HEPA-filtered exhaust, HEPA-filtered exhausted enclosure (glovebox), Biological safety cabinet class II, B1 or B2
Nanoaerosols and gas phase synthesis (on substrate)	Vapor deposition, vapor condensation, rapid solidification, aerosol techniques, gas phase agglomeration, inert gas condensation (flame pyrolysis, high temperature evaporation), or spraying	Exposures may occur with direct leakage from the reactor, product recovery, processing and packaging of dry powder, equipment cleaning, and maintenance.	Glovebox or other sealed enclosure with HEPA-filtered exhaust Appropriate equipment for monitoring toxic gas (e.g., CO)

*Table derived from DHHS (NIOSH) Publication Number 2012-147.

Prior to research, principal investigators or laboratory managers must evaluate and take measures to control:

- The procedure or operation;
- The ability of the material to become airborne;
- The frequency, duration, and quantity of the nanomaterials being used;
- Cleaning and maintenance procedures;
- Storage;
- Emergency response procedures; and
- Waste management.

1. Engineering Controls

- Work with nanomaterials in a properly functioning fume hood, glove box, ventilated enclosure, or other form of local exhaust, unless a risk assessment by the principal investigator or lab manager determines ventilation is not required and the nanomaterials pose no risk to lab personnel.
- Do not use positive pressure laminar flow hoods for protection from nanomaterials.
- Use equipment with high-efficiency particulate air (HEPA) filters for removal and/or cleaning of areas contaminated by nanomaterials.

2. Work Practices

- Ensure lab personnel working with engineered nanomaterials receive training on the associated hazards and risks. Documentation of training is recommended.
- Review the safety data sheet(s) prior to use.
- Avoid manipulating nanomaterials in open systems or in a free particle state (e.g., handling dry nanopowders on a bench top).
- Whenever possible, handle nanomaterials attached to substrates or in solutions to minimize airborne release.
- Avoid creating large, highly concentrated aerosols of combustible nanomaterials.
- Store liquid and solid nanomaterials in unbreakable, tightly sealed containers.
- Label secondary containers with a chemical name and hazard class(s), if applicable. Use the word "Nano" to differentiate from other containers.
- Close all containers when not in use.
- Work in an isolated area of the lab, preferably in a fume hood or approved ventilated enclosure. Post appropriate warnings to notify other lab personnel of the risks.

- Clean all working surfaces potentially contaminated with nanomaterials at the end of each experiment and the end of each day with a HEPA vacuum and/or wet wiping. Do not dry sweep or use compressed air.
- Clean contaminated clothing (e.g., lab coats) through an approved vendor.

3. Personal Protective Equipment

- Wear all personal protective equipment (PPE) specified in the safety data sheet(s) and Workplace Hazard Assessment Form.
- Wear ANSI Z87.1-certified eyewear while working with nanomaterials.
- Wear gloves impervious to the materials and/or chemicals being used.
- Wear long sleeve shirts, lab coats, and clothing that covers the legs (without cuffs).
- Remove contaminated gloves inside the fume hood or under local ventilation and place in sealed bags to prevent nanoparticles from becoming airborne.
- Wear respiratory and face protection in conjunction with ANSI Z87.1-certified eyewear, if required by the principal investigator or laboratory manager.
- Lab personnel required to wear respirators must comply with all requirements of the **UConn Respirator Program**.
- Wear closed-toed footwear. Disposable, over-the-shoe booties may be necessary to prevent tracking nanomaterials from the lab.

I. Controlled Substances

Controlled substances are drugs, immediate precursors, or other substances regulated under the Controlled Substances Act (CSA) by both the federal Drug Enforcement Administration (DEA) and the State of Connecticut - Department of Consumer Protection, Drug Control Division (CT-DCP). The DEA classifies controlled substances into five schedules based on their medicinal value, harmfulness, risk to public health, and potential for abuse and/or addiction. Schedule I controlled substances are the most restrictive. A comprehensive list of controlled substances, DEA drug code numbers, and CSA schedules is available on the **DEA website**. A summary of the schedules, descriptions, and examples of controlled substances is listed below:

Controlled Substance Schedules		
Schedule	**Description**	**Examples**
I.	Drugs, substances, or chemicals with no currently accepted medical use and a high potential for abuse.	Heroin, Marijuana, Lysergic Acid Diethylamide (LSD), Methaqualone
II.	Drugs, substances, or chemicals with a high potential for abuse, with use potentially leading to severe psychological or physical dependence.	Adderall, Cocaine, Fentanyl, Hydromorphone, Methadone, Methamphetamine, Meperidine, Oxycodone, Ritalin
III.	Drugs, substances, or chemicals with a moderate to low potential for physical and psychological dependence.	Anabolic steroids, Tylenol with codeine, ketamine, testosterone, buprenorphine
IV.	Drugs, substances, or chemicals with a low potential for abuse and low risk of dependence.	Xanax, Soma, Valium, Ativan, Talwin, Ambien, Tramadol
V.	Drugs, substances, or chemicals with lower potential for abuse than Schedule IV and consist of preparations containing limited quantities of certain narcotics.	Lomotil, Motofen, Lyrica, Parepectolin

Lab personnel authorized to work with controlled substances must maintain compliance with the **Controlled Substances Policy**.

J. Formaldehyde

Formaldehyde is used as an embalming fluid, tissue preservative, sterilizer, and fumigant in laboratories. In its purest form, formaldehyde is a toxic, flammable gas. In labs, the gas is more commonly dissolved in water and used as an aqueous solution called formalin. Formaldehyde is a skin and respiratory sensitizing agent that can trigger an allergic reaction in normal tissue after single or repeated exposures. It is also acutely toxic, corrosive, flammable, mutagenic, and a known human carcinogen.

The Occupational Safety and Health Administration (OSHA) prohibits employee exposure to formaldehyde above its established limits below:

Formaldehyde Exposure Limits		
Name	**Exposure Limit (parts per million)**	**Description**
Action Level	0.5	The action level is calculated as an 8-hour time-weighted average, which is the trigger for increased industrial hygiene monitoring and initiation of worker medical surveillance.
Permissible Exposure Limit (PEL)	0.75	The PEL (i.e., 0.75 parts formaldehyde per million parts of air) is measured as an 8-hour time-weighted average.
Short-Term Exposure Limit (STEL)	2	The STEL is the maximum exposure allowed during a 15-minute period.

Air monitoring, medical surveillance, and other requirements are required when lab personnel become exposed to formaldehyde at or above the action level, permissible exposure limit, or short-term exposure limit as well as when individuals develop signs and symptoms of overexposure. To ensure lab personnel are not overexposed to formaldehyde, periodic exposure monitoring is required. Lab personnel working with formaldehyde outside of properly functioning fume hoods must contact **Environmental Health and Safety** to schedule air monitoring.

K. Respirable Crystalline Silica

Crystalline silica (silicon dioxide) is a mineral in the earth's crust found in soil, sand, granite, and other types of rock. It is used in many materials such as concrete, glass, mortar, pottery, ceramics, and numerous other products. There are three forms of crystalline silica: quartz, cristobalite, and tridymite. Silica gels, commonly found in laboratories, are amorphous and are not covered by the **OSHA Respirable Crystalline Silica standard**.

Respirable crystalline silica includes the portion of airborne crystalline silica capable of entering the gas-exchange regions of the lungs if inhaled (typically particle sizes of

≤10μm). Respirable-sized particles are generated during high-energy operations like abrasive blasting, cutting, drilling, grinding, sawing, and crushing silica-containing materials. Exposure to respirable crystalline silica can lead to silicosis (a permanent scarring of the lungs), chronic obstructive pulmonary disease (COPD), lung cancer, kidney disease, autoimmune disorders, and other negative health effects.

OSHA requires additional controls and monitoring for employees exposed to respirable crystalline silica above the following exposure limits:

Respirable Crystalline Silica Exposure Limits		
Exposure Limit	**Definition**	**Required Action**
Action Level	The concentration of airborne respirable crystalline silica of 25 μg/m3, calculated as an 8-hour time-weighted average.	Exceeding the action level requires compliance with the OSHA standard and the University's Silica Exposure Control Plan.
Permissible Exposure Limit (PEL)	The concentration of airborne respirable crystalline silica of 50 μg/m3, calculated as an 8-hour time-weighted average.	Exceeding the PEL requires respiratory protection, compliance with the OSHA standard, and the University's Silica Exposure Control Plan.

Principal investigators, laboratory managers, and/or departments are required to assess the exposure of each employee who is or may reasonably be expected to be exposed to respirable crystalline silica at or above the action level. Engineering controls (e.g., fume hoods, HEPA-filtered exhaust systems, etc.) and work practice controls (e.g., cleaning using wet methods or HEPA-filtered vacuums) are required to keep employees below OSHA exposures limits.

Lab personnel are required to contact EHS if operations that generate respirable crystalline silica are being conducted and must comply with the **Silica in General Industry Exposure Control Plan**. A combination of air monitoring and/or use of objective data may be required to ensure employee exposures are at or below the action level. Additional monitoring, training, **respiratory protection**, and/or medical surveillance may be necessary if air monitoring data results exceed the action level or permissible exposure limit.

Note: The OSHA standard does not apply to occasional, brief exposures to respirable crystalline silica that last 15 minutes or less and occur no more often than once per day (e.g., using a hand-held drill for less than 15 minutes). However, dust control measures are still recommended.

L. Combustible Dusts

Combustible dusts are solids finely ground into particles, fibers, chips, chunks, or flakes that present a fire and/or explosion hazard when suspended in air under certain conditions. Types of dusts include, but are not limited to; metal dust, such as aluminum and magnesium; wood dust; plastic or rubber dust; biosolids; coal dust; organic dust, such as flour, sugar, and paper; and dusts from certain textiles. Different dusts of the same material can have different ignitability and explosive characteristics depending on particle size, shape, and moisture content.

For a fire or explosion hazard to exist, the following five conditions must be present: oxygen in air, a combustible dust, dispersion of dust particles, confinement of the dust cloud, and an ignition source. The explosion pentagon below provides a visual representation of these conditions.

When all five conditions are met, an initial dust explosion in equipment can cause accumulated dust to become airborne. If the airborne dust is ignited, it may cause one or more secondary explosions that can be more destructive than the primary explosion.

Lab personnel working with equipment that use or generate combustible dusts (e.g., labs involved with casting metal (i.e., foundry), using 3D printers with combustible powders, etc.) may be at greater risk of fires and dust explosions without suitable engineering controls and work practices in place.

Note: This does not apply to lab personnel using small quantities of combustible dusts in laboratory experiments.

Principal investigators or laboratory managers must conduct a dust hazard analysis to determine the appropriate engineering controls, work practices, administrative controls and PPE necessary for the operations and combustible dusts specific to their labs. **NFPA 652-19 Standard on the Fundamentals of Combustible Dust** can be used as a guide. The following requirements must be met when handling combustible dusts.

1. **Administrative Controls**

   - Ensure equipment and systems handling combustible dusts are designed, installed, and maintained in accordance with manufacturer requirements.
   - Consult safety data sheets (SDSs) to identify potential combustible dusts handled in the lab.
   - Assess laboratory operations to determine the potential for combustible dust formation and potential ignition sources.
   - Train individuals working with equipment that use combustible dusts on the hazards, procedures, equipment, maintenance, housekeeping, and emergency procedures.
   - Develop **lab-specific standard operating procedures** (LSOPs) that describe the steps and appropriate safety controls that must be followed prior to working with a piece of equipment using combustible dusts.

2. **Engineering Controls**

   - Work in a fume hood, use local exhaust ventilation, use a dust collection system, or another dust mitigation system, if feasible.

- Ensure that vacuum cleaners used for dust collection do not generate static electricity. All conductive components, including wands and attachments, must be bonded and grounded.
- Ensure equipment or enclosures with the potential to accumulate combustible dust have explosion/pressure relief vents that are directed to a safe location away from lab personnel.
- Separate equipment using combustible dusts with distance and barriers, if feasible.
- Bond and ground electrical equipment to control static electricity.
- Use appropriate electrical equipment and wiring for the work being performed.
- Minimize friction in belts, bearings, and other equipment with moving parts.
- Separate heated surfaces and heating systems from dust accumulation areas.

3. Work Practices

- Operate and maintain equipment in a manner that minimizes the escape of dust.
- Control open flames, sparks, and other ignition sources in areas where dusts may accumulate.
- Inspect labs for dust residues and dust accumulation regularly.
- Minimize dust accumulation on surfaces by implementing a regular cleaning schedule.
- Ensure that cleaning methods do not generate dust clouds.
- Keep lab surfaces free of unnecessary materials and equipment to facilitate cleaning and to minimize combustible dust accumulation.
- Wear personal protective equipment indicated in the workplace hazard assessment.

M. Lithium Batteries

Lithium batteries are commonly found in laptops, tablets, phones, and other equipment found in laboratories. They are normally safe to use when designed, manufactured, used, and charged properly. However, the use of poorly designed, defective, damaged, or improperly used batteries has resulted in fires leading to severe injuries and property damage. Lab personnel using lithium metal or lithium-ion batteries for research or teaching must ensure they:

- Purchase batteries, chargers, and associated equipment from manufacturers who certify their equipment to an appropriate test standard (e.g., UL 2054) and/or by a Nationally Recognized Testing Laboratory (NRTL), if feasible.
- Ensure batteries and chargers are purchased from the same manufacturer or an authorized distributor/reseller. Batteries from one manufacturer may not be compatible with a charger from another manufacturer.
- Follow the manufacturer's instructions for storage, use, charging, and maintenance.
- Remove devices and batteries from the charger once they are fully charged. Ensure batteries are not overcharged or left charging overnight.
- Store lithium batteries and devices in dry, cool locations, away from heat sources flammables, and other incompatible materials.
- Inspect batteries for signs of damage (e.g., cracks, bulges, leaks, smoke, elevated temperatures, etc.) before each use.
- Handle lithium batteries and devices that use lithium batteries with care. Avoid damage to batteries or devices.
- Remove damaged batteries from service. Never use a damaged battery.
- Limit the number of batteries being charged simultaneously to the greatest extent possible.
- Dispose of used or damaged batteries through EHS. Never dispose of lithium batteries in the regular trash.

Principal investigators and lab managers must ensure lab workers are aware of the hazards associated with lithium batteries and the proper procedures to follow for management and disposal.

N. Thorium and Uranium Compounds

Thorium and uranium compounds (e.g., thorium acetate, thorium nitrate, uranyl acetate, uranyl nitrate, etc.) are regulated as radioactive source materials by the Nuclear Regulatory Commission (NRC). Lab personnel handling or working with thorium and uranium compounds must complete online Uranium/Thorium Compound User Training developed by Radiation Safety through HuskySMS prior to use.

Radiation Safety is required to include the amounts of thorium and uranium in the University inventory. Prior to placing an order for thorium or uranium compounds, lab personnel must report the proposed quantities and location(s) of the compounds to

Radiation Safety. Failure to contact Radiation Safety prior to ordering may result in UConn exceeding regulatory limits. To minimize total quantities, Radiation Safety requires:

- Contacting Radiation Safety with the name and gram weight of the compound prior to ordering;
- Purchasing the smallest quantity for the desired application; and
- Sharing stocks with other researchers (Radiation Safety can provide a list of researchers possessing thorium and uranium compounds upon request).

Barcodes on empty chemical bottles previously containing thorium and uranium compounds must be sent to EHS prior to disposal for compliance with the Laboratory Chemical Inventory Program. Unwanted thorium and uranium compounds or waste containing thorium and uranium must be disposed of through Radiation Safety.

XV. Laboratory Equipment

Departments, principal investigators, laboratory managers, and other lab personnel are responsible for the proper usage and maintenance of equipment used in laboratories. Equipment used in labs must be installed and maintained as specified by the manufacturer. All repair and calibration work on laboratory equipment must be conducted by qualified personnel. Prior to purchasing or relocating equipment, principal investigators or laboratory managers must complete an Equipment Form to ensure the lab meets the spatial, mechanical, electrical, ventilation, and other requirements of the device. In addition to the general work practices for equipment listed below, lab personnel must also follow any additional requirements listed by the manufacturer.

A. Centrifuges

- Follow the manufacturer's instructions for safe operation.
- Ensure tubes or containers are balanced, hung properly, and not overfilled.
- Inspect tubes or containers for cracks or flaws before using them.
- Ensure that the lid is closed before starting the centrifuge. The disconnect switch should automatically shut off the centrifuge when the top is opened.
- Do not exceed a rotor's maximum rated speed.
- Do not overload a rotor beyond its maximum mass without reducing the rated rotor speed.
- Check O-rings and grease the seals per manufacturer specifications.

- Clean the rotors as specified by the manufacturer.
- Use, change out, and maintain rotor(s) specified by the manufacturer.
- Use local exhaust ventilation for samples containing flammable and/or hazardous materials.
- Inspect the components of the centrifuge each time it is used. Replace parts if signs of corrosion or cracks appear on the rotors, cone area, and/or tube cavity.

B. Heating Equipment

- Follow the manufacturer's instructions for safe operation.
- Never use laboratory ovens to prepare food for human consumption.
- Do not use ovens to dry volatile chemical samples.
- Do not dry glassware that has been rinsed with an organic solvent in an oven.
- Exhaust ovens as specified by the manufacturer.
- Do not use mercury thermometers to monitor oven temperatures. Use bimetallic strip thermometers.
- Use only hot plates with fully enclosed heating elements.
- Do not store flammable materials near hot plates.
- Use only heating mantles with a variable autotransformer to control the input voltage. Never plug them directly into a 110-V line.
- Never exceed the input voltage recommended by the mantle manufacturer.
- Avoid using water or other volatile substances near oil, salt, or sand baths.
- Monitor oil baths using a thermometer or other thermal sensing device to ensure temperatures do not exceed the flash point of the oil being used.
- Use thermal-sensing devices that turn off electric power to prevent overheating if an oil bath must be left unattended.
- Clamp thermocouples used by controlling devices to maintain contact with the medium or object being heated at all times.
- Mount oil baths on a stable horizontal support such as laboratory jacks. Avoid use of iron rings.
- Use metal pans or heavy-walled porcelain dishes over Pyrex glassware for containing oil baths.
- Do not heat seal containers or metal-containing objects in a microwave.
- Never operate microwave ovens with the doors open.
- Never use heat guns in areas with flammable liquids or vapors.

C. Pressure and Vacuum Systems

- Follow the manufacturer's instructions for safe operation.
- Conduct procedures involving high pressure vacuum systems in a properly functioning chemical fume hood.
- Use appropriate shielding for high pressure vacuum systems, if required by the principal investigator or laboratory manager.
- Ensure glass vessels are designed for the intended operation.
- Inspect glass vessels for cracks, scratches, or etching marks before each use.
- Do not allow water, solvents, and/or corrosive gases to be drawn into vacuum systems.
- Use a trapping device for distillation or similar operations requiring a vacuum.
- Ensure traps are appropriate for the materials (e.g., particulates, solvents, or reactive, corrosive, or toxic gases).
- Vent vacuum pumps to a suitable exhaust system.
- Drain and replace vacuum pump oil when it becomes contaminated. Contaminated pump oil must be disposed of through EHS.
- Use protective guards on belt-driven mechanical pumps.
- Use drip pans to contain leaks and dispose of contents regularly through EHS.

D. Refrigerators and Freezers

- Follow the manufacturer's instructions for safe operation.
- Flammable chemicals must be stored in an approved explosion-proof or flammable storage refrigerator or freezer.
- Chemicals stored in refrigerators or freezers must be compatible.
- Do not plug refrigerators or freezers into extension cords or power strips.
- Never store uncapped or partially opened containers (e.g., chemicals covered with aluminum foil, glass stoppers, wooden corks, etc.) of chemicals in a refrigerator.
- Samples and chemicals stored in refrigerators must be appropriately labeled.

E. Solvent Stills

- Follow the manufacturer's instructions for safe operation.
- Operate stills in a properly functioning chemical hood.
- Run stills during normal business hours if feasible.
- Use polycarbonate shields around the stills to protect lab personnel.

- Never use air to deactivate a still. Use argon, nitrogen, or another inert gas agreed upon by PI or laboratory manager.
- Never add solvents, indicators, or drying agents while the still is hot.
- Quench the still at the end of each procedure. Do not allow residual material to accumulate. Residual waste liquids/reactive metals must be disposed of as hazardous waste through EHS.

F. Miscellaneous Equipment

- Operate and maintain laboratory equipment in accordance with the manufacturer's specifications.
- Ensure equipment with moving or rotating parts is appropriately guarded or enclosed.
- Exclude ferromagnetic objects from the immediate vicinity of equipment that generates strong magnetic fields, such as a nuclear magnetic resonance (NMR) system.
- Ensure usage of 3D printers complies with **EHS guidelines** for safe use.
- Ensure equipment that exposes lab personnel to significant noise levels (e.g., ultrasonicator) is evaluated by EHS. Individuals exposed to noise sources of 85 decibels or greater for an 8-hour average duration must be entered into the **Hearing Conservation Program**.
- Ensure equipment that exposes lab personnel to radioactive isotopes or sources (e.g., electron capture detectors in gas chromatographs, liquid scintillation counters, etc.) is in full compliance with **Radiation Safety Manual**.
- Ensure all X-ray equipment complies with the **Analytical X-Ray Safety Program**.
- Ensure usage of Class 3B and 4 lasers comply with the **Laser Safety Manual**.

XVI. Medical Consultation and Medical Examinations

Principal investigators, laboratory managers, and lab personnel working in laboratories at the University must be afforded medical attention, including follow-up examinations, deemed necessary by the examining physician, under the following circumstances:

- Whenever an employee develops **signs or symptoms** associated with a hazardous chemical exposure;
- Where exposure monitoring reveals an exposure level 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;

- Whenever an accident such as a spill, leak, fire, explosion, or other occurrence results in the likelihood of a hazardous exposure; or
- At the request of the University Chemical Hygiene Officer.

All medical examinations and consultations shall be performed by or under the direct supervision of a licensed physician. Medical exams/consultations must be conducted within a reasonable timeframe from the date the incident occurred and shall be provided without cost or loss of pay to the employee.

XVII. Records and Recordkeeping

The University of Connecticut is required to maintain records of any monitoring results required to assess employee exposures to toxic or harmful chemicals in the course of employment in accordance with **29 CFR 1910.1020**, *Access to employee exposure and medical records*. EHS maintains records of the following information:

- Exposure monitoring results
- Training
- Fume hood inspections
- Laboratory inspections

Exposure monitoring results shall be preserved and maintained for at least 30 years. EHS also maintains separate databases regarding employee training, fume hood inspections, and laboratory inspections.

XVIII. Chemical Hygiene Plan Confirmation

The Chemical Hygiene Plan Confirmation is recorded through HuskySMS. Click on the **Chemical Hygiene Plan Confirmation** hyperlink to review the plan and comply with the requirement.

XIX. References and Additional Resources

- American Industrial Hygiene Association, Nanotechnology Working Group. (2015). Personal Protective Equipment for Engineered Nanoparticles. Retrieved from **https://www.aiha.org/government-affairs/PositionStatements/PPE%20for%20ENP_FINAL.pdf**
- Centers for Disease Control and Prevention, the National Institute for Occupational Safety and Health. (2012). General Safe Practices for Working with Engineered Nanomaterials in Research Laboratories. Retrieved from **https://www.cdc.gov/niosh/docs/2012-147/pdfs/2012-147.pdf**
- Centers for Disease Control and Prevention, the National Institute for Occupational Safety and Health. (2013). Occupational Exposure to Carbon Nanotubes and Nanofibers. Retrieved from **www.cdc.gov/niosh/docs/2013-145/pdfs/2013-145.pdf**
- Code of Federal Regulations. Title 40 - Protection of Environment. Part 261 - Identification and Listing of Hazardous Waste. (2012). Retrieved from **https://www.gpo.gov/fdsys/pkg/CFR-2012-title40-vol27/xml/CFR-2012-title40-vol27-part261.xml**
- Nano.gov. (n.d.) the United States National Nanotechnology Initiative. Retrieved from **https://www.nano.gov//**
- National Research Council. Prudent Practices in the Laboratory: Handling and Management of Chemical Hazards, Updated Version. (2011). National Academies Press, Washington, DC.
- NFPA 652. Standard on the Fundamentals of Combustible Dust (2019). National Fire Protection Association.
- United States Department of Labor, Occupational Safety and Health Administration. (n.d.). Safety and Health Topics – Nanotechnology. Retrieved from **https://www.osha.gov/dsg/nanotechnology/nanotechnology.html**
- United States Department of Labor, Occupational Safety and Health Administration. (2013). 29 CFR 1910.1200- Hazard Communication. Retrieved from **https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=standardsandp_id=10099**
- United States Department of Labor, Occupational Safety and Health Administration. (2013). 29 CFR 1910.1200 Appendix A – Toxic and Hazardous Substances – Health Hazard Criteria. Retrieved from **https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDSandp_id=10100**
- United States Department of Labor, Occupational Safety and Health Administration. (2013). 29 CFR 1910.1053. Respirable Crystalline Silica. Retrieved from **https://www.osha.gov/laws-regs/regulations/standardnumber/1910/1910.1053**
- United States Department of Labor, Occupational Safety and Health Administration. (2013). 29 CFR 1910.1200 Appendix B — Physical Hazard Criteria. Retrieved from **https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDSandp_id=10101**
- United States Department of Labor, Occupational Safety and Health Administration. (2019). Preventing Fire and/or Explosion Injury from Small and Wearable Lithium Battery Powered Devices. Retrieved from **https://www.osha.gov/sites/default/files/publications/shib011819.pdf**