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UCCS LABORATORY SAFETY MANUAL



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AA – Setting Up A Lab
AB – Storage Guidelines and Limits
AC - Job Hazard Analysis

1 Introduction

Research and education in laboratories, whether traditional science and engineering or art related involve a variety of hazards. It is the University of Colorado Colorado Springs (UCCS) policy to protect and promote the health and safety of faculty, staff, students and the environment. Faculty, staff and students who may be exposed to chemical and/or physical hazards in the learning and research environments should be informed of the nature of these hazards and how to protect themselves and others who may also be exposed.

1.1 Purpose

The purpose of this manual is to describe the proper use and handling practices and procedures to be followed by people working with hazardous chemicals and/or physical hazards in UCCS laboratories in order to protect them from potential health and physical hazards presented by chemicals or physical hazards used in the workplace, and to keep chemical exposures below specified limits. It is based on the recommendations of the National Research Council in their publication, "[Prudent Practices in the Laboratory – Handling and Disposal of Chemicals](#)".

It is intended to fulfill the requirements of the following regulations:

- Chemical Hygiene Plan - 29 CFR 1910.1450 "Occupational Exposure to Hazardous Chemicals in Laboratories"
- Hazardous Waste Management Plan – 40 CFR 262 and 6 CCR 1007-3
- Hazardous Waste Preparedness and Prevention Plan – 40 CFR 265 and 6 CCR 1007-3
- Hazard Communication Plan – 29 CFR 1910.1200
- Hazardous Materials Management Plan – Colorado Springs Fire Department

1.2 Campus Policy

The UCCS Executive Team has adopted a policy (400-002 Hazardous Materials Management) which states:

"University community members who handle hazardous substances on behalf of the University are required to maintain, use and dispose of such substances in accordance with the applicable CU Colorado Springs Hazardous Material Management Plan, State, Federal and Local laws and regulations as a condition of their employment, academic program or contractual agreement with the University. University community members should obtain assistance in ascertaining his/her obligations under these laws and regulations from the Department of Public Safety, Environmental Health and Safety Manager. Any community member who violates any such laws or instructions given by the Department of Public Safety, Environmental Health and Safety shall be deemed to have acted outside the scope of his/her authority."



1.3 Scope

This guideline applies to all UCCS operated (leased or owned) facilities and equipment (including vehicles). It also applies to any UCCS employee, volunteer or student worker who works directly with chemicals or other physical hazards, or is in close proximity to anyone conducting research using chemicals or other physical hazards which falls under federal and state regulations or guidelines who should be familiar with all portions pertinent to their work.

The degree of protection required is based on the potential hazard posed by the material under both ordinary and emergency working conditions. Issues and hazards specific to individual laboratories, including personnel training, should be addressed in a Laboratory Specific Safety Plan (LSSP) which based upon hazards may be required to be developed by designated laboratories. For purposes of this guideline, laboratory is defined in very broad terms as “a building, part of a building, or other place equipped to conduct scientific experiments, tests, investigations, etc. or in which chemicals or other physical hazards are utilized as a normal part of operations.” There is no requirement for significant chemicals to be present in order for the location to fall under this guideline. However, there are areas on campus which are not normally thought of as a laboratory that are subject to this guideline. The following is an example of areas subject to this guideline:

- Chemistry academic and research labs
- Biology academic and research labs
- Physics academic and research labs where chemical/physical hazards are present
- Engineering academic and research labs where chemical/physical hazards are present
- Health Sciences academic and research labs where chemical/physical hazards are present
- Biofrontiers Labs
- Photography Lab
- Pool Operations
- Facilities Chemical Storage/Use Operations
- Auxiliary Facilities Chemical Storage/Use Operations
- Art studios where chemical/physical hazards are present

This list is not intended as an exclusive list but rather as an example.

This plan discusses safe practices and procedures for research and educational laboratories and for day to day operations involving the use of hazardous materials. It is not intended to be a fully comprehensive reference but rather a starting reference. There may be chemicals, procedures and other circumstances in each laboratory that present unique or unusual hazards not addressed here; these hazards are best addressed by the principle investigator or supervisor of the respective laboratory with specific operating procedures developed in consultation with Environmental Health & Safety (EHS) if necessary. Further information on general chemical safety or specific items can be obtained through the Environmental Health & Safety (EHS) office.

1.4 Regulatory Status

UCCS is registered with the EPA as a Small Quantity Generator (SQG) of hazardous waste. It becomes the responsibility of each person to identify any possible hazardous waste that

he or she might be generating and then to assure that the waste is handled in a manner consistent with regulations.

Facilities at UCCS that have been issued a Hazardous Materials Operations permit by the City of Colorado Springs Fire Department include:

- Campus Services Building (including grounds garages, flammable storage building, bulk gas facility, paint shop, warehouse, auto bays and maintenance facilities/shops)
- Engineering & Applied Science Building (microelectronics laboratory, physics laboratories & shop)
- Centennial Hall (all laboratories, prep rooms, chemical stockroom & solvent storage)
- Osborne Center (all laboratories, stockrooms and prep areas, storage rooms & hazardous waste storage room)
- Recreation Center (including chemical storage rooms)

2 Duties and Responsibilities

An essential component of any laboratory chemical safety program is to clearly articulate and clarify the different roles and responsibilities of all the stakeholders. Clarifying roles and responsibilities for implementing the Laboratory Safety Manual (the Manual) will establish accountability, streamline processes, enhance safety and avoid confusion and questions in meeting the Manual's objective.

2.1 Departmental Responsibility

Departments should have firm commitments to safety and communicate this to all personnel. Each department is responsible for laboratory safety including but not limited to the following:

- Assure that renovations and designs for new laboratory facilities incorporate required safety features.
- Allocate the personnel and financial resources to facilitate a safe working environment, safe working practices and safe handling and disposal of hazardous materials and waste. EHS is funded to cover the cost of routine hazardous waste disposal for the campus.
- Decontaminate areas where hazardous or radioactive materials are used or stored. Thorough decontamination using EHS approved methods must occur prior to maintenance, renovation, reallocation of space, or closure. It is the responsibility of the lab coordinator, principal investigator and their department to arrange proper disposal of all hazardous materials prior to personnel relocations or facility closure.
- Delegate responsibility for safety to principal investigators and staff personnel (such as a safety liaison, lab coordinators, lab proctors or chemical hygiene officer) in a clear and unambiguous manner, and hold them accountable for those areas to which their responsibility pertains.
- Require participation in the Laboratory Registration Program. This program may require the development of a Laboratory Specific Safety Plan that should include personnel training, standard operating procedures, hazard identification, emergency action plans and record keeping.



2.2 Departmental Chemical Hygiene Officer

- Ensure all activities related to the use of hazardous chemicals and physical hazards in laboratories are conducted in a safe manner as well as in compliance with OSHA regulations as specified in 29 CFR Part 1910.1450, University Policy and Procedures and the UCCS Laboratory Safety Manual
- Participate in the campus Chemical Management Team.
- Work with principal investigator's (PI's) to develop, review and approve Job Hazard Analysis and Standard Operating Procedures detailing all aspects of proposed research activities that involve hazardous materials.
- Work with the PI's on the approval process for the purchase of highly toxic, reactive, or carcinogenic or other inherently hazardous materials.
- Investigate and complete a report for chemical or physical hazard related incidents and exposures in their department.
- Provide guidance with personal protective equipment selection based on the findings in the job hazard analysis.
- Disseminate chemical and physical hazard safety information throughout their department through emails, posting, and other forms of communications.
- Provide general chemical and physical hazard safety guidance to department staff, students and faculty.
- Facilitate the use of the Laboratory Registration Program by the Principal Investigators and department staff.

2.3 Principal Investigator, Laboratory Supervisor, Laboratory Proctor or other Faculty Member

- Monitor operations for safety, advising laboratory students and staff on safety matters, and serve as a focus for safety concerns of the laboratory staff.
- Ensure submission of a Laboratory Registration Form (Appendix A) for each distinctive non-academic instruction laboratory (i.e. R&D laboratory).
- Assist in the development of a Laboratory Specific Safety Plan (LSSP) (Appendix B) for each distinctive R & D laboratory for which they are responsible and for which a LSSP is required.
- Check the status or operation of general safety equipment such as fire extinguishers, drench hoses, safety showers and eyewash stations.
- Educate personnel in the procedures, safe operations and the use of personal protective equipment. Document this training. Appendix Q, R, W and W-2 are example documentation forms which can be utilized.
- Investigate accidents and near misses and report them to the appropriate supervisors, EHS and Risk Management.
- Conduct internal safety audits and recommend improvements.
- Monitor storage, labeling and use of hazardous materials.
- Ensure that the lab is in compliance with hazardous waste regulations and that student, staff and faculty receive formal, annual training (if applicable).
- Maintain safety related files, accident reports, safety equipment, and SDS.
- Maintain a complete written current inventory of all chemicals, gases, biological, lasers, radioactive and other hazardous materials in their areas.
- Familiarize yourself with the document Appendix U PI Responsibilities.
- Familiarize yourself with the document Appendix AA Setting Up a Lab



2.4 Employees and Students

- Follow all safety and health procedures specified in the Laboratory Safety Manual and the Laboratory Specific Safety Plan and by their laboratory supervisor.
- Complete required health and safety training sessions.
- Report accidents, unhealthy and unsafe conditions, near misses, and minor injuries to their supervisor,
- Notify their personal physician if any personal health conditions could lead to serious health situations in the laboratory. For example, someone with a compromised immune system may need to take extra precautions when working with biological agents.
- In conjunction with the PI, complete the On-the-Job Safety Training. Appendix Q, R, and W-2 are example documentation forms which can be utilized to record this training

2.5 Environmental Health & Safety (EHS)

- Review, evaluate and revise (if necessary) initially, and annually thereafter the UCCS Laboratory Safety Manual;
- Approve the provisions of the Manual and submit the Manual to the Chemical Management Team for adoption.
- Review and approve those procedures and/or hazardous chemicals specified in the Manual as requiring prior approval. This review process will also determine and specify conditions under which such procedures and/or hazardous chemical use may be conducted;
- Review ongoing and proposed programs in laboratory chemical safety and health and providing recommendations for program enhancements and improved compliance;
- Eliminate or curtail any activity considered to constitute a significant danger to the health and safety or the environment.
- Oversee the administration of the Manual and training;
- Provide advice and clarification in regard to the Manual;
- Conduct periodic unscheduled and planned inspections of University facilities to ensure compliance with the Manual.
- Provide a safe, efficient mechanism for the removal of hazardous wastes (excluding radioactive materials and compressed gases in cylinders larger than lecture bottle size and lecture bottle size cylinder which are non-returnable) from University laboratories and arranging for proper subsequent management and disposal of those wastes;
- Serve as a liaison on behalf of the University to regulatory agencies concerning regulatory compliance with occupational safety and health and environmental concerns, and
- Ensure that adequate records are kept of all inspections, exposure monitoring, emergency responses, and hazardous waste activities.

2.6 Other Departments

Other departments or agencies involved with various aspects of chemical safety include the following:

- Facilities Management is responsible for the maintenance and repair of the physical facilities including ensuring that safety devices installed as permanent improvements or installations of the building by Facilities Management or through Planning Design &



Construction, are in proper working condition (e.g. emergency eyewashes and showers, and fume hoods).

- Department of Public Safety and the Colorado Springs Fire Department provide emergency services (e.g. medical, fire, security).

3 Definitions

- Laboratory - a building, part of a building, or other place equipped to conduct scientific experiments, tests, investigations, etc. or in which chemicals or other physical hazards are utilized as a normal part of operations
- Chemical Hygiene Officer - an employee who is designated by the employer, and who is qualified by training and experience, to provide technical guidance in the development and implementation of the provisions of the Laboratory Safety Manual. This definition is not intended to place limitations on the position description or job classification that the designated individual shall hold within the employer's organizational structure.
- Regulated Area - a laboratory, an area of a laboratory or device such as a laboratory hood for which access is limited to persons who are aware of the hazards of the substances in use and the precautions required.
- Hazardous Chemical - any element, chemical compound or mixture of elements and/or compounds which is a physical hazard or a health hazard.

4 Laboratory Registration Program

Laboratory registration is the process the university uses to maintain laboratory emergency contacts and information, develop and maintain laboratory chemical inventories, and establish laboratory safety inspections for ensuring compliance with the UCCS Laboratory Safety Manual and thereby compliance with city, county, state and federal regulations.

The laboratory registration process requires the principal investigator of the laboratory or her/his designee (laboratory manager/supervisor, coordinator, etc.) to complete and submit a Laboratory Registration Form (Appendix A) and current Chemical Inventory. The Departmental CHO may complete one registration form for all academic labs within their department if the hazards present in the various labs are fundamentally the same.

Otherwise they may group labs together on registration forms (e.g. chemistry lab, biology lab, anatomy & physiology lab). The Laboratory Registration Program serves several purposes:

- it provides emergency contact information so that in the event of a power outage or other system failure, appropriate individuals can be notified so research is not lost or compromised;
- it provides emergency contact information that is readily available to emergency responders in case an emergency requires that we contact a person knowledgeable of the operations in the laboratory; and,
- it provides EHS with accurate information regarding the operations of the lab so that we can ensure that UCCS is providing a safe work/learning environment for our faculty, staff and students.

The completed forms are submitted to EHS for review. Based upon the hazards identified on the form, EHS may recommend that the laboratory needs to establish additional safety protocols such as a Laser Safety Plan. EHS will review the registration form with the PI in an effort to verify that appropriate engineering controls, standard operating procedures,



personal protective equipment and emergency equipment are in place to provide a safe work environment for the individuals working in the specified Laboratory.

On an annual basis, EHS will send out a verification copy to the PI or departmental CHO, who can then update any changes and/or verify that nothing has changed. This will assist in having accurate, up-to-date information. Each semester, EHS may request updated employee rosters (see Appendix A-1 Laboratory Registration Personnel Update Form).

5 Laboratory Specific Safety Plan

In addition to being subject to the guidelines found in this Laboratory Safety Manual, all non-academic laboratories may be required to develop a Laboratory Specific Safety Plan (LSSP) (Appendix B). Unless specifically requested by EHS academic labs do not require a LSSP. EHS has developed a fill-in-the-blank LSSP (Appendix B) (available on the EHS website www.uccs.edu/pusafety/environmental.html). The LSSP template can work as a self-audit to help ensure that personnel are proactively addressing concerns about chemical, physical and potential health exposures. In addition to the LSSP, laboratories may also have to develop or incorporate additional safety related plans based on the hazards present in the specified laboratory. The LSSP in conjunction with the Laboratory Registration form serves several purposes:

- it is intended to clearly specify the potential hazards in the laboratory and the designated safety protocols intended to mitigate these hazards;
- it is intended to assist labs in identifying weaknesses in their safety preparedness;
- it is intended to identify those individuals who require training

Completed forms should be submitted to EHS prior to commencing operations. Please contact EHS at 719-255-3212 if you have any questions, concerns, or need guidance relating to the information discussed in this Plan. (A fill-in the blank LSSP form is available on the EHS website www.uccs.edu/pusafety/environmenta.html)

6 Hazard Awareness and Identification

6.1 Overview

You need to be familiar with the hazardous chemical substances you are working with in the laboratory. Being able to recognize the physical and health hazards of a chemical before you handle it is very important. Once the potential hazards of a chemical have been determined, you can take the appropriate steps in the handling and storage of that chemical to protect yourself and others.

In addition, you need to recognize other hazards which may be present in the laboratory such as biohazards, lasers, and radiological hazards.

6.2 Chemical Hazard Identification

An integral part of hazard communication is hazard identification. With few exceptions, chemical containers used and stored at UCCS must be labeled to identify their contents. Labeling is important to prevent accidental misuse and inadvertent mixing of incompatible chemicals. Proper labeling facilitates quick decision-making and action in an emergency (i.e.,

spill, exposure, fire, etc.), avoiding the expense of handling, management, and disposal of unknown chemicals.

Everyone who works with hazardous chemicals should know how to read and interpret hazard information. Signs, labels, placard, and symbols alert employees to the known hazards in a particular location.

Labeling Requirements by Type of Container

Specific labeling requirements vary with the type of container. Any media can be used to label containers as long as it is resistant to smearing and fading. Old labels must be completely defaced or removed when reusing containers, unless the old label accurately describes the new contents.

- **Permanent containers** - those containers as received from the manufacturer or containers to which you have transferred a material for storage. Permanent containers must be labeled with specific information as discussed in Section 6.2.2
- **Durable containers** - containers that are not provided by the manufacturer but which hold chemicals that will be used only in one work area⁴, usually for longer than one day and by more than one person. Examples include stock solutions and dilutions of chemical products. Durable containers must be labeled with the following information: chemical name and concentration; date of preparation and preparer's initials. Generally they should also bear a NFPA diamond as described in Section 6.2.1 below.
- **Transient containers** - containers that will be used to hold chemicals for one work shift or less *and* that will be under the direct control of the person filling the container. No labeling is required for these containers until they are no longer under the control of the person who prepared the material. Examples include solutions that will be used immediately in an experiment, cleaning solutions or paint that will be used by the end of a shift. Transient containers can easily be inadvertently left unlabeled at the end of the day, so consideration should be given to labeling them in accordance with the requirements for durable containers whenever possible. If a transient container is left unattended in an unsecured area, it must be labeled as for durable containers

The table below summarizes the information required on different container labels.

| Information Required on Label | Permanent Container | Durable Container | Transient Container |
|---------------------------------|---------------------|-------------------|---------------------|
| Product Name | • | • | • |
| Hazard Symbols (classification) | • | ⊛ | |
| Signal Word | • | ⊛ | |
| Hazard Statements | • | ⊛ | |
| Precautionary Statements | • | ⊛ | |
| Supplier Identification | • | • | |
| Date of preparation | | • | |
| Preparer's initials | | • | |

⊛ a NFPA label can be utilized to meet these requirements

Special Circumstances

Small containers, such as vials and test tubes, can be labeled as a group by labeling the outer container (*i.e.* rack or box). Alternatively, a placard can be used to label the storage location for small containers (*i.e.* shelf, refrigerator, *etc.*)

Labels must be replaced if they become illegible.

Other Identification requirements

- Refrigerators and freezers need content identification and whether or not they are explosion-proof.
- Chemical storage cabinets are required to have content identification signage with one or more of the Hazardous Class symbols.

6.2.1 NFPA Labels

The National Fire Protection Association (NFPA) diamond in the illustration below is one method of identifying chemical hazards. NFPA uses a scale of 0 – 4 to rate each hazard, with 0 indicating “no hazard” and 4 indicating the most extreme hazard. The following is a detailed explanation of the NFPA hazard classification codes:

a. Health (Blue):

- 4 - Can cause death or major injury despite medical treatment
- 3 - Can cause serious injury despite medical treatment
- 2 - Can cause injury. Requires prompt medical treatment
- 1 - Can cause irritation if not treated
- 0 - No hazard

b. Flammability (Red):

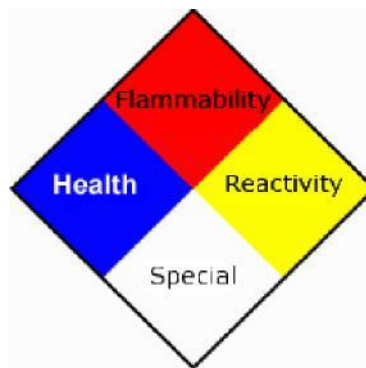
- 4 - Very flammable gases or liquids
- 3 - Can ignite at normal temperatures
- 2 - Ignites with moderate heat
- 1 - Ignites with considerable preheating
- 0 - Will not burn

c. Reactivity (Yellow):

- 4 - Readily detonates or explodes
- 3 - May detonate or explode with strong initiating force or heat under confinement
- 2 - Normally unstable, but will not detonate
- 1 - Normally stable. Unstable at high temperature and pressure
- 0 - Normally stable and not reactive with water.

d. Specific Hazard (White):

- Oxidizer – OX
- Acid – ACID
- Alkali – ALK
- Corrosive - COR
- Use No Water - W
- Radioactive – (see image at right)



Many chemicals fall under more than one hazard class. Extra care should be taken when handling or storing chemicals with multiple hazards.

6.2.2 Manufacturer Labels

The manufacturer's label will contain 6 categories of information.

1. Product identification:

Names or numbers used on a hazardous product label or in a safety data sheet. They provide a unique means by which the product user can identify the chemical substance or mixture.

- Chemical identity required for substances
- For mixtures either:
 - All the ingredients contributing to the hazard of the mixture/alloy, or
 - All the ingredients contributing to any health hazards presented by the product other than irritation and aspiration.

2. Pictograms of the hazards for this product:

It is a symbol inside a diamond with a red border, denoting a particular hazard class (e.g., acute toxicity/lethality, skin irritation/corrosion, etc.).

3. Signal Word – Warning or Danger:

One word used to indicate the relative severity of hazard and alert the reader to a potential hazard on the label and safety data sheet. The GHS includes two signal words:

- “Warning” for less severe hazard categories and;
- “Danger” for more severe hazard categories.

4. Hazard Statements about the specific hazards of this product:

Phrases assigned to each hazard category that describes the nature of the hazard.

Examples of hazard statements are: “Harmful if swallowed,” “Highly flammable liquid and vapor” and “Harmful to aquatic life.”

- Describe the hazards covered by the GHS
- Indicate the degree of severity of the hazard
- Text of the statements has been harmonized
- Harmonized statements are assigned to each hazard class and category, and have been codified (a numbering system has been applied to them for ease of reference)

Physical Hazards – H2XX

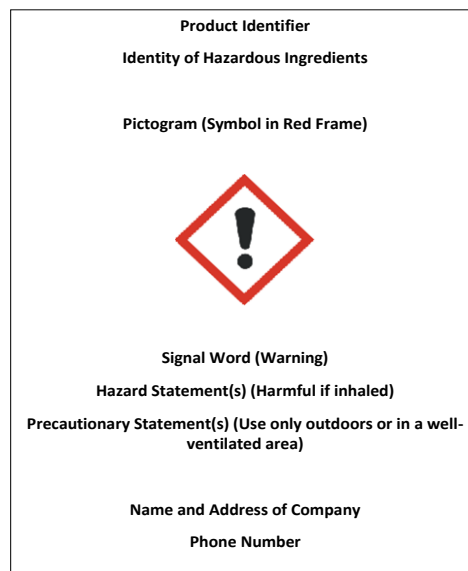
Health Hazards – H3XX

Environmental Hazards – H4XX

Example: H318 Causes serious eye damage

5. Precautionary statements regarding handling or storage of this product:

Phrases that describe recommended measures that should be taken to minimize or prevent adverse effects resulting from exposure to a hazardous product, or improper storage or handling of a hazardous product. These phrases cover prevention, response, storage, and disposal of products





- Precautionary statements are required. The GHS includes possible statements, but they have not yet been harmonized
 - There are 5 types of statements:
 - General – P1XX
 - Prevention – P2XX
 - Response – P3XX
 - Storage – P4XX
 - Disposal – P5XX
 - These have been assigned to hazard classes and categories, and codified (numbered).
 - Example: P280 Wear eye protection/face protection.
 - Some systems may choose to illustrate precautionary information using pictograms. These are not harmonized in the GHS.
6. Manufacturer's name and contact information:
Under the GHS supplier identification would include the name, address and telephone number of the manufacturer or supplier of the substance

Labels must be legible, in English, and prominently displayed. Other languages may be displayed in addition to English. Chemical manufacturers, importers, and distributors who become newly aware of any significant information regarding the hazards of a chemical must revise the label within six months

Whenever possible a date of receipt needs to be added by the user to the label.

Exceptions

Exceptions to the labeling requirements include the following items:

- Consumer products (e.g., hair spray)
- Food and food products labeled in accordance with the Food, Drug and Cosmetic Act
- Samples and specimens received in a lab for testing when the exact composition is not known
- Pesticides labeled in accordance with the Federal Insecticide, Fungicide, and Rodenticide Act
- Non-toxic and harmless chemicals are also exempt from other labeling requirements so long as they are labeled with the chemical name. If you have a labeling question please refer to [EH&S](#).










6.3 Classification of Chemical Hazards

The hazard a chemical presents depends on its physical and toxicological properties. Chemicals are considered a physical hazard if they are flammable or reactive (i.e., unstable—including explosives, organic peroxides, monomers, pyrophorics, and water reactives), or if they are combustible liquids, oxidizers or compressed gases. Chemicals that present a physical hazard are classified according to their hazardous properties. Chemicals that can cause reversible or irreversible damage to the human body are considered health hazards and are classified as toxics. This classification includes systemic poisons, irritants, carcinogens, asphyxiates, teratogens, mutagens, anesthetics and corrosives. Be aware that many chemicals exhibit multiple hazards, in which case, the more prevalent hazard must be considered. Contact EHS for help in identifying chemical hazards if you are unsure or need further guidance on proper handling.

The new GHS system has identified groups of hazards. Defined criteria are used to assign a hazard classification

| | |
|-----------------------|---------------|
| Physical Hazards | 16 categories |
| Health Hazards | 10 categories |
| Environmental Hazards | 2 categories |

The following diagram depicts the pictograms used in the GHS, with the hazard classes they are applied to. Whenever they appear on a label or safety data sheet, they need to be contained within a red border.

| GHS Pictograms and Hazard Classes | | |
|---|---|--|
|  |  |  |
| <ul style="list-style-type: none"> • Oxidizers | <ul style="list-style-type: none"> • Flammables • Self-reactives • Pyrophorics • Self-heating • Emits flammable gas • Organic peroxides | <ul style="list-style-type: none"> • Explosives (1.1-1.4) • Self-reactives • Organic peroxides |
|  |  |  |
| <ul style="list-style-type: none"> • Acute toxicity (severe) | <ul style="list-style-type: none"> • Corrosive to metals • Skin corrosion • Serious eye damage | <ul style="list-style-type: none"> • Gases under pressure |
|  |  |  |
| <ul style="list-style-type: none"> • Carcinogenicity • Respiratory sensitization • Toxic to reproduction • Specific target organ toxicity (repeated) • Germ cell mutagenicity • Aspiration hazard | <ul style="list-style-type: none"> • Aquatic toxicity (acute) • Aquatic toxicity (chronic) | <ul style="list-style-type: none"> • Acute toxicity (harmful) • Skin/eye irritation • Skin sensitization • Specific target organ toxicity (single) • Hazardous to the ozone layer |

6.3.1 Oxidizers

An oxidizer is a material that yields oxygen readily to cause or enhance the combustion (oxidation) of organic matter. Materials that do not contain oxygen can also be oxidizers because of their ability to accept electrons. Examples: nitrates, permanganates, dichromates, peroxides, nitric acid, perchloric acid and chlorine.

6.3.2 Flammables

A flammable is any solid, liquid, vapor or gas that ignites easily and burns rapidly. A flammable solid is a solid, other than an explosive, that ignites readily and burns vigorously. Examples: magnesium, sulfur, decaborane, and anhydrous sodium sulfide.



A flammable liquid is a liquid that gives off vapors readily ignitable at room temperature. The Department of Transportation (DOT) defines it as a liquid with a flash point at or below 141°F, and NFPA and OSHA define it as a liquid with a flash point below 100°F. (The flash point of a liquid is the temperature at which sufficient vapors are given off by the liquid to form an ignitable mixture with air.) Many common organic solvents have flash points well below room temperature, including acetone, ethyl ether, hexane and benzene.

A flammable gas is a gas that at normal atmospheric pressure forms a flammable mixture with air. Examples: hydrogen, acetylene and propane.

Conditions for a Fire

Improper use of flammable liquids can cause a fire. The following conditions must exist for a fire to occur:

- Flammable material (i.e., fuel) must be present in sufficient concentration to support a fire.
- Oxygen or an oxidizer must be present.
- An ignition source (i.e., heat, spark, etc.) must be present.

When working with flammables, always take care to minimize vapors which act as fuel.

6.3.3 Combustible liquids

The DOT defines a combustible liquid as a liquid with a flash point above 141°F and below 200°F. NFPA and OSHA define it as a liquid with a flash point at or above 100°F but below 200°F. These liquids, even though not classified as flammable liquids, still present a significant fire hazard. Examples: kerosene, glacial acetic acid and phenol.

6.3.4 Reactives

A chemical is reactive, or unstable, if it has a tendency to undergo chemical reaction either by itself or with other materials with the release of energy. Undesirable effects such as pressure build-up, temperature increase or the formation of noxious, toxic or corrosive byproducts may occur because of the chemical's reactivity to heating, shock, direct contact with other materials or other conditions in use or in storage. Reactives can be divided into the following hazards:



6.3.5 Pyrophoric

A pyrophoric is a material that ignites spontaneously in air. Pyrophoric chemicals are also known as air-sensitive compounds or as spontaneously combustible. Examples: the Alkali metals (sodium, potassium), hydrides (lithium aluminum hydride) and white phosphorus. Prior to procuring a pyrophoric chemical or compound, PI's must file a Hazardous Chemical Procurement and Use Authorization (Appendix X) form with EHS.

6.3.6 Organic peroxides

Organic peroxides are those organic compounds containing the bivalent -O-O- structure. These chemicals are very unstable and may be explosive. A common organic peroxide is benzoyl peroxide. Refer to Appendix I for specific peroxide management guidelines and a list of common peroxide forming chemicals.

6.3.7 Explosives.

A material is classified as explosive if it produces a sudden, almost instantaneous release of pressure, gas and heat when subjected to abrupt shock, pressure or high temperature. Examples: "dry" picric acid (2, 4, 6-trinitrophenol), 2, 4, 6-trinitrotoluene (TNT) and nitroglycerine. Prior to procuring an explosive chemical or compound, PI's must file a Hazardous Chemical Procurement and Use Authorization (Appendix X) form with EHS.



6.3.8 Monomers

Under appropriate conditions, monomers undergo polymerization, in which the monomers combine with each other to form repeating structural units, or a polymer. If not controlled, polymerization can occur at a rate that releases large amounts of energy that can cause fires, explosions or burst containers. Examples: formaldehyde and styrene.

6.3.9 Water reactive

A water reactive material is one that by contact with water becomes spontaneously flammable or gives off a flammable or toxic gas. Examples: the Alkali and Alkaline Earth metals, hydrides (sodium borohydride) and strong acids (sulfuric acid).

6.3.10 Toxics

A toxic is any chemical that, when ingested, inhaled or absorbed, or when applied to, injected into, or developed within the body in relatively small amounts, by its chemical action may cause damage to biological structure and/or disturbance of biological function.



The biological effects – whether beneficial, indifferent or toxic – of all chemicals are dependent on a number of factors, including:

- Dose (the amount of chemical to which one is exposed)
- Duration of exposure (both length of time and frequency)
- Route of entry:
 - Ingestion
 - Absorption through the skin
 - Inhalation



- Injection
- Individual response and history
- One's exposure to other chemicals
- Mixing the toxin with other chemicals

NOTE: *Inhalation and dermal absorption are the most common methods of chemical exposure in the workplace.*

The most important factor in toxicity is the dose-time relationship. In general, the more toxin to which an individual is exposed, and the longer they are exposed to it, the stronger their physiological response will be. However, an individual's response can also depend on several other factors, including:

- Health
- Gender
- Genetic predisposition
- An individual's exposure to other chemicals
- Previous sensitization
- Chemical mixtures

NOTE: *When a person becomes sensitized to a chemical, each subsequent exposure may often produce a stronger response than the previous exposure.*

NOTE: *Combining a toxic chemical with another chemical can increase the toxicity of either or both chemicals.*

IMPORTANT: *Minimize exposure to any toxic chemical.*

Damage can also be acute (immediate) or chronic (delayed). Acute toxicity is the effect manifested on short exposure or single contact. Chronic toxicity is the effect observed when a toxic substance acts on the body over time. This can be due to multiple or continuous exposure.

Examples of acute toxins include the following:

- Hydrogen cyanide
- Hydrogen sulfide
- Nitrogen dioxide
- Ricin
- Organophosphate pesticides
- Arsenic

IMPORTANT: Do not work alone when handling acute toxins. Use a fume hood to ensure proper ventilation, or wear appropriate respiratory protection if a fume hood is not available.

Examples of chronic toxins include the following:

- Mercury
- Lead
- Formaldehyde

Damage can be local (direct) or systemic (indirect). Local toxicity is the effect of a substance on the body area that has been exposed to the substance. Systemic toxicity is the effect of a substance on body tissue after absorption into the bloodstream.

Many systemic toxins are organ or system specific and can be classified as:

- Hematotoxins. Chemicals that affect blood-forming tissues. Examples: cyanides and benzene.
- Neurotoxins. Chemicals that affect the nervous system. Examples: carbon disulfide, mercury, methanol, and Botulinum toxin.
- Nephrotoxins. Chemicals that damage the kidneys. Examples: chloroform and carbon tetrachloride.
- Hepatotoxins. Chemicals that damage the liver. Examples: ethanol and carbon tetrachloride.

6.3.11 Corrosives

Corrosives are materials that by direct action are damaging to body tissue or corrosive to metal. Damage can range from minor skin irritation to actual physical disruption of body tissue. Note that corrosives are also physical hazards. Examples of the different types of corrosive chemicals are listed below:



- Acidic corrosives:
 - Inorganic Acids
 - Hydrochloric acid
 - Nitric Acid
 - Sulfuric acid
- Organic Acids
 - Acetic Acid
 - Propionic acid
- Alkaline, or basic, corrosives
 - Sodium hydroxide
 - Potassium hydroxide
- Corrosive dehydrating agents
 - Phosphorous pentoxide
 - Calcium oxide
- Corrosive oxidizing agents:
 - Halogen gases
 - Hydrogen peroxide (concentrated)
 - Perchloric acid
- Organic corrosive:
 - Butylamine

Health Consequences

Extreme caution should be taken when handling corrosive chemicals, or severe injury may result.

- a. Concentrated acids can cause painful and sometimes severe burns.
- b. Inorganic hydroxides can cause serious damage to skin tissues because a protective protein layer does not form. Even a dilute solution such as sodium or potassium hydroxide can saponify fat and attack skin.

- c. At first, skin contact with phenol may not be painful, but the exposed area may turn white due to the severe burn. Systemic poisoning may also result from dermal exposure.
- d. Skin contact with low concentrations of hydrofluoric acid (HF) may not cause pain immediately but can still cause tissue damage if not treated properly. Higher concentrations of HF (50% or greater) can cause immediate, painful damage to tissues.

6.3.12 Compressed gas

A compressed gas is any material which at room temperature and atmospheric pressure is a gas, but is contained under pressure as a compressed, liquefied or dissolved gas. Compressed gases present a physical hazard due to the storage pressure, but can also exhibit overt hazards such as, flammability, corrosivity, or toxicity. Examples: hydrogen (compressed gas), acetylene (gas dissolved in a solvent) and chlorine (liquefied gas).

Compressed gases in the laboratory present chemical and physical hazards. The gases may be toxic, corrosive, flammable, or explosive (reactive). If compressed gases are accidentally released, they may cause the following:

- Depleted oxygen atmosphere, potentially resulting in asphyxiation (includes inert gases)
- Fire or explosion
- Adverse health effects from chemical exposure
- Physical damage to facilities or injuries to personnel as a result of the sudden release of potential energy

Cylinders that fall or are knocked over or dropped can be very dangerous and can cause serious injuries. If a valve is knocked off a compressed gas cylinder, the cylinder can become a high speed, potentially lethal projectile.

IMPORTANT: Cylinders can travel through walls much like a torpedo travels through water. They can cause structural damage, severe injury, and even death.

Because disposal of compressed gas cylinders is difficult and expensive, be sure to arrange a return agreement with suppliers prior to purchase.

6.3.13 Cryogenic Materials

A cryogenic material is one which is a gas at room temperature that has been cooled to a temperature where it condenses to a liquid. Cryogenic materials present a physical hazard due to their extremely cold temperatures (less than -150°C). Examples: liquid nitrogen (LN₂), liquid oxygen and liquid helium.

Cryogenic fluids are extremely cold liquefied gases, such as liquid nitrogen or liquid oxygen, and are used to obtain extremely cold temperatures. Most cryogenic liquids are odorless, colorless, and tasteless. When cryogenic liquids are exposed to the atmosphere, however, they create a highly visible and dense fog.

Cryogenics pose numerous hazards. A person who is exposed to cryogenics can have significant health consequences. All cryogenics, with the exception of oxygen, can displace breathable air and can cause asphyxiation. Cryogenics can also cause frostbite on exposed skin and eye tissue.

IMPORTANT: Be aware of the tremendous expansion and threat of asphyxiation when a cryogenic liquid vaporizes at room temperature.

There is also an increased risk of fire in areas where liquid cryogenics are stored and used. For example, cryogenic vapors from liquid oxygen, liquid hydrogen or other flammable cryogenics may cause a fire or explosion if ignited. Materials that are normally noncombustible (e.g., carbon steel) may ignite if coated with an oxygen-rich condensate. Liquefied inert gases, such as liquid nitrogen or liquid helium, are capable of condensing atmospheric oxygen and causing oxygen entrapment or enrichment in unsuspected areas. Extremely cold metal surfaces are also capable of entrapping atmospheric oxygen.

Because the low temperatures of cryogenic liquids may affect physical properties of materials such as stainless steel or aluminum, take care to select equipment materials accordingly.

6.3.14 Carcinogens

Carcinogens are materials that can cause cancer in humans or animals. Several agencies including OSHA (Occupational Safety & Health Administration), NIOSH (The National Institute for Occupational Safety and Health), and IARC (International Agency for Research on Cancer) are responsible for identifying carcinogens. There are very few chemicals known to cause cancer in humans, but there are many suspected carcinogens and many substances with properties similar to known carcinogens.



Examples of known carcinogens include the following:

- Asbestos
- Benzene
- Tobacco smoke
- Hexavalent Chromium
- Aflatoxins

Zero exposure should be the goal when working with known or suspected carcinogens.

OSHA regulated carcinogens are listed in Appendix M.

6.3.15 Asphyxiates

Vapors or gases that can cause unconsciousness or death by suffocation are called asphyxiates. Asphyxiates can be classified as simple or chemical.

- Simple asphyxiates are materials that displace available oxygen in the air. Examples: nitrogen and carbon dioxide.
- Chemical asphyxiates are materials that reduce the blood's ability to carry oxygen or interfere in the body's utilization of oxygen. Examples: carbon monoxide and hydrogen cyanide.

6.3.16 Anesthetics

Anesthetics are materials that depress the central nervous system, producing loss of sensation or feeling. Examples: chloroform and ether.

6.3.17 Teratogens

Teratogens are materials that adversely affect a developing embryo or fetus. Heavy metals, some aromatic solvents (benzene, toluene, xylenes, etc.), and some therapeutic drugs are among the chemicals that are capable of causing these effects. In addition, the adverse effects produced by ionizing radiation, consuming alcohol, using nicotine and using illicit drugs are recognized.



While some factors are known to affect human reproduction, knowledge in this field (especially related to the male) is not as broadly developed as other areas of toxicology. In addition, the developing embryo is most vulnerable during the time before the mother knows she is pregnant. Therefore, it is prudent for all persons with reproductive potential to minimize chemical exposure.

6.3.18 Mutagens

Mutagens are materials that induce genetic mutations in DNA, usually by chronic exposure. Some mutagens are also carcinogens.

Examples of mutagens are:

- Ethidium bromide
- Nitrous acid
- Radiation

6.3.19 Irritants

Irritants are materials that cause a reversible inflammation or irritation to the eyes, respiratory tract, skin, and mucous membranes. Irritants cause inflammation through long-term exposure or high concentration exposure. For the purpose of this section, irritants do not include corrosives.

Examples of irritants include the following:

- Ammonia
- Formaldehyde
- Halogens
- Sulfur dioxide
- Poison ivy
- Phosgene
- Dust
- Pollen
- Mold



6.3.20 Sensitizers

Sensitizers are materials that may cause little or no reaction upon first exposure. Repeated exposures may result in severe allergic reactions.

Examples of sensitizers include the following:

- Isocyanates
- Nickel salts
- Beryllium compounds

- Formaldehyde
- Diazomethane
- Latex

NOTE: *Some people who often use latex-containing products may develop sensitivity to the latex. A sensitized individual's reaction to latex exposure can eventually include anaphylactic shock, which can result in death. To minimize exposure to latex, use non-latex containing gloves, such as nitrile gloves*

6.3.21 Mercury

Mercury is a naturally occurring metal that has several forms. Metallic mercury is the familiar heavy, shining, silver-white liquid at room temperature. If heated, it becomes a colorless, odorless gas. Mercury also vaporizes at room temperature, though at a slower rate. Mercury IS KNOWN TO BE TOXIC to humans, especially young children and unborn babies. **However, mercury is not a health threat when safely encased.**

Many commercial products and items contain metallic mercury and/or mercury compounds. Mercury-containing products are regulated as hazardous waste for disposal. **All mercury-containing products and items must be turned in to Environmental Safety for proper disposal.**

Examples of items that can contain mercury include:

- **Thermostats.** Many temperature control devices contain an ampoule of mercury metal. When replacing defective thermostats select a digital type replacement, which does not use mercury. **Do not attempt to disassemble a mercury-containing thermostat or otherwise disturb the housing** Package the entire unit in a plastic bag for pick-up by [Environmental Safety](#).
- **Fluorescent and High Intensity Bulbs.** Some fluorescent, neon, mercury vapor, high-pressure sodium, metal halide, and high intensity lamps contain regulated quantities of mercury. These items must be properly disposed via the Universal Waste (Recycling) Coordinator in Facilities Management or Environmental Safety.
- **Batteries.** Certain types of batteries contain significant amounts of mercury and must be turned in to Environmental Safety for proper disposal.
- **Thermometers, Manometers, Sphygmomanometers, etc.** Replace mercury based equipment with digital or organic liquid based equipment whenever possible. **Never use mercury thermometers in ovens or other heat producing equipment.**
- **Electrical Switches and Dials.** Some electrical switches and dials contain mercury. Care should be taken to prevent breakage or leakage of mercury when removing these types of items from service; leave them intact and bag in plastic for pick-up by [Environmental Safety](#).
- **Paints.** Prior to 1991, mercury was incorporated into some paint formulations as a biocide agent. Mercury-containing paints and related items (i.e., brushes, rags, etc.) must be bagged in plastic and turned in to [Environmental Safety](#) for proper disposal.
- **Agricultural Products.** A very limited number of agricultural fungicides contain Mercury. Mercury-containing fungicides must be returned to the distributor or bagged in plastic and turned in to [Environmental Safety](#) for proper disposal.

Routes of Exposure

Mercury may enter the body through inhalation, ingestion or skin absorption and cause serious damage to many systems of the body. Once in the bloodstream metallic mercury travels to other parts of the body, including the brain and kidneys, and can remain in these organs for months.

Health Effects

MERCURY HEALTH EFFECTS ARE CUMULATIVE!

- Mercury causes damage to the nervous system and brain -- unborn and young children are most vulnerable because their nervous systems are still developing.
- Mercury also causes damage to the kidneys, liver, stomach, respiratory system, intestines, and increases blood pressure and heart rate.
- Skin contact can cause an allergic reaction resulting in skin rashes.
- Contact with the eyes can cause severe irritation.
- Swallowing mercury can cause nausea, vomiting and diarrhea.
- Mercury vapor causes damage to the lining of the mouth and lungs. High levels of mercury vapor exposure can cause death.
- Mercury exposure can result in
 - General fatigue,
 - Tremors,
 - Insomnia,
 - Weakness,
 - Memory loss,
 - Headaches,
 - Irritability,
 - Nervousness,
 - Changes in hearing and vision,
 - Emotional disturbance, and
 - Unsteadiness.

6.3.22 Homeland Security Chemicals of Interest

Regulations at Title 6 Code of Federal Regulations Part 27 require all chemical facilities (including universities) comply with the Chemical Facility Anti-Terrorism Standards (CFATS). The rule requires that a chemical facility that either possesses or later comes into possession of listed chemicals (<http://www.dhs.gov/appendix-a-chemicals-interest-list>) in quantities that meet or exceed threshold quantities report them to the Department of Homeland Security (DHS). Under this regulation, a University building is deemed a chemical facility and EHS is charged with reporting building storage exceedances to DHS. EHS relies on the accuracy of your chemical inventories to determine what is reportable.

DHS can require a facility to prepare a security vulnerability assessment and implement a site security plan. Failure to comply with these requirements can result in fines and/or imprisonment.

DHS regulates certain chemicals in the rule in any amount if transported (shipped) away from campus. See Table 6.3.22 below for a list of 22 chemicals regulated in any amount if shipped.



Do not ship these chemicals without notifying EHS in advance. EHS is responsible for reporting all UCCS shipments of these chemicals to DHS.

a. Do Not Ship List

DHS identifies 22 chemicals that are reportable in any amount when transported (shipped) away from campus. The following table, Table 6.3.21 Reportable if Shipped Chemical List, provides a list of these chemicals by name and CAS number.

Table 6.3.22 Reportable if Shipped Chemical List

| | |
|---|-------------------------------------|
| Acetone cyanohydrin, stabilized (75-86-5) | Magnesium phosphide (12057-74-8) |
| Aluminum phosphide (20859-73-8) | Methyldichlorosilane (75-54-7) |
| Boron tribromide (10294-33-4) | Phosphorus oxychloride (10025-87-3) |
| Bromine pentafluoride (7789-30-2) | Phosphorus pentasulfide (1314-80-3) |
| Bromine trifluoride (7787-71-5) | Phosphorus trichloride (7719-12-2) |
| Calcium phosphide (1305-99-3) | Potassium phosphide (20770-41-6) |
| Chlorine dioxide (10049-04-4) | Sodium phosphide (12058-85-4) |
| Chloroacetyl chloride (79-04-9) | Strontium phosphide (12504-16-4) |
| Chlorosulfonic acid (7790-94-5) | Sulfuryl chloride (7791-25-5) |
| Lithium amide (7782-89-0) | Titanium tetrachloride (7550-45-0) |
| Lithium nitride (26134-62-3) | Trichlorosilane (10025-78-2) |

b. Do Not Ship Labels

If you possess any of the 22 listed chemicals in a purchased formulation, attach a warning label to the original container to remind workers that the substance is regulated and cannot be shipped away from campus without prior EHS notification. Notify EHS before shipments by calling 719-255-3212.

c. Disposing of Chemicals on the Do Not Ship List

If you wish to dispose of any of these “do not ship” chemicals, you must submit a chemical waste collection request to EHS as described in waste section of this manual.

6.3.23 Dual Use of Research Materials

Under the Policy for Institutional DURC Oversight, the identification of DURC-related risks and the management of those risks begin with the identification, by PIs, of research that directly involves nonattenuated forms of 1 or more of the 15 listed agents. Any such research that is identified must then be assessed for whether the research produces, aims to produce, or can be reasonably anticipated to produce one or more of seven listed experimental effects.

a. Identification and Assessment by PIs of Research That Requires Institutional Review

As noted above, PIs are required to submit research for Institutional review as soon as any of the following three criteria are met:



- The PI's research directly involves nonattenuated forms of one or more of the listed agents; or
- The PI's research with nonattenuated forms of one or more of the listed agents also produces, aims to produce, or can be reasonably anticipated to produce one or more of the seven listed experimental effects; or
- The PI concludes that his or her research with nonattenuated forms of one or more of the listed agents that also produces, aims to produce, or can be reasonably anticipated to produce one or more of the seven listed experimental effects may meet the definition of DURC and should be considered (or reconsidered) by the IBC for its DURC potential.

b. Research Involving the Listed Agents

To initiate the institutional review process, PIs are to notify the IBC if they are conducting research that directly uses nonattenuated forms of one or more of the following agents:

- Avian influenza virus (highly pathogenic)
- Bacillus anthracis
- Botulinum neurotoxin (in any quantity)
- Burkholderia mallei
- Burkholderia pseudomallei
- Ebola virus
- Foot-and-mouth disease virus
- Francisella tularensis
- Marburg virus
- Reconstructed 1918 influenza virus
- Rinderpest virus
- Toxin-producing strains of Clostridium botulinum
- Variola major virus
- Variola minor virus
- Yersinia pestis

c. Experimental Effects

When a PI determines that his or her research does directly involve nonattenuated forms of one or more of these listed agents, he or she must also assess whether the research produces, aims to produce, or is reasonably anticipated to produce one or more of the experimental effects listed below, and this assessment should be provided to the institution for its consideration during the review of the research.

The categories of experimental effects are as follows:

- Enhances the harmful consequences of the agent or toxin;
- Disrupts immunity or the effectiveness of an immunization against the agent or toxin without clinical and/or agricultural justification;
- Confers to the agent or toxin resistance to clinically and/or agriculturally useful prophylactic or therapeutic interventions against that agent or toxin or facilitates their ability to evade detection methodologies;
- Increases the stability, transmissibility, or the ability to disseminate the agent or toxin;
- Alters the host range or tropism of the agent or toxin;
- Enhances the susceptibility of a host population to the agent or toxin; and



- Generates or reconstitutes an eradicated or extinct listed agent or toxin.

6.4 Safety Data Sheets

A SDS for each hazardous chemical must be available in the laboratory. The SDS must be readily accessible to all laboratory personnel. SDS must be updated on a continual basis. Researchers and students should consult two SDS resources for every chemical they plan to use before they start the experiment or procedure. This review will be used in the development of the SOP and process safety review. An annual review of all SDS should be included as part of the annual chemical safety training refresher. Accidents involving chemicals will require a SDS be provided to emergency response personnel and to the attending physician so proper treatment can be administered. The "rule of thumb" is that a person working in a laboratory should be able to produce a SDS for any hazardous chemical found in the laboratory within five minutes.

An SDS is a document that details information about chemicals and along with the container label is a good source of information for chemical safety. It consists of 16 sections and provides the following information:

Section 1, Identification includes product identifier; manufacturer or distributor name, address, phone number; emergency phone number; recommended use; restrictions on use.

Section 2, Hazard(s) identification includes all hazards regarding the chemical; required label elements.

Section 3, Composition/information on ingredients includes information on chemical ingredients; trade secret claims.

Section 4, First-aid measures includes important symptoms/ effects, acute, delayed; required treatment.

Section 5, Fire-fighting measures lists suitable extinguishing techniques, equipment; chemical hazards from fire.

Section 6, Accidental release measures lists emergency procedures; protective equipment; proper methods of containment and cleanup.

Section 7, Handling and storage lists precautions for safe handling and storage, including incompatibilities.

Section 8, Exposure controls/personal protection lists OSHA's Permissible Exposure Limits (PELs); Threshold Limit Values (TLVs); appropriate engineering controls; personal protective equipment (PPE).

Section 9, Physical and chemical properties lists the chemical's characteristics.

Section 10, Stability and reactivity lists chemical stability and possibility of hazardous reactions.



Section 11, Toxicological information includes routes of exposure; related symptoms, acute and chronic effects; numerical measures of toxicity.

Section 12, Ecological information*

Section 13, Disposal considerations*

Section 14, Transport information*

Section 15, Regulatory information*

Section 16, Other information, includes the date of preparation or last revision.

Chemical manufacturers and distributors must provide the purchasers of hazardous chemicals with an appropriate SDS for each hazardous chemical/product purchased. If a SDS was not provided with the shipment of a hazardous chemical, one must be requested from the manufacturer or distributor in a timely manner. Each person working with chemicals should have access to the SDS for all chemicals they use. "Access" may be achieved via any of the ways listed below:

- SDS may be managed as printed hard copies in an organized fashion such as a binder. If SDS are managed as hard copy, then laboratories are strongly urged to print the SDS sheets for their chemicals from the manufacturer that produced them and keep them in a clearly marked three ring binder in the laboratory on a bookshelf where they will be visible to all employees. These printed SDS must be updated and current.
- SDS may be maintained through a bookmarked Internet site. If the Internet is used, each person in the lab who uses chemicals must be registered, if required by the site, and trained to use the site to access and print a SDS. A functioning computer with internet access and a functioning printer must be available in the laboratory. If a laboratory chooses to use electronic access, the SDS website link must be posted on the computer or in another conspicuous location to facilitate easy access. Online SDSs are generally updated frequently by the provider. SDS provided by the ChemWatch System, the Canadian Center for Occupational Health and Safety, Fisher Scientific, Sigma-Aldrich and Acros are kept up to date. Researchers will need to assure that the SDS provided by other sources are current. Provisions are needed for dealing with long-term interruptions to power, the network, or the server which would make electronic versions unavailable.
- SDS may be stored on a computer as an electronic file. If this method is used, each person in the laboratory must be trained to access and print a SDS. A functioning computer and a functioning printer must be available in the laboratory. If a laboratory chooses to use electronic access, desktop icons or shortcuts must be used on the computer or posted in a conspicuous location to facilitate easy access. These electronic copies must be updated and current. Provisions are needed for dealing with long-term interruptions to power, the network, or the server which would make electronic versions unavailable.
- During power or ventilation outages, laboratories must be evacuated due to the loss of laboratory ventilation and possible loss of containment of hazardous materials. Although



the laboratories must evacuate, there may still be a need for a researcher to access a SDS. Although the University Internet and Network Systems are very reliable, outages have occurred. Laboratories must develop a plan to access a SDS in the event of an outage. Training on accessing SDS during an outage must be provided.

- Options for accessing a SDS during these outages include, but are not limited to:
 - Maintaining a backup electronic file of the SDS on a laptop computer with a fully charged battery.
 - Contacting the appropriate vendor and requesting a CD loaded with the SDS. Access is also needed to a laptop with a fully charge battery.
- Accessing the online internet site through a laptop with a charged battery provided the network or server is functional.

Chemical substances developed in the laboratory

- If the composition of a chemical substance produced for laboratory use is known and determined to be hazardous, the PI or CHO shall supply appropriate training
- If the chemical produced is a by-product whose composition is not known, the PI or CHO shall assume that it is hazardous and implement the guidelines found in this Manual.
- If the chemical substance is produced for another user outside of the laboratory, the PI shall comply with the Hazard Communication Standard (29 CFR 1910.1200) including the requirements for the preparation of a Safety Data Sheet and labeling

6.5 Biological, Laser and Radiological Hazards

6.5.1 Biological Hazards

Biological hazard (biohazard) refers to plants, animals, or their products that may present a potential risk to the health and well-being of humans or animals and the environment. Infectious biological agents can be bacterial, viral, rickettsia, fungal, or parasitic.

Before any work is undertaken using biological agents, a determination of the potential hazard must be made and approved by the Institutional Biosafety Committee. It may be necessary to develop a written Biosafety Plan which includes the standard microbiology procedures and practices to be followed; special facilities and equipment needed; and safe handling, transportation, storage, and treatment procedures. An emergency action plan should be developed to cover fire, spills, accidents, injuries, illness, aerosol releases, equipment shut down procedures, etc. Also, bio-research labs may require special placarding on their entrance doors including the universal biohazard symbol.

Bloodborne Pathogens

UCCS has adopted the OSHA 1910.1030 Bloodborne Pathogen Standard to protect workers who may be exposed to blood from microorganisms that can cause disease in humans. Such pathogens include the hepatitis B virus (HBV) and the human immunodeficiency virus (HIV), which causes AIDS.



Since exposure to blood could potentially be fatal, the standard covers student, staff and faculty who may be reasonably anticipated to come into contact with human blood and other potentially infectious materials in order to perform their jobs. "Good Samaritan" acts such as assisting a co-worker who has a nosebleed would not be covered

Workers at risk who may be exposed to blood or other potentially infectious materials may include:

- Physicians, Nurses and Medical Technologists including students during practicals
- Research laboratory scientists including student workers and volunteers
- Some Maintenance and Custodial staff
- Law Enforcement staff

For questions concerning the Campus Bloodborne Pathogen program, contact EHS at 719-255-3212.

6.5.2 Laser Hazards

Lasers are classified as I, II, III, or IV based on the radiation intensity and the potential for producing injury. A Class I laser poses the least risk, while a Class IV laser poses considerable risk. Other hazards include electrical, chemical, and fire.

- **Class I Lasers** cannot emit laser radiation that is known to be hazardous. They typically operate at 0.4 microwatts of continuous (cw) power. Class I lasers are exempt from control measures except during service.

Note that an embedded Class III or IV laser can be considered a Class I laser if it is totally enclosed, has engineering controls and interlocks, and is properly labeled. Such a laser requires Class IV controls during service and only qualified service personnel may service it.

- **Class II Lasers** are low power visible wavelength lasers that emit at less than one milliwatt of power. These could cause eye damage, but the human aversion response to bright light normally prevents harm. There is a secondary class called Class IIa that is based on a 1000 second viewing exposure. Class IIa lasers should not be viewed. Some controls may be necessary for this class.
- **Class III Lasers** are divided into Class IIIa and Class IIIb. Class IIIa lasers produce outputs of 1-5 milliwatts. These lasers should never be viewed directly. Limited controls are needed for this intermediate power class. Class IIIb lasers are moderate power lasers (cw-5-500 mW; pulsed to 10 joules/cm²). Some controls are needed, and they must not be viewed directly. Generally, they will not produce a diffuse reflection that is hazardous unless the viewer is quite close to the reflection. Class IIIb lasers are also considered an ignition/fire hazard.
- **Class IV Lasers** are high power. They pose significant risk for eye and skin burns. Both direct viewing and scattered viewing are dangerous. Class IV laser facilities require significant control measures. Class IV lasers also have the potential to cause fire and chemical releases (such as fumes).

6.5.3 Radiological Hazards

The Nuclear Regulatory Commission (NRC) regulates radioactive materials used in research or academic applications at the University. The State of Colorado has entered into an agreement with the NRC to govern the safe use of radioactive materials, designating the Colorado Department of Public Health and Environment (CDPHE) as responsible for developing and implementing applicable State regulations. The University of Colorado Boulder has been issued a radioactive materials license and is responsible for the safe use of these materials on the Boulder and the Colorado Springs campuses through the Radiation Safety / Health Physics Unit at Environmental Health and Safety at CU Boulder. The Radiation Safety Handbook provides details on the program as implemented.

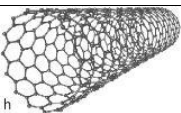
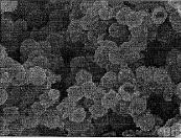
Currently UCCS has only sealed sources and radiation generating equipment on campus.

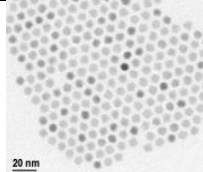
6.6 Nanotechnology

Nanotechnology is an emerging industry and area of research that involves the engineering of items on a molecular level. Considerable advancements in nanotechnology have already been made and this is a growing area of research at UCCS. Because of the broad range of possible nanotechnology applications, continued evaluation of the potential health risks associated with exposure to nanomaterial (NM) is essential to ensure their safe handling.

Engineered nanoparticles are materials purposefully produced with at least one dimension between 1 and 100 nanometers. Nanomaterials are both naturally occurring in the environment and intentionally produced. Intentionally produced nanomaterials are referred to as Engineered Nanomaterials (ENMs). Nanoparticles (NPs) often exhibit unique physical and chemical properties that impart specific characteristics essential in making engineered materials, but little is known about what effect these properties may have on human health. Research has shown that the physicochemical characteristics of particles can influence their effects in biological systems. These characteristics include particle size, shape, surface area, charge, chemical properties, solubility, oxidant generation potential, and degree of agglomeration. Until the results from research studies can fully elucidate the characteristics of NPs that may pose a health risk, precautionary measures are warranted. The most common types of ENMs are carbon based materials such as nanotubes, metals and metal oxides such as silver and zinc oxide, and quantum dots made of compounds such as zinc selenide

Types of Nanomaterials

| | Type | Examples |
|---|-------------------------|---|
|  | Carbon Based | Buckyballs or Fullerenes, Carbon Nanotubes#, Dendrimers <i>Often includes functional groups like * PEG (polyethylene glycol, Pyrrolidine, N,N-dimethylethylenediamine, imidazole</i> |
|  <small>Figure 3. 500nm</small> | Metals and Metal Oxides | Titanium Dioxide (Titania)**, Zinc Oxide, Cerium Oxide (Cerial), Aluminum oxide, Iron Oxide, Silver, Gold, and Zero Valent Iron (ZVI) nanoparticles |

| | | |
|---|---------------------|--|
|  | <p>Quantum Dots</p> | <p>ZnSe, ZnS, ZnTe, CdS, CdTe, CdSe, GaAs, AlGaAs, PbS, InP <i>Includes crystalline nanoparticle that exhibits size-dependent properties due to quantum confinement effects on the electronic states (ISO/TS 27687:2008)</i></p> |
|---|---------------------|--|

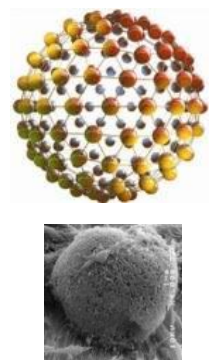
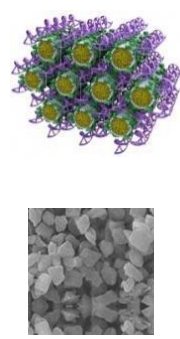
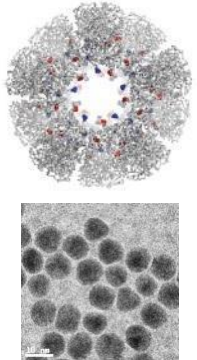
Carbon Nanotubes are subject to a proposed Recommended Exposure Limit of TWA 7 ug/m³ due to the risk of developing respiratory health effects.

** Nano-Titanium Dioxide is subject to a proposed Permissible Exposure Limit of TWA 0.3 mg/m³ due to the risk of developing lung cancer. There are mixed studies regarding TiO₂ skin penetration. Some studies indicate TiO₂ and ZnO does not pass through the stratum corneum, while others indicate significant penetration through the skin.

6.6.1 Potential Health Concerns

- The potential for NM to enter the body is among several factors that scientists examine in determining whether such materials may pose an occupational health hazard.
- In general, the risk of exposure is lowest when nanomaterials are bound in a solid matrix with little potential to create airborne dust or when in a non-volatile liquid suspension. The risk of exposure increases when nanomaterials are used as fine powders or are suspended in volatile solvents or gases. Refer to the chart below for risk levels.
- NM has the greatest potential to enter the body through the respiratory system if they are airborne and in the form of respirable-sized particles (NPs). They may also come into contact with the skin or be ingested.
- Based on results from human and animal studies, airborne NPs can be inhaled and deposit in the respiratory tract; and based on animal studies, NPs can enter the blood stream, and translocate to other organs.
- Experimental studies in rats have shown that equivalent mass doses of insoluble incidental NPs are more potent than large particles of similar composition in causing pulmonary inflammation and lung tumors. Results from in vitro cell culture studies with similar materials are generally supportive of the biological responses observed in animals.
- Experimental studies in animals, cell cultures, and cell-free systems have shown that changes in the chemical composition, crystal structure, and size of particles can influence their oxidant generation properties and cytotoxicity.
- Studies in workers exposed to aerosols of some manufactured or incidental microscopic (fine) and nanoscale (ultrafine) particles have reported adverse lung effects including lung function decrements and obstructive and fibrotic lung diseases. The implications of these studies to engineered NPs, which may have different particle properties, are uncertain.
- Research is needed to determine the key physical and chemical characteristics of NPs that determine their hazard potential.

Risk Level

| Risk Level | Material State or Type of Use | Examples | |
|--|---|---|---|
| Category 1 Lower Exposure Potential | Material State <i>No potential for airborne release (when handling)</i> <ul style="list-style-type: none"> • Solid: Bound in a substrate or matrix • Liquid: Water-based liquid suspensions or gels • Gas: No potential for release into air (when handling) Type of Use <ul style="list-style-type: none"> • No thermal or mechanical stress | <ul style="list-style-type: none"> • Non- destructive handling of solid engineered nanoparticle composites or nanoparticles permanently bonded to a substrate |  |
| Category 2 Moderate Exposure Potential | Material State <i>Moderate potential for airborne release (when handling)</i> <ul style="list-style-type: none"> • Solid: Powders or Pellets • Liquid: Solvent-based liquid suspensions or gels • Air: Potential for release into air (when handling) Type of Use <ul style="list-style-type: none"> • Thermal or mechanical stress induced | <ul style="list-style-type: none"> • Pouring, heating ,or mixing liquid suspensions (e.g., stirring or pipetting), or operations with high degree of agitation involved (e.g., sonication) • Weighing or transferring powders or pellets • Changing bedding out of laboratory animal cages |  |
| Category 3 Higher Exposure Potential | Material State <i>High potential for airborne release (when handling)</i> <ul style="list-style-type: none"> • Solid: Powders or Pellets with extreme potential for release into air • Gas: Suspended in gas | <ul style="list-style-type: none"> • Generating or manipulating nanomaterials in gas phase or in aerosol form • Furnace operations • Cleaning reactors • Changing filter elements • Cleaning dust collection systems used to capture nanomaterials • High speed abrading / grinding nanocomposite materials |  |

6.6.2 Potential Safety Concerns

- Although insufficient information exists to predict the fire and explosion risk associated with powders of NMs, nanoscale combustible material could present a higher risk than coarser material with a similar mass concentration given its increased particle surface area and potentially unique properties due to the nanoscale.
- Some NMs may initiate catalytic reactions depending on their composition and structure that would not otherwise be anticipated based on their chemical composition.

6.6.3 Working with Engineered Nanomaterials

Nanomaterial-enabled products such as nanocomposites, surface-coated materials, and materials comprised of nanostructures, such as integrated circuits, are unlikely to pose a risk of exposure during their handling and use as materials of non-inhalable size. However, some of the processes used in their production (e.g., formulating and applying nanoscale coatings) may lead to exposure to NMs, and the cutting or grinding of such products could release respirable-sized nanoparticles.

Maintenance on production systems (including cleaning and disposal of materials from dust collection systems) is likely to result in exposure to nanoparticles if deposited NMs are disturbed.

The following workplace tasks can increase the risk of exposure to nanoparticles:

- Working with NMs in liquid media without adequate protection (e.g., gloves)
- Working with NMs in liquid during pouring or mixing operations, or where a high degree of agitation is involved
- Generating nanoparticles in non-enclosed systems
- Handling (e.g., weighing, blending, spraying) powders of NMs
- Maintenance on equipment and processes used to produce or fabricate NMs and the cleaning-up of spills and waste material containing NMs
- Cleaning of dust collection systems used to capture nanoparticles
- Machining, sanding, drilling, or other mechanical disruptions of materials containing nanoparticles

Use the table below to identify the controls needed to work with the risk level of your nanomaterial (Category 1, 2, or 3).

| Risk level | Controls | |
|---|-----------------------|--|
| <p style="text-align: center;">Category 1 Low Exposure Potential</p> | Engineering | <ul style="list-style-type: none"> • Fume Hood or Biosafety Cabinet. Perform work with open containers of nanomaterials in liquid suspension or gels in a laboratory-type fume hood or biosafety cabinet, as practical. |
| | Work Practices | <ul style="list-style-type: none"> • Storage and labeling. Store in sealed container and secondary containment with other compatible chemicals. Label chemical container with identity of content (include the term “nano” in descriptor). • Preparation. Line workspace with absorbent materials. • Transfer in secondary containment. Transfer between laboratories or buildings in sealed containers with secondary containment. • Housekeeping. Clean all surfaces potentially contaminated with nanoparticles (i.e., benches, glassware, apparatus) at the end of each operation using a HEPA vacuum and/or wet wiping methods. DO NOT dry sweep or use compressed air. • Hygiene. Wash hands frequently. Upon leaving the work area, remove any PPE and wash hands, forearms, face, and neck. • Notification. Follow institution’s hazard communication processes for advanced notification of animal facility and cage labeling/management requirements if dosing animals with the nanomaterial |
| | PPE | <ul style="list-style-type: none"> • Eye protection. Wear proper safety glasses with side shields (for powders or liquids with low probability for dispersion into the air) • Face protection. Use face shield where splash potential exists. |

| | | |
|---|-----------------------|--|
| | | <ul style="list-style-type: none"> • Gloves. Wear disposable gloves to match the hazard, including consideration of other chemicals used in conjunction with nanomaterials (refer to Table 1. Glove Choices for Nanomaterials) • Body protection. Wear laboratory coat and long pants (no cuffs). • Closed toe shoes. |
| Category 2 Moderate Exposure Potential | Engineering | <ul style="list-style-type: none"> • Fume Hood, Biosafety Cabinet, or Enclosed System. Perform work in a laboratory-type fume hood, biosafety cabinet* (must be ducted if used in conjunction with volatile compounds), powder handling enclosure, or enclosed system (i.e., glove box, glove bag, or sealed chamber). |
| | Work Practices | <ul style="list-style-type: none"> • Category 1 Work Practices. Follow all work practices listed for Category 1. • Access. Restrict access. • Signage. Post signs in area. • Materials. Use antistatic paper and/or sticky mats with powders. |
| | PPE | <ul style="list-style-type: none"> • Category 1 PPE. Wear all PPE listed for Category 1. • Eye protection. Wear proper chemical splash goggles (for liquids with powders with moderate to high probability for dispersion into the air). • Gloves. Wear two layers of disposable, chemical-protective gloves. • Body protection. Wear laboratory coat made of non-woven fabrics with elastic at the wrists (disposable Tyvek®-type coveralls preferred). • Closed toe shoes. Wear disposable over-the-shoe booties to prevent tracking nanomaterials from the laboratory when working with powders and pellets. • Respiratory Protection. If working with engineering controls is not feasible, respiratory protection may be required. Consult an EHS professional for more information (i.e., N95 respirator, or one fitted with a P-100 cartridge). |
| Category 3 High Exposure Potential | Engineering | <ul style="list-style-type: none"> • Enclosed System. Perform work in an enclosed system (i.e., glove box, glove bag, or sealed chamber). |
| | Work Practices | <ul style="list-style-type: none"> • Category 2 Work Practices. Follow all work practices listed for Category 2. |
| | PPE | <ul style="list-style-type: none"> • Category 2 PPE. Wear all PPE listed for Category 2. • Body protection. Wear disposable Tyvek®-type coveralls with head coverage. • Respiratory Protection. If working with engineering controls is not feasible, respiratory protection may be required. Consult an EHS professional for more information (i.e., N95 respirator, or one fitted with a P-100 cartridge). |

6.7 Physical Hazards

UCCS laboratories may contain a number of physical hazards. Sections 7.7, 7.8 and 7.10 discuss many of these physical hazards and how to control them in a laboratory environment. These include but are not limited to the following types of hazards:



Compressed gases
Magnetic field generators
Noise
Power Tools
Electrical sources
High voltage equipment (>600 volts)
Mechanical equipment

Each Principal Investigator should identify the types of physical hazards present in his/her laboratory. Once the hazards are identified, then appropriate standard operating procedures (SOPs) which include training requirements, engineering controls and procedural controls should be developed. These SOPs should attempt to minimize the hazards.

6.8 Chemical Procurement

The primary control of chemicals is through the procurement process. Individuals will use discretion in purchasing chemicals, limiting purchases only to those amounts required for the specific activity.

The decision to purchase a chemical shall be a commitment to handle and use the chemical properly from initial receipt to ultimate disposal. For those individuals or departments planning to use chemicals for the first time, chemical purchases must be coordinated in advance with the EHS to ensure that appropriate handling & storage facilities, as well as personal protective equipment as required, are in place.

The lab managers (i.e. chemistry, biology, etc.), who have sufficient training and have previously addressed environmental and safety concerns, may independently order chemicals without review by EHS. This designation is training specific and cannot be delegated.

The purchase of chemicals for academic instruction should be handled through a centralized stockroom to ensure minimum quantities of hazardous chemicals are in laboratories or in storage. Chemicals purchased for R&D should also be handled through the centralized stockroom. Chemical purchases should be made in conjunction with the UCCS preferred vendor programs whenever possible.

Chemical purchases should not be determined by the cheaper unit price basis of large quantities. This cheaper price is often offset by the large cost of disposal when the product goes out of date or is no longer required. Therefore, chemicals should be ordered in minimum quantities to suffice for the current use. In addition, users should explore the availability of less hazardous materials for the same operation.

The size of the container may also determine how much to buy. Certain fire codes regulate flammable solvent container size per square feet of laboratory (see Storage section).

All chemicals delivered to the respective stockroom(s) are opened and verified for container and label integrity by authorized, trained personnel only. A date of receipt and additional hazard labels may be placed on the container. Once the chemical is ready to be stored, it is entered into inventory or transferred to the appropriate Principal Investigator if ordered for a specific R&D laboratory.



For purposes of the management of hazardous chemicals, procurement by donation must be controlled in the same manner as chemical purchases. No individual may accept donation of chemicals that are regulated as hazardous without the prior approval of EHS. A request for approval of donations must include the specific chemical names (with CAS number of constituents 20% or greater), associated hazards, ORIGINAL purchase date, expiration date and the appropriate Safety Data Sheet (SDS).

UCCS does have a license to purchase non-denatured Ethyl Alcohol. If you have a need for non-denatured Ethyl Alcohol, then please contact EH&S for the license number and record keeping requirements.

6.9 Transportation and Receiving

The U.S. Department of Transportation regulates the shipment of hazardous materials. Anyone who packages, receives, unpacks, signs for, or transports hazardous chemicals must be trained and certified in Hazardous Materials Transportation. Warehouse personnel, shipping and receiving clerks, truck drivers, and other employees who pack or unpack hazardous materials must receive this training as well. Contact EHS or refer to the EHS website for more information on shipping and receiving hazardous chemicals.

6.10 Chemical Inventories

The OSHA Laboratory Standard requires employees to be trained in the hazards of the chemicals present in the workplace. As a result, laboratories shall develop inventories to assure that proper training for all chemicals is provided.

Individuals who use, store or handle chemicals are responsible for maintaining a current inventory. This inventory shall be in a electronic format which is either accessible by or submittable to EHS in a timely manner. The preferred inventory management tool is Quartzly (www.quartzly.com). At typical inventory will include the following information:

- Inventory Date
- Chemical Location (building name, room number, if located in specific locker or storage unit - indicate as specifically as possible)
- Chemical Label Name
- Constituents (if available and material is not a pure chemical)
- Manufacturer (if trade name product)
- CAS Number (if applicable)
- Physical State (Solid, liquid, gas)
- # of containers
- Amount/container
- Units of measure per container (solids by weight, liquids by volume, gases by cylinder size)
- Notes (optional)
- Hazards (if known) – EHS can assist with this
- NFPA Fire (Red) Rating from label or SDS – EHS can assist with this
- NFPA Health (Blue) Rating from label or SDS – EHS can assist with this
- NFPA Reactivity (Yellow) Rating from label or SDS – EHS can assist with this

A sample form as an Excel spreadsheet is included on the EHS website <http://www.uccs.edu/pusafety/environmental/hazardous-materials/hazmat-inventories.html>. EHS can also help with setting up a Quartzzy(www.quartzy.com) account as part of the UCCS Quartzzy account. The Department/Unit may submit the inventory in an existing inventory format, as long as this minimum information is included, the EHS can open the format and the inventory is submitted electronically.

A designated person, such as the laboratory manager or a student assistant, may physically conduct the inventory but the individual responsible for the laboratory (Primary Investigator, Director, Department Chair, etc.) is ultimately responsible for accuracy and must ensure the inventory is submitted by July 31st annually.

During the course of the inventory, the individual should check the following:

- Condition of containers (no leakage, corrosion, or crystallization)
- Verify that highly toxics are stored in secondary containment (adequate to contain the contents in catastrophic failure of the primary container) when required
- Hazards are indicated on the individual containers as well as adjacent to the storage location (usually using the NFPA diamond)
- That excess or unused chemicals are returned to stock or properly disposed
- That chemicals are properly stored with incompatibles segregated
- That highly toxics are stored in a locked cabinet and that cabinet is kept locked

Questions or problems should be referred to EHS.

Maintaining a current inventory can reduce the number of unknowns and the tendency to stockpile chemicals. It also provides an opportunity to check the integrity of the chemicals and containers (i.e. picric acid that has become dry) and assures that a laboratory has not exceeded the quantity limitations for certain classes of chemicals

7 Mitigating Hazards in the Laboratory

7.1 General Laboratory Safety Practices

All chemicals are, to some degree, poisonous to the human body. Routes of entry include inhalation, skin and eye absorption, ingestion and injection. The following are general guidelines which apply to all laboratory situations. More specific guidance for various classes of hazards can be found in the following sections.

7.1.1 Work Habits

- a. Do not store food or beverages in the laboratory environment.
- b. Do not pipette by mouth.
- c. Do not casually dispose of chemicals down the drain
- d. Wash hands before and after work in a laboratory, and after spill clean-ups.
- e. Restrain loose clothing (e.g. sleeves, full cut blouses, neckties etc.), long hair and dangling jewelry.
- f. Protection should be provided for the lab worker and for nearby co-workers.
- g. Always inform co-workers of plans to carry out hazardous work before starting.
- h. First aid and CPR training is recommended for all lab personnel.
- i. Review all procedures before commencing any work
- j. Always wash your hands before leaving lab.
- k. Never work alone



7.1.2 Safety Wear

- a. Lab coats must be worn at all times in the wet chemistry research laboratories.
- b. Closed toed shoes and long pants must be worn in the lab.
- c. Wear gloves that will resist penetration by the chemical being handled and which have been checked for pinholes, tears, or rips.
- d. Always wear ANSI (or equivalent standard) approved eye or face protection when working with chemicals in the laboratory.
- e. Contact lenses are discouraged.
- f. Use respiratory protection (dust mask or respirator) when appropriate.

7.1.3 Facilities and Equipment

All operators of laboratory equipment must be adequately instructed and trained in the safe use of laboratory equipment and the precautions to be taken when the equipment is used.

- a. All moving belts and pulleys must have safety guards.
- b. Keep up-to-date emergency phone numbers posted.
- c. Have appropriate equipment and materials available for spill control; replace when necessary.
- d. Always keep up with housekeeping in the laboratory (floor must be dry at all times).
- e. Floors, walkways, hallways, and stairways must be kept clear at all times to eliminate slipping and tripping hazards.
- f. Access routes to emergency equipment (emergency showers and eyewash facilities, fire extinguishers, first aid kits) must be kept clear of obstruction.
- g. All laboratory equipment must accompany safe operating procedures

7.1.4 Purchasing, Use and Disposal

- a. Label all chemicals accurately with date of receipt, or preparation, and initialed by the person responsible. Add pertinent precautionary information for handling.
- b. Never open a reagent container until the label has been read and completely understood.
- c. Unlabeled bottles (a special problem) must be identified to the extent that they can so that they can then be classified as hazardous or non-hazardous waste.
- d. Incompatible and hazardous wastes are properly segregated in clearly marked containers affixed with workplace labels.
- e. Disposal of solvents meets all municipal, provincial, and federal regulations.
- f. Only order what you need.

7.1.5 Substitutions

- a. Where possible, reduce risks by using diluted substances instead of using concentrated.
- b. Use micro/semi-micro techniques instead of macro-techniques.
- c. Use films, videotapes, and other methods rather than experiments involving hazardous substances.
- d. Evaluate all substitutions before changing procedures.
- e. Always substitute a less toxic material when possible.

7.1.6 General Guidelines

Always follow these guidelines when working with chemicals:

- a. Assume that any unfamiliar chemical is hazardous and treat it as such.



- b. Know all the hazards of the chemicals with which you work. Carefully read the label before using a chemical. Review the Safety Data Sheet (SDS) for any special handling information. For example, perchloric acid is a corrosive, an oxidizer, and a reactive. Benzene is an irritant that is also flammable, toxic, and carcinogenic.
- c. Never underestimate the potential hazard of any chemical or combination of chemicals. Consider any mixture or reaction product to be at least as hazardous as – if not more hazardous than – its most hazardous component.
- d. Properly label all chemical containers. Never use chemicals from an unlabeled container. Provide secondary spill containment for all hazardous liquid chemicals.
- e. Date all chemicals when they are received and again when they are opened.
- f. Follow all chemical safety instructions, such as those listed in Safety Data Sheets or on chemical container labels, precisely.
- g. Minimize your exposure to any chemical, regardless of its hazard rating, and avoid repeated exposure.
- h. Use personal protective equipment (PPE), as appropriate for that chemical.
- i. Use the buddy system when working with hazardous chemicals. Don't work in the laboratory alone.
- j. Children should not be allowed in the laboratory.
- k. Proper engineering controls including fume hoods, chemical storage cabinets and ventilation systems are critical for ensuring a safe work environment.
- l. Appropriate clothing should be worn by all persons entering the lab, including guests. Cotton is preferable to synthetics. The use of lab coats or aprons should be required. Shorts or other clothing that leaves significant areas of skin exposed should not be allowed. Substantial footwear should also be required (no bare feet, open-toed shoes or sandals). Coats, jackets, etc. should be hung in designated areas. Backpacks and briefcases should be kept out of lab work areas.
- m. Loose hair should be restrained. Jewelry that fits tight to the skin (rings, bracelets) should be removed. Dangling jewelry is also a hazard and should be removed.
- n. Horseplay is not allowed in the lab. This includes the loud playing of radios and tape recorders, and the use of earphones, which may interfere with communication.
- o. No preparation, storage or consumption of food and drink is permitted in the lab.
- p. Unauthorized experiments will not be allowed. All laboratory work must be approved by the principal investigator or instructor. Follow predetermined procedures; deviations have caused serious accidents.
- q. As a minimum, splash goggles must be worn when working with chemicals. This should apply to all researchers, students, instructors, and visitors.
- r. Laboratory glassware should never be used as containers for food or drink. Chipped or broken glassware should never be used without fire polishing.
- s. Know what other work is being performed in your laboratory and become aware of the potential hazards. Be inquisitive about hazards. Understanding the hazards of each substance and knowing the severity of the hazard. Lab coordinators, instructors and Safety Data Sheets (SDS) are good starting points for this information.
- t. All pressurized vessels and gas tanks should be adequate for the working pressure to be used. Secure all pressurized gas cylinders properly with a strap or chain to a secure structure.
- u. Keep aisles and exits clear. Eliminate trip hazards. Bicycles should not be allowed in campus laboratories or buildings. Keep the work area cleared of unnecessary equipment, supplies, etc. Keep apparatus away from the front edge of the workbench. Apparatus should be set up so that control valves and switches for water, gas, and electricity are accessible and that it is not necessary to reach through the apparatus to access them.



- v. Evacuation of a vacuum desiccator should only be done when it is protected by a Desi-guard. Dewar flasks should be properly wrapped with either vinyl electrician tape or friction tape to prevent injury from implosion.
- w. Know routes of escape in case of fire or other emergencies. Know the locations and types of available fire extinguishers. Know the location of the nearest available telephone and emergency number. This information should be posted as part of your emergency action plan.
- x. Never pipette by mouth
- y. Use safety cans and approved chemical cabinets for storage of flammable and volatile liquids.
- z. Establish Hazardous Waste Satellite Accumulation areas (SAAs) and label receptacles for waste collection before beginning work. Properly dispose of waste. NO HAZARDOUS CHEMICALS DOWN THE DRAIN.
- aa. Vent apparatus which may discharge toxic chemicals (vacuum pumps, distillation columns, etc.) into local exhaust devices.
- bb. Inspect gloves and test fume hoods and glove boxes before use
- cc. Inspect equipment or apparatus for damage before adding a hazardous chemical or beginning a hazardous procedure. Do not use damaged equipment
- dd. When transporting chemicals between the work area and other areas, use secondary containment (such as a tray, rack, cart or rubber carrier) to protect against spills, leaks or container breakage. Always use a secondary container when transporting hazardous or highly odorous chemicals on an elevator.
- ee. Principal Investigators and lab instructors must be continually on the alert for infractions of the rules. Individuals may be careless or willfully disregard safety rules in the interest of speed or convenience, and such violations should be dealt with immediately. Principal Investigators, instructors and administrators should bear in mind that they may be legally responsible for accidents or injuries in laboratories under their control

7.2 Identify and Assess Hazards

Supervisors are required to identify hazards and conduct a hazard assessment before any equipment, machinery, or work process is used or started. Potential hazards include exposure to chemicals, heat, noise, vibration, violence, and ergonomic problems. The hazard assessment should be done in consultation with a health and safety committee member or, if there is no committee, a person who is familiar with the job process. A hazard assessment guide can be found in Appendix AC. Additional training on completing Job Hazard Analysis can be found on the EHS training website.

Once the hazards have been identified and assessed, it is necessary to control these chemical hazards used in the laboratory. There are four types of controls for minimizing or eliminating hazards:

- Substituting with less hazardous material
- Engineering controls
- Administrative controls
- Personal protective equipment

Elimination of a hazardous product or substitution with a less hazardous product represents the best solution. Engineering controls are the next best choice for controlling hazardous materials. They do not require continual monitoring and are more likely to be used; however, they do require regular maintenance and are more expensive to implement. The next type of control is administrative and it includes written procedures,

training, supervision and scheduling of activities. The use of personal protective equipment represents the least effective type of control; its effectiveness is limited by the dependence on individuals wearing it, and its discomfort.

7.3 Chemical Safety

7.3.1 Solvent Safety

Organic solvents are often the most hazardous chemicals in the work place. Solvents such as ether, alcohols, and toluene, for example, are highly volatile and flammable. Perchlorinated solvents, such as carbon tetrachloride (CCl₄), are non-flammable. But most hydrogen-containing chlorinated solvents, such as chloroform, are flammable. When exposed to heat or flame, chlorinated solvents may produce carbon monoxide, chlorine, phosgene, or other highly toxic gases.

Always use volatile and flammable solvents in an area with good ventilation or preferably in a fume hood. Never use ether or other highly flammable solvents in a room with open flames or other ignition sources present, including non-intrinsically safe fixtures.

Solvent Exposure Hazards

Health hazards associated with solvents include exposure by the following routes:

- Inhalation of a solvent may cause bronchial irritation, dizziness, central nervous system depression, nausea, headache, coma, or death. Prolonged exposure to excessive concentrations of solvent vapors may cause liver or kidney damage. The consumption of alcoholic beverages can enhance these effects.
- Skin contact with solvents may lead to defatting, drying, and skin irritation
- Ingestion of a solvent may cause severe toxicological effects. Seek medical attention immediately.

The odor threshold for the following chemicals exceeds acceptable exposure limits. Therefore, if you can smell it, you may be overexposed — increase ventilation immediately! Examples of such solvents are:

- Chloroform
- Benzene
- Carbon tetrachloride
- Methylene chloride

NOTE: *Do not depend on your sense of smell alone to know when hazardous vapors are present. The odor of some chemicals is so strong that they can be detected at levels far below hazardous concentrations (e.g., xylene).*

Some solvents (e.g., benzene) are known or suspected carcinogens.

Reducing Solvent Exposure

To decrease the effects of solvent exposure, substitute hazardous solvents with less toxic or hazardous solvents whenever possible. For example, use hexane instead of diethyl ether, benzene or a chlorinated solvent.

7.3.2 Safe Handling Guidelines for Flammables

- a. Handle flammable chemicals in areas free from ignition sources.
- b. Storage cabinets must be conspicuously labeled to indicate that they contain flammable liquids.
- c. Do not store in or adjacent to exits, elevators, or routes that provide access to exits.
- d. If flammable liquids are to be stored cold, the refrigerators and freezers must meet explosion proof standards.
- e. According to the Fire Code the maximum volume of flammable liquid allowed outside a flammable safety cabinet is provided in Appendix AB.
- f. Never heat flammable chemicals with an open flame. Use a water bath, oil bath, heating mantle, hot air bath, hot plate, etc. Such equipment should be intrinsically safe, with no open sparking mechanisms.

NOTE: *When using an oil bath, make sure the temperature is kept below the oil flash point.*

- g. Use ground straps when transferring flammable chemicals between metal containers to avoid generating static sparks.
- h. Work in an area with good general ventilation and use a fume hood when there is a possibility of dangerous vapors. Ventilation will help reduce dangerous vapor concentrations, thus minimizing this fire hazard.
- i. Restrict the amount of stored flammables in the laboratory, and minimize the amount of flammables present in a work area.

NOTE: *The NFPA has established formal limits on the total amounts of flammable liquids that may be stored or used in laboratories. (NFPA 30 and 45)*

- j. Only remove from storage the amount of chemical needed for a particular experiment or task.

7.3.3 Guidelines for Gas Cylinders

To ensure safe storage of gas cylinders:

- a. Check the label. The cylinder must be clearly marked with its contents and with any hazard warnings. Do not rely on color to identify container contents.
- b. Secure all cylinders to a wall or bench using brackets or clamping devices designed for such. Cylinders may also be stored in gas cylinder racks or floor stands. (A cylinder dolly should not be used for storage.)
 - i. Fasten cylinders individually (not ganged or grouped).
 - ii. Fasten cylinders with a sturdy chain or strap; bungee cords and rope are not acceptable as a means of securing compressed gas cylinders.
- c. Store cylinders in a well-ventilated area that is cool and dry. Ignition sources such as heat, sparks, flames, and electrical circuits should be kept away from gas cylinders.
- d. When not in use (i.e., the regulator has been removed), gas cylinders should be stored with a safety cap attached.
- e. Minimize the number of hazardous gas cylinders in a laboratory. Do not exceed the following:
 - i. Three 10" x 50" flammable gas and/or oxygen cylinders, and
 - ii. Two 9" x 30" liquefied flammable gas cylinders, and



- iii. Three 4" x 15" cylinders of severely toxic gases (e.g., arsine, chlorine, diborane, fluorine, hydrogen cyanide, methyl bromide, nitric oxide, phosgene).
- f. Store cylinders of flammables and oxidizing agents at least 20 feet apart, or separate these items with a fire wall.
- g. Do not store cylinders with corrosive materials.
- h. Do not store cylinders on the tops of shelves or cabinets.
- i. Keep flammable gases away from doorways or exit routes.
- j. Separate full cylinders from empty cylinders. Label empty cylinders "Empty."
- k. Do not store gas cylinders in hallways or public areas. Cylinders should be stored in a secure area.
- l. Close valves, and release pressure on the regulators when cylinders are not in use.
- m. Dispose of old lecture bottles. Return lecture bottles to the supplier or dispose of them as hazardous waste.

Handling and working with compressed gas cylinders:

- a. Never move a gas cylinder unless the cylinder safety cap is in place.
- b. When working with particularly hazardous gases use special procedures and work in approved gas storage cabinets.
- c. The gas cylinder should be chained or otherwise secured to an approved cylinder cart or dolly when being transported. Do not move a cylinder by rolling it on its base.
- d. Only use regulators approved for the type of gas in the cylinder. Do not use adapters to interchange regulators. Also, never try to repair or modify a gas regulator or its pressure gauges.
- e. Do not use Teflon tape when attaching the regulator.
- f. When opening a cylinder valve, follow these guidelines:
 - i. Direct the cylinder opening away from people.
 - ii. Open the valve slowly. Never open a cylinder valve without a regulator.
- g. For a leaking cylinder:
 - i. Close the valve if it is open and contact the supplier to pick it up.
 - ii. If the valve is already closed, leave the laboratory and shut the door behind you. Contact EHS immediately.
- h. Do not use oil or other lubricant on valves and fittings.
- i. Do not use oxygen as a substitute for compressed air.
- j. Do not lift cylinders by the safety cap.
- k. Do not tamper with the safety devices on a cylinder. Have the manufacturer or supplier handle cylinder repairs.
- l. Do not change a cylinder's label or color. Do not refill cylinders yourself.
- m. Do not heat cylinders to raise internal pressure.
- n. Do not use compressed gas to clean your skin or clothing.
- o. Do not completely empty cylinders. Maintain at least 30 psi pressure.
- p. Do not use copper (>65% copper) connectors or tubing with acetylene. Acetylene can form explosive compounds with silver, copper, and mercury.
- q. Always wear impact resistant glasses or goggles when working with compressed gases.
- r. Store according to compatibility.
- s. Separate flammable gases from oxidizing gases with noncombustible partitions.
- t. Store hazardous gases with poor warning properties in exhausted enclosures
- u. Do not subject compressed gas cylinders to cryogenic temperatures.

7.3.4 Guidelines for the Safe Handling of Cryogenic Liquids

- a. Follow these guidelines when working with cryogenic liquids:
- b. Before working with cryogenic liquids, acquire a thorough knowledge of cryogenic procedures, equipment operation, safety devices, and material properties. Cryogenic training should be documented.
- c. Reject delivery of unsafe cylinders.
- d. Keep equipment and systems extremely clean.
- e. Avoid skin and eye contact with cryogenic liquids. Wear appropriate personal protective equipment, such as a laboratory coat, temperature resistant gloves, and chemical splash goggles. Also, do not inhale cryogenic vapors.
- f. Pre-cool receiving vessels to avoid thermal shock and splashing.
- g. Use tongs to place and remove items in cryogenic liquid.
- h. When discharging cryogenic liquids, purge the line slowly. Only use transfer lines specifically designed for cryogenic liquids.
- i. Rubber and plastic may become very brittle in extreme cold. Handle these items carefully when removing them from cryogenic liquid.
- j. Store cryogenic liquids in double-walled, insulated containers (e.g., Dewar flasks) which are designed for this use.
- k. Tape exposed glass on cryogenic containers. In the event the container breaks or implodes, the tape will reduce fragmentation and violent dispersal of glass shards.
- l. Do not store cylinders of cryogenic liquids in hallways or other public areas.
- m. Refer to Appendix N for additional details on the handling and storage of liquid nitrogen.

7.3.5 Safe Handling Guidelines for Corrosives

To ensure safe handling of corrosives, the following special handling procedures should be used:

- a. Always store corrosives properly. Segregate acids from bases and inorganics from organics. Refer to the Chemical Storage section of this Manual for more information.
- b. Always wear a laboratory coat, gloves and chemical splash goggles when working with corrosives. Wear other personal protective equipment, as appropriate.
- c. To dilute acids, carefully add the acid to the water, not the water to the acid. This will minimize any reaction.
- d. Corrosives, especially inorganic bases (e.g., sodium hydroxide), may be very slippery; handle these chemicals with care and clean any spills, leaks, splashes, or dribbles immediately.
- e. Work in a chemical fume hood when handling fuming acids or volatile irritants (e.g., ammonium hydroxide).
- f. A continuous flow eye wash station should be in every work area where corrosives are present. An emergency shower should also be within 55 feet of the area.

7.3.6 Safe Handling Guidelines for Reactives

- a. Store in cool, dry area away from normal work areas and protected from shock, vibration, incompatible chemicals, elevated temperatures, and rapid temperature changes
- b. Store as required according to the nature of their individual hazards e.g. metal hydrides; some hydrogenation catalysts; picric acid; dinitrophenol; trinitrotoluene



- c. For air reactive chemicals use a glove box or fill the head space of the container with an inert gas before sealing the container.
- d. Water sensitive chemicals
 - a. Store in cool, dry areas designed to prevent accidental contact with water and other incompatible substances.
 - b. Storage construction should be fire-resistant.
 - c. Protect chemicals from water from sprinkler systems.
- e. Secondary containment is recommended.

7.3.7 Safe Handling Guidelines for Oxidizers and Peroxidizable Compounds

- a. Store oxidizers separate from flammable or combustible materials and reducing agents e.g. nitrates; chromates; permanganates; chlorates; peroxides
- b. All peroxidizable compounds should be stored away from heat and light (which catalyse the peroxidation reaction) and reducing agents, and protected from physical damage and ignition sources.
- c. An inventory of all peroxidizable material is required. These substances must be inspected and tested for peroxides regularly after the container is opened. A simple test procedure for detection of peroxides in substances such as alkali metals, alkali metal alkoxides, amides or organometallics is not available.

7.4 Chemical Storage Guidelines

Proper chemical storage is as important to safety as proper chemical handling. Chemicals must be stored in secured areas, i.e., not accessible to the general public. Highly toxic and reactive materials need additional means of security such as lockable cabinets.

Chemicals should be stored in approved closed containers and cabinets with secondary containment to prevent releases, separated by compatible hazard class (flammable/oxidizers/acids/bases/reactives) to avoid unwanted reactions and unnecessary exposure to occupants. Whenever possible, protective coated chemical bottles and glassware should be purchased and used to reduce hazardous spills due to breakage. It is important to note that certain hazardous materials are not permitted in many of our campus buildings, since the facilities are not constructed for high hazard use. Such materials include highly toxic gases, pyrophorics and highly reactive or unstable compounds. EHS should be consulted before any of these substances are brought onto Campus.

Do not indiscriminately store chemicals in alphabetical order. This can lead to incompatible chemicals being stored next to each other. Instead, store chemicals according to their hazards—for example, flammables, corrosives, toxics, reactives, etc. For chemicals that have multiple hazards, segregate according to the most prominent hazard.

7.4.1 General Storage Guidelines

Follow these guidelines for safe chemical storage:

- a. Read chemical labels and the SDS for specific storage instructions.
- b. Store chemicals in a well-ventilated area; however, do not store chemicals in a fume hood.
- c. Label all new material with the date in which it was received and the date in which it was opened. This will help prevent the accumulation of outdated chemicals and ensure that older chemicals are used first.



- d. Maintain an inventory of all chemicals in storage. A copy of the inventory should be maintained at a location outside of the laboratory.
- e. Promptly discard outdated chemicals or chemicals no longer needed by the laboratory. Contact EHS for disposal
- f. Return chemical containers to their proper storage location after use.
- g. Store glass chemical containers so that they are unlikely to be broken. Glass containers should never be stored directly on the floor.
- h. Large metal containers can be stored on the floor in an isolated location.
- i. Store all hazardous liquid chemicals below eye level of the shortest person working in the laboratory.
- j. Never store hazardous chemicals in a public area or corridor. Hazardous chemicals must be kept in a secured area.
- k. Do not store chemicals near heat sources or in direct sunlight.
- l. Periodically inspect storage locations for signs of corrosion or leakage and misplaced chemicals
- m. Flammable liquid storage cabinets should have an FM approval and meet OSHA and NFPA standards.
- n. Nothing should be stored/placed on top of a flammable liquid storage cabinet.
- o. Shelves and cabinets in flammable liquid storage cabinets should be anchored solidly to the wall and safety lips should be installed along the front edges of exposed shelves to keep materials from falling.
- p. Heavier items should always be stored closer to the ground.
- q. Hazardous liquid chemical storage must have adequate secondary spill containment devices in place. Priority should be given to acids, reactives, flammables, toxic compounds, radioactive and any other materials that could present a hazard, or affect your ability to work in case of a spill.
 - i. Secondary containment can be provided by the use of plastic tubs or storage cabinets with containment features to prevent the spread of spilled or leaking chemicals.
 - ii. Containment materials used should not be reactive with the chemicals stored in them.

7.4.2 Separating and Storing Hazardous Chemical

See chart – Appendix AB – Separation and Storage of Hazardous Materials

In addition to the guidelines above, there are storage requirements for separating hazardous chemicals. Follow these guidelines to ensure that hazardous chemicals are stored safely:

- a. Group chemicals according to their hazard category (i.e., corrosives, flammables, toxins, etc.), not alphabetically, and separated by some sort of physical barrier. An alphabetical storage system may place incompatible chemicals next to each other.
- b. Separate acids from bases and inorganic acids or bases from organic acids or bases. Store these chemicals near floor level.
- c. Isolate perchloric acid from all other chemicals and from organic materials. Do not store perchloric acid on a wooden shelf or spill paper.
- d. Separate highly toxic chemicals and carcinogens from all other chemicals. This storage location should have a warning label and should be locked.
- e. Time-sensitive chemicals, such as those that form peroxides, should not be kept longer than twelve months from purchase or six months after opening. If they are kept longer, then they need to be measured and monitored for peroxide development. If stratification



- of liquids, precipitate formation, and/or change in color or texture is noted, contact EHS immediately.
- f. Picric acid must be stored under a layer of liquid, as picric crystals are highly explosive. If picric acid dries out (forming yellow crystals), do not touch the container! Contact EHS immediately!
 - g. If flammables need to be chilled, store them in a laboratory-safe refrigerator, not in a standard (household style) refrigerator.
 - h. Chemicals may be stored in the cabinets underneath a chemical fume hood provided the cabinetry is designed for that use.
 - i. Cabinetry designed for flammable storage vents into the fume hood exhaust duct.
 - ii. Cabinetry designed for corrosives storage vents directly into the fume hood. Flammable chemicals should never be stored in this type of cabinets!
 - iii. Some cabinetry is only designed for general storage or with a drying rack. These cabinets are not meant to be used for hazardous chemical storage.
 - i. Flammables should be stored in a well-ventilated area and large quantities in a flammable storage cabinet. Contact EHS for more information on allowable storage of flammable liquids per NFPA Code.
 - i. Flammable, volatile chemicals should be kept in a cool place, away from sources of heat and ignition.
 - ii. If flammables are stored in refrigerators/freezers, the units should be designed, manufactured and UL-approved to have spark-free interiors. Any refrigerator or freezer not designed for the storage of flammables needs to have "EXPLOSION HAZARD: Do Not Store Flammables in This Refrigerator" marked on the outside of the door.
 - iii. The total volume of flammable solvents in the laboratory should be limited to the amount needed for approximately one week of operations or the limit prescribed by NFPA (National Fire Protection Association), UBC (Uniform Building Code), and UFC (Uniform Fire Code), whichever is more restrictive.
 - iv. For most laboratories the amounts are:
 - a. 4 gallons of Class I (flashpoint less than 73oF) and Class II (flashpoint greater than 73o F but less than 140oF) flammable liquids
 - b. Up to 12 gallons of Class III (flashpoint greater than 140o F but less than 200oF) combustible liquids may be stored in each laboratory
 - j. No food is to be stored in the same refrigerator as chemicals, film or batteries. Hazardous substances can be absorbed by the food and subsequently ingested by individuals.
 - k. Corrosives should be stored in a corrosive storage cabinet. However, acids and bases should be stored separately to prevent their mixing and reacting violently in the event of an accident.
 - l. Strong oxidizing agents should be stored away from organic materials and strong reducing agents to prevent the risk of fire and/or violent reactions in the event of an accident.
 - m. Cyanides and sulfides should be stored well away from acids to prevent the generation of the respective toxic gases in the event of an accident.

Segregation by incompatibilities: Chemicals should be segregated by hazard classification and compatibility in a well identified area, with local exhaust ventilation. In many of the UCCS facilities, chemicals are stored using the JT Baker SAF-T-DATA Hazard and Storage Codes. The chemicals are stored according to their color code:

- Orange...Moderate Hazard
- White...Corrosive Hazard
- White Stripe...Corrosive, but stored apart from White
- Yellow...Reactive/Oxidizer Hazard
- Yellow Stripe...Reactive, but stored apart from Yellow
- Blue...Health Hazard (Toxic)
- Red...Flammable Hazard
- Red Stripe...Flammable, but stored apart from Red

The following table provides examples of incompatible chemicals:

| CHEMICAL | INCOMPATIBLE WITH . . . |
|-----------------|--|
| Acetic acid | Chromic acid, nitric acid, hydroxyl compounds, ethylene glycol, perchloric acid, peroxides, permanganates |
| Acetylene | Chlorine, bromine, copper, fluorine, silver, mercury |
| Acetone | Concentrated nitric and sulfuric acid mixtures |
| Alkali metals | Water, carbon tetrachloride or other chlorinated hydrocarbons, carbon dioxide, halogens |
| Ammonia | Mercury, chlorine, calcium hypochlorite, iodine, bromine, hydrofluoric acid |
| Chlorates | Ammonium salts, acids, powdered metals, sulfur, finely divided organic or combustible materials |
| Chlorine | Ammonia, acetylene, butadiene, butane, methane, propane (or other petroleum gases), hydrogen, sodium carbide, benzene, finely divided metals, turpentine |
| Cyanide | Acids |
| Fluorine | Most other chemicals |
| Nitrates | Sulfuric acid |
| Oxygen | Oils, grease, hydrogen, flammable liquids, solids, or gases |
| Perchloric acid | Acetic anhydride, bismuth and its alloys, alcohol, paper, wood, grease, oils, |
| Sodium | Carbon tetrachloride, carbon dioxide, water |
| Sulfides | Acids |

7.5 Hygiene and Chemical Safety

Good personal hygiene will help minimize exposure to hazardous chemicals. When working with chemicals, follow these guidelines:

- a. Wash hands frequently and before leaving the laboratory. Also, wash hands before eating, drinking, smoking or applying makeup.



- b. Wear appropriate personal protective equipment (PPE). Always wear protective gloves when handling any hazardous chemicals.
- c. Remove PPE before leaving the laboratory and before washing hands.
- d. Remove contaminated clothing immediately. Do not use the clothing again until it has been properly decontaminated.
- e. Follow any special precautions for the chemicals in use.
- f. Do not eat, drink, smoke or apply makeup around chemicals.
- g. Tie back long hair when working in a laboratory or around hazardous chemicals.
- h. Do not keep food, beverages, or food and beverage containers anywhere near chemicals or in laboratories where chemicals are in use.
- i. Do not use laboratory equipment, including laboratory refrigerators/freezers, to store or serve food or drinks.
- j. Do not wash food and beverage utensils in a laboratory sink.
- k. Do not sniff or taste chemicals.
- l. Do not touch door knobs, telephones, computer keyboards, etc. with contaminated gloves.

7.6 Special Precautions for working with specific chemical hazards

7.6.1 Light-Sensitive Materials

- a. Light-Sensitive Materials: Materials which react in the presence of light, forming new compounds which can be hazardous, or resulting in conditions such as pressure build-up inside a container which may be hazardous.
- b. Store light-sensitive materials in a cool, dark place in amber colored bottles or other containers which reduce or eliminate penetration of light.
- c. Date containers on receipt and upon opening, and dispose of surplus material after one year if unopened or 6 months if opened.

7.6.2 Perchloric Acid

Perchloric acid can be dangerously reactive. Aqueous perchloric acid at concentrations less than 70% at room temperatures is a strong acid. At elevated temperatures or concentrations greater than 70% it is a strong oxidizing agent and can cause violent explosions if misused. Anhydrous perchloric acid (greater than 85%) is unstable even at room temperatures and ultimately decomposes spontaneously with a violent explosion. Contact with oxidizable material can cause an immediate explosion.

Follow these guidelines for the proper use of perchloric acid in the laboratory:

- a. Perchloric acid in concentrations greater than 70% is not recommended.
- b. Any procedure involving heating of perchloric acid must be conducted in a properly functioning perchloric acid fume hood with the sash down.
- c. Do not allow perchloric acid to come into contact with organic material or dehydrating agents.
- d. Anhydrous perchloric acid should only be made as required and should never be stored. Only experienced faculty should handle anhydrous perchloric acid. EHS should be contacted prior to any work with anhydrous perchloric acid.
- e. Do not allow contact with metals to prevent the formation of metal perchlorates which are very unstable and can explode.
- f. Do not allow contact with wood or paper as fires can result from such contact.



7.6.3 Hydrogen Fluoride / Hydrofluoric Acid

Hydrogen Fluoride is a colorless fuming gas or liquid. In its liquid state it's called Hydrofluoric Acid (HF). HF is an extremely corrosive material. All forms, including vapors and solutions, can cause severe, slow-healing burns to human tissue, including the lungs and eyes. At concentrations greater than 50% the burning is noticeable in a matter of minutes or less, while at concentrations below 50% the burns may not be felt until several hours after exposure. Burns from concentrated acid involving as little as 2.5% of body surface have resulted in death. Because it has a low boiling point and a high vapor pressure, HF must be kept in a non-glass pressure container. HF dissolves glass; therefore, it should never be stored in a glass container.

IF YOU ARE EXPOSED TO HF GAS, SEEK IMMEDIATE CARE AT THE NEAREST HOSPITAL EMERGENCY ROOM. FOR CONTACT WITH HF ACID, FLUSH WITH LARGE AMOUNTS OF COLD WATER FOR AT LEAST 15 MINUTES WHILE REMOVING CONTAMINATED CLOTHING. APPLY CALCIUM GLUCONATE GEL AND SEEK IMMEDIATE EMERGENCY MEDICAL ATTENTION.

Hydrogen Fluoride Gas or Hydrofluoric Acid

Contact EHS prior to obtaining HF gas or liquid. EHS must review and pre-approve experimental and research protocols (see Appendix C -Questionnaire for Use of Hydrogen Fluoride Gas and Hydrofluoric Acid).

Laboratory Information Required:

A completed Experimental Protocol outlining proposed use of HF. Protocol must include details such as:

- HF quantities, concentration, pressure, temperature, flow rate, etc.
- Personal Protective Equipment (see HF PPE Chart) - gloves, eye/face protection, etc.
- Engineering Controls - fume hood, gas cabinet, special exhaust device, alarm monitoring system, etc.
- Safe Handling Requirements - routine leak detection, emergency evacuation procedure in case of accidental release/exposure, location of emergency shower and eye/face wash unit(s), location of calcium gluconate gel, posted emergency room contact phone numbers, etc.
- A complete laboratory Chemical and Gas Inventory is required to determine if incompatibilities exist for ventilation and storage needs.

Storage and Engineering Requirements:

- Maximum quantity of HF allowed will be determined on a case by case basis for each Experimental Protocol.
- HF gas cylinders must be stored in an approved vented gas cylinder cabinet with a HF alarm sensor that will detect an immediate HF release.
 - Alarm monitoring system should be easy to calibrate by Laboratory User(s).
 - Alarm monitoring system should have battery back-up in case of power outage.
- HF acid container(s) are required to be stored in an approved vented corrosive cabinet.
- EHS and Facilities Management will conduct a code review to determine additional Engineering Control requirements. Controls may include, but not be limited to, fume hood or other ventilation containment, room pressurization, duct work and exhaust fan(s), exhaust scrubbers, system alarms, placarding, etc.



Personal Protective Equipment (PPE) & Safe Handling Requirements:

- a. Emergency shower and eye/face wash unit(s) may be required. Flush and assure their proper operation at least weekly.
- b. Experimental Protocols and Safety Data Sheets must be posted in visible, prominent locations in the lab. All laboratory personnel must be trained on Experimental Protocols.
- c. 2.5% calcium gluconate gel must be immediately available in Lab.

In HF exposures, time is crucial. Immediately wash the affected area(s) with copious amounts of water to minimize the extent and the depth of the burn. Never let a HF burn go untreated, as extensive damage could result. Any area that is exposed to HF must be treated immediately with calcium gluconate or another appropriate material to stop its reaction with human tissue. Medical attention should be sought as quickly as possible. Ensure medical personnel are aware that HF is involved. Mistakes in treatment can occur if a miscommunication results in treatment for a hydrochloric acid burn instead of a hydrofluoric acid burn.

7.6.4 Mercury

Mercury and its compounds are very common in laboratories. Because of its widespread use, mercury's hazardous nature may be overlooked or ignored. Elemental mercury is volatile, and its vapors are extremely toxic. Because of the vapors' high toxicity, it is very important to clean up mercury spills promptly and thoroughly. If this is not done, mercury can accumulate and vaporize over time. Inorganic and organic mercury compounds are also highly toxic.

Follow these guidelines for the proper use of mercury in the laboratory:

- a. All work with elemental mercury should be performed over trays to capture and contain any spillage.
- b. All work involving mercury should be done in a properly functioning chemical fume hood.
- c. Clean up all mercury spills immediately. If you do not have the appropriate spill-control equipment, do not clean the spill yourself, as you can make the situation worse by creating small droplets that can end up in inaccessible locations such as cracks and crevices. For assistance, contact EHS.
- d. Be careful not to heat any surfaces that may contain mercury residue, as increased temperature greatly increases the vapor pressure of mercury.
- e. Red spirit thermometers are a nontoxic alternative to mercury thermometers and should be used whenever possible.

7.7 Nanotechnology Safety

(Adopted from guidelines as written by Dr. Peter Lichty of Lawrence Berkeley National Laboratory and Guidance from NIOSH).

Reason for concern related to potential EHS risks associated with nanotechnologies and in particular, carbon nanotubes, have recently surfaced. For this reason, UCCS's EHS department is recommending an approach referred to as control banding to address the potential risks associated with research in areas concerned with nanotechnologies.

Control banding (CB) is a strategy for qualitative risk assessment and management of hazards in the workplace. The strategy involves a process to group workplace risks into control bands based on combinations of hazard and exposure information. CB strategies are not intended to

be predictive exposure models. The tables in Appendix T provide general guidelines for specific nanotechnologies already in use in many areas of research. It is recommended that this table be used a guideline to develop SOP for all nanotechnology related research. At a minimum, any new research involving nanotechnologies should be reviewed from a Process Hazard Analysis perspective.

7.7.1 General Precautionary Measures

Given the limited amount of information about health risks that may be associated with nanomaterials (NM), taking measures to minimize worker exposures is prudent.

- For most processes and job tasks, the control of airborne exposure to nanoaerosols can be accomplished using a variety of engineering control techniques similar to those used in reducing exposure to general aerosols.
- The implementation of a risk management program in workplaces where exposure to NMs exists can help to minimize the potential for exposure to nanoparticles. Elements of such a program should include the following:
 - Evaluating the hazard posed by the nanomaterial based on available physical and chemical property data, toxicology, or health-effects data
 - Assessing the worker's job task to determine the potential for exposure
 - Educating and training workers in the proper handling of NMs (e.g., good work practices)
 - Establishing criteria and procedures for installing and evaluating engineering controls (e.g., exhaust ventilation) at locations where exposure to NMs might occur
 - Developing procedures for determining the need for and selecting proper personal protective equipment (e.g., clothing, gloves, respirators)
 - Systematically evaluating exposures to ensure that control measures are working properly and that workers are being provided the appropriate personal protective equipment
- Ensure that comprehensive standard operating procedures (SOPs) are in place. SOPs should document ways to minimize exposure, such as by reconstituting nanoparticles (NPs) inside vials and not weighing powder, performing procedures inside containment; working atop disposable absorbent pads; selecting and requiring the use of personal protective equipment (PPE) such as gloves, safety goggles, etc.; transporting NPs in sealed containers inside a secondary containment system; and, pre-planning spill procedures. Train staff on SOPs prior to work.
- Consider adding bindings or coatings which have been shown to reduce the toxicity of similar engineered nanoparticles (ENPs), if your research goals allow their addition to your ENP.
- Be sure to consider the hazards of precursor materials in evaluating process hazards.
- Prevent skin and eye contact with NPs or NP-containing solutions by using appropriate personal protective equipment (PPE). Specify PPE to protect all skin areas which may become contaminated with NPs (lab coats, sleeves, aprons, etc. in addition to gloves). EH&S generally recommends a glove thickness of at least 15 mil, or double gloves if using thin gloves. If NPs are in solution, the glove must be impermeable to the solvent. Neoprene gloves work well for most dry applications.
- Clean surfaces so they are visibly clean at the end of each shift or earlier if the process is complete, using high efficiency particulate air (HEPA)-filtered vacuums or wet wipe methods with damp, soapy towels. Dispose of the towels as hazardous waste; do not dry and re-use them.

- Engineering control techniques such as source enclosure (i.e., isolating the generation source from the worker) and local exhaust ventilation systems should be effective for capturing airborne nanoparticles. Current knowledge indicates that a well-designed exhaust ventilation system with a high-efficiency particulate air (HEPA) filter should effectively remove NMs.
- The use of good work practices can help to minimize worker exposures to NMs. Examples of good practices include cleaning of work areas using HEPA vacuum pickup and wet wiping methods, preventing the consumption of food or beverages in workplaces where NMs are handled, providing hand-washing facilities, and providing facilities for showering and changing clothes.
- No guidelines are currently available on the selection of clothing or other apparel (e.g., gloves) for the prevention of dermal exposure to nanoaerosols. However, some clothing standards incorporate testing with nanometer-sized particles and therefore provide some indication of the effectiveness of protective clothing.
- Respirators may be necessary when engineering and administrative controls do not adequately prevent exposures. Currently, there are no specific limits for airborne exposures to engineered nanoparticles although occupational exposure limits exist for some larger particles of similar chemical composition. It should be recognized that exposure limits recommended for non-nanoscale particles may not be health protective for nanoparticle exposures (e.g., the OSHA Permissible Exposure Limit [PEL] for graphite may not be a safe exposure limit for carbon nanotubes). The decision to use respiratory protection should be based on professional judgment that takes into account toxicity information, exposure measurement data, and the frequency and likelihood of the worker's exposure. While research is continuing, preliminary evidence indicates that NIOSH-certified respirators will be useful for protecting workers from nanoparticle inhalation when properly selected and fit tested as part of a complete respiratory protection program.
- Consider if there are ways to destroy waste NPs or to reduce their potential hazards, and implement the procedures if possible rather than disposing of the NPs into the environment.
- Manage waste NPs as if they are hazardous waste. The particles may not strictly qualify as hazardous waste under current rules. However, carefully controlled disposal as hazardous waste is far preferable to disposal in solid waste or wastewater, where particles will very likely escape into the environment.
- Equipment previously used with NPs should be evaluated for potential contamination prior to disposal or reuse for another purpose.
- Facility components including exhaust systems and internal filters should be evaluated and cleaned if necessary prior to maintenance, modification or demolition

Additional Resources:

- National Institute of Occupational Safety and Health's Approaches to Safe Nanotechnology :<http://www.cdc.gov/niosh/docs/2009-125/>
- National Nanotechnology Initiative: <http://www.nano.gov/>
- Environmental Protection Agency Perspective on Nanotechnology: <http://epa.gov/ncer/nano/index.html>

7.8 Physical Safety

There are a variety of physical hazards that can be found in a laboratory environment. Many of these hazards are similar to those found in every home, and if common sense is applied, risks

are fairly easy to minimize. This section will focus on common physical hazards and how to reduce the risk associated with them.

7.8.1 Aerosol Production

Liquid or solid particles suspended in air are referred to as “aerosols.” Aerosols containing infectious agents and hazardous materials can pose a serious health risk. If inhaled, small aerosol particles can readily penetrate and remain deep in the respiratory tract. Also, aerosol particles can easily contaminate equipment, ventilation systems, and human skin. Because they may remain suspended in the air for long periods of time after they are initially discharged, steps should be taken to minimize the production of and exposure to aerosols.

The following may produce aerosols:

- Centrifuge
- Blender
- Shaker
- Magnetic stirrer
- Sonicator
- Pipette
- Vortex mixer
- Syringe and needle
- Vacuum-sealed ampoule
- Grinder, mortar, and pestle
- Test tubes and culture tubes
- Heated inoculating loop
- Separatory funnel
- Animals
- Hot plate (if chemicals are spilled onto the hot surface)
- Chemical or biological spills

Follow these guidelines to eliminate or reduce the hazards associated with aerosols:

- a. Conduct procedures that may produce aerosols in a certified biological safety cabinet or a chemical fume hood.
- b. Keep tubes stoppered when vortexing or centrifuging.
- c. Allow aerosols to settle for five to ten minutes before opening a centrifuge, blender, or tube.
- d. Place a cloth soaked with disinfectant over the work surface to kill any biohazardous agents.
- e. Slowly reconstitute or dilute the contents of an ampoule.
- f. When combining liquids, discharge the secondary material down the side of the container or as close to the surface of the primary liquid as possible to avoid splattering the material.
- g. Avoid splattering by allowing inoculating loops or needles to cool before touching biological specimens.
- h. Use a mechanical pipetting device.

7.8.2 Electrical Safety

Electrical safety is an important component of laboratory safety. When using electrical equipment in a laboratory, the guidelines below should be followed:



- a. Check electrical cords and switches for damage prior to using equipment or appliances. Damaged cords (cords with frayed or exposed wires or with damaged or missing plug prongs) should be repaired promptly or the equipment should be locked/tagged out until the cord can be repaired.
- b. Use extension cords only when necessary and only on a temporary basis (less than eight hours). Do not use extension cords in place of permanent wiring. Contact Physical Plant to request new outlets if your work requires equipment in an area without an outlet.
- c. Use extension cords that are the correct size or rating for the equipment in use. The diameter of the extension cord should be the same or greater than the cord of the equipment in use.
- d. Do not run electrical cords above ceiling tiles, through walls or across thresholds.
- e. Keep electrical cords away from areas where they may be pinched and areas where they may pose a tripping or fire hazard (e.g., doorways, walkways, under carpet, etc.)
- f. Avoid plugging more than one appliance in each outlet. If multiple appliances are necessary, use a single approved power strip with surge protection and a circuit breaker. Do not overload the circuit breaker.
- g. Avoid “daisy-chaining” or “bird-nesting.” Connecting power strips and/or extension cords in a series or cluster is against fire and electrical codes.
- h. Use ground fault circuit interrupters when using electrical equipment near water sources.
- i. Keep access to electrical panels clear of obstructions. Three (3) feet in front of the panel is the distance required by code.

7.8.3 Mechanical/Equipment Safety

We realize that many of you may be working in areas where equipment does not yet exist for the processes that you are developing. Regardless of whether you are having to develop equipment for your processes or if you are using existing equipment; these are the fundamental elements of equipment safety:

1. Use the correct equipment for the job. Equipment should be used for its intended purpose only. Never modify or adapt equipment without guidance from the equipment manufacturer or EHS.
2. Do not defeat, remove, or override equipment safety devices! Doing so can result in injury or even death. (Example: Defeating a fume hood sash lock.
3. Know how to properly operate equipment. This may require documented, specific training. Also the user must be familiar with applicable safeguards and maintenance requirements.
4. Inspect equipment for damage and for required safety features prior to use.
5. Ensure that equipment meets the following requirements:
 - a. Controls and safeguards are adequate and functional (e.g., interlocks that shut-off equipment automatically and guards that protect moving parts and belts).
 - b. The location is safe (and well-ventilated, if necessary).
 - c. Equipment works properly.

IMPORTANT: *Disconnect any equipment that is unsafe or does not work properly, and remove it from service (lock out/tag out). Notify other users of the problem.*

6. Use equipment properly. Do not use the equipment in ways it was not designed or intended to be used.

7.8.4 Lock-Out/Tag-Out Concerns

Energy sources including electrical, mechanical, hydraulic, pneumatic, chemical, thermal, or other sources in machines and equipment can be hazardous to workers. During the servicing and maintenance of machines and equipment, the unexpected startup or release of stored energy can result in serious injury or death to workers.

Workers servicing or maintaining machines or equipment may be seriously injured or killed if hazardous energy is not properly controlled. Injuries resulting from the failure to control hazardous energy during maintenance activities can be serious or fatal! Injuries may include electrocution, burns, crushing, cutting, lacerating, amputating, or fracturing body parts, and others.

Examples of equipment/machines that may be encountered at UCCS that are subject to LO/TO include but are not limited to: gas, water and steam lines; HVAC equipment including air handlers and boilers; kitchen equipment such as slicers, mixers, dishwashers, trash compactors, and garbage disposals; woodworking and metalworking machines; printing presses; laboratory equipment such as centrifuges, autoclaves and high powered lasers; conveyors; motor vehicles; hydraulic lifts; elevators, etc.

In general, LO/TO must be observed during service and maintenance activities including: constructing, installing, setting up, adjusting, inspecting, modifying, lubricating, cleaning or un-jamming, and adjusting or changing tools.

This SOP and the cited OSHA standard do NOT apply to work on electric systems operating at **50 volts or more**. Rather, these activities are subject to specific energy isolation requirements and work practice controls covered by other OSHA standards

Failure to control hazardous energy accounts for nearly 10 percent of the serious accidents in many industries. Proper lockout/tagout (LOTO) practices and procedures safeguard workers from hazardous energy releases. OSHA's [Lockout/Tagout Fact Sheet](#) (PDF*) describes the practices and procedures necessary to disable machinery or equipment to prevent hazardous energy release. The OSHA standard for The Control of Hazardous Energy (Lockout/Tagout) ([29 CFR 1910.147](#)) for general industry outlines measures for controlling different types of hazardous energy. The LOTO standard establishes the employer's responsibility to protect workers from hazardous energy. Employers are also required to train each worker to ensure that they know, understand, and are able to follow the applicable provisions of the hazardous energy control procedures:

- Proper lockout/tagout (LOTO) practices and procedures safeguard workers from the release of hazardous energy. The OSHA standard for The Control of Hazardous Energy (Lockout/Tagout) ([29 CFR 1910.147](#)) for general industry, outlines specific action and procedures for addressing and controlling hazardous energy during servicing and maintenance of machines and equipment. Employers are also required to train each worker to ensure that they know, understand, and are able to follow the applicable provisions of the hazardous energy control procedures. Workers must be trained in the purpose and function of the energy control program and have the knowledge and skills required for the safe application, usage and removal of the energy control devices.
- All employees who work in an area where energy control procedure(s) are utilized need to be instructed in the purpose and use of the energy control procedure(s), especially prohibition against attempting to restart or reenergize machines or other equipment that are locked or tagged out.



- All employees who are authorized to lockout machines or equipment and perform the service and maintenance operations need to be trained in recognition of applicable hazardous energy sources in the workplace, the type and magnitude of energy found in the workplace, and the means and methods of isolating and/or controlling the energy.
- Specific procedures and limitations relating to tagout systems where they are allowed.
- Retraining of all employees to maintain proficiency or introduce new or changed control methods.

OSHA's [Lockout/Tagout Fact Sheet](#) (PDF*) describes the practices and procedures necessary to disable machinery or equipment to prevent the release of hazardous energy.

Employee Training

All “**authorized**” and “**affected**” employees must complete LO/TO training, consisting of both general training provided by EHS and supplemental specific training provided by the supervisor or delegate. Specific training by the supervisor must include site-specific equipment/machines and related LO/TO procedures.

- An “**Affected Employee**” is an employee whose job requires him/her to operate or use a machine or equipment on which servicing or maintenance is being performed under LO/TO, or whose job requires him/her to work in an area in which such servicing or maintenance is being performed.
- An “**Authorized Employee**” is a person who locks out or tags out machines or equipment in order to perform servicing or maintenance on that machine or equipment.

OSHA provides an on-line interactive [LO/TO training program](#).

Written LO/TO Procedures

As a general rule, specific procedures must be documented for each piece of equipment subject to LO/TO. These procedures must contain the following information:

- A specific statement of the intended use of the procedure;
- Specific procedural steps for shutting down, isolating, blocking, and securing machines/equipment to control all sources of hazardous energy;
- Specific procedural steps for the placement, removal, and transfer of LO/TO devices and responsibility for the devices;
- Specific requirements for testing a machine or equipment to determine and verify the effectiveness of LO/TO device and other energy control measures.

Periodic Review

Supervisors must periodically (at least annually) review written procedures & observe employees performing tasks to verify continued efficacy and employee adherence to LO/TO procedures. The review must include discussion with “Authorized” and “Affected Employees” to reinforce each employee’s responsibilities relative to the procedure.

Minor Servicing

Minor tool changes and adjustments and other minor servicing activities which take place during normal production operations are not subject to LO/TO standards provided ALL of the following criteria are met.

- The activity is routine. It is performed as part of a regular and prescribed course of action/procedure and is performed in accordance with established practices/industry standards.
- The activity is repetitive. It is repeated regularly as part of the production process or cycle.



- The activity is integral to the use of the equipment for production (the activity must be essential to the production process).
- The activity is conducted with effective production-mode safeguards in place.
- The activity does not require extensive disassembly of the machinery/equipment.
- The activity is performed using alternative measures (tools or guarding) which provide effective employee protection.

Cord & Plug

The LO/TO procedural requirements do NOT apply if the machinery/equipment is completely de-energized simply by unplugging it and the cord/plug remains under the control of the person conducting the service/repair. If the equipment/machine is not unplugged; if the cord/plug does not remain under the exclusive and immediate control of the person conducting the repair/service, or; if the equipment has multiple energy sources, then the LO/TO standard applies and all procedural steps must be followed. Pneumatic tools may also fall into this category provided that they can be completely isolated from their energy source and bled of stored energy.

LO/TO Procedural Steps

Steps to effectively accomplish a LO/TO state are listed below and depicted in the flow charts at the end of this SOP (reprinted from OSHA). Each step must be accomplished in the stated order, and captured/described in a written LO/TO procedure. All affected and authorized employees must receive LO/TO training, including procedures specific to their work. See EHS SOP, Lockout/Tagout for Machines & Equipment: Training & Inspections.

Step 1: Identify Hazardous Energy

Step 2: Communicate

Step 3: Shut-down

Step 4: Isolate

Step 5: Apply LO/TO device(s)

Step 6: Relieve Stored Energy

Step 7: Verify

Step 8: Service

Step 9: Inspect

Step 10: Remove LO/TO

Step 11: Communicate

7.8.5 Equipment Guards and Mounting

- a. Guards
Belts, pulleys, and other exposed moving equipment parts must be guarded. Equipment covers should be in place.
- b. Instruction Manuals
Operator's manuals should be available and workers using the equipment should know where such manuals can be found, and should review the manuals prior to using the equipment.
- c. Mounting
Equipment designed to be used in a particular location should be permanently fixed in place to prevent movement from vibration or earthquake. This is especially important for equipment which may topple (e.g., a drill press) or which needs to be balanced (e.g., a centrifuge).



7.8.6 Noise/Auditory Safety

Many laboratory environments are noisy due to the number and type of equipment used in them. While some equipment is inherently noisy, others only become noisy when there is a problem, such as a loose belt. In noisy environments, precautions should be taken to protect personnel from hearing loss. Ear plugs or other hearing protection may be necessary. If equipment is operating at a louder than normal noise level, maintenance may need to be scheduled. EHS can recommend hearing protection devices based on noise levels in the workspace and on individual needs.

7.8.7 Glass & Metal Sharps

Accidents involving glassware are a leading cause of laboratory injuries. Careful handling and disposal of metal and glass sharps can minimize the risk of cuts and puncture wounds, not only for laboratory personnel, but for other university employees as well.

Laboratory Glassware

Follow these practices for using laboratory glassware safely:

- a. Prevent damage to glassware during handling and storage.
- b. Inspect glassware before and after each use. Discard or repair any cracked, broken, or damaged glassware. The chemistry department stockroom can salvage some chipped/broken glassware via heat polishing.
- c. Thoroughly clean and decontaminate glassware after each use.
- d. When inserting glass tubing into rubber stoppers, corks, or tubing, follow these guidelines:
 - i. Use adequate hand protection, such as a glass tubing insertion tool.
 - ii. Lubricate the tubing.
 - iii. Hold hands close together to minimize movement if the glass breaks
- e. When possible, use plastic or metal connectors instead of glass connectors.
- f. Heat and cool large glass containers slowly to reduce the risk of thermal shock.
- g. Use Pyrex or heat-treated glass for heating operations.
- h. Never use laboratory glassware to serve food or drinks or wash laboratory glassware in the same sink in which food and beverage utensils are washed.
- i. Use thick-walled and/or round-bottomed glassware for vacuum operation. Flat-bottomed glassware is not as strong as round-bottomed glassware.
- j. Use a mesh glass sleeve around glassware or tape glassware that is under pressure. This will contain the glass in one place should it break.
- k. Use a standard laboratory detergent to clean glassware.

IMPORTANT: Do not use chromic acid to clean glassware. Use a standard laboratory detergent. Chromic acid is extremely corrosive and expensive to dispose of. Chromic acid must not be disposed in the sanitary sewer system.

When handling glassware, follow these safety guidelines:

- a. When handling cool flasks, grasp the neck with one hand and support the bottom with the other hand.
- b. Lift cool beakers by grasping the sides just below the rim. For large beakers, use two hands: one on the side and one supporting the bottom.



- c. Never carry bottles by their necks.
- d. Use a cart or specially designed secondary container to transport large and/or heavy bottles.
- e. Do not pick up broken glass with bare or unprotected hands. Use a brush and dust pan to clean up broken glass. Remove broken glass in sinks by using tongs for large pieces and cotton held by tongs for small pieces and slivers.

Metal Sharps

Metal sharps should be carefully stored and handled properly. Follow these guidelines:

- a. Do not uncap a needle by placing the cap in your mouth.
- b. Never re-cap a used syringe needle by hand or mouth, and never manipulate (bend, break, shear, remove from syringe, etc.) a needle. Immediately place used/contaminated sharps in a sharps disposal container.
- c. Do not leave sharps, including razor and scalpel blades, lying unprotected on bench tops. Place in a secondary container when not in use or when being transported.
- d. If a needle/syringe must be reused,
 - i. Use self-sheathing syringes or other safety devices for re-capping sharps whenever possible. The one-handed scoop method may be used as a last resort.
 - ii. Place the uncapped syringe/needle in cork or foam, or place it in a tray or other type of secondary container when not in use and when being transported.

7.8.8 Temperature

Equipment that produce extreme temperatures are often used in laboratories. Whether the equipment is a -80 freezer, a walk-in cooler or freezer, cryogenic liquids, a hotplate, an oven, or an autoclave, caution should be taken whenever extreme temperatures may be encountered. Not using appropriate protective equipment, such as temperature resistant gloves, when using this equipment can lead to painful injuries.

Before using temperature generating equipment, become familiar with proper procedures and handling techniques. Pay special attention to the personal protective equipment required for that equipment. Posting signs that warn of the hazard may help reduce the likelihood of someone accidentally touching an extremely hot or cold surface – such as a hot plate - especially if it is not obvious that the equipment is on.

7.8.9 Pressurized Systems

Pressurized systems have the potential to cause extensive damage and injury if extreme precaution is not taken. Pressurized systems include compressed gases, liquid cryogenic cylinders, and vacuum systems, among others. When working with pressurized systems, remember:

- a. Do not conduct a reaction in, or apply heat to, a closed system apparatus unless the equipment is designed and tested to withstand pressure. See American Society of Mechanical Engineers (ASME) Code, Section VIII for more information about maximum allowable working pressure (MAWP).
- b. Pressurized systems should have an appropriate relief valve set at the MAWP.
- c. Pressurized systems must be fully shielded and should not be conducted in an occupied space until safe operation has been assured. Until safe operation is assured, remote operation is mandatory.



Safety points to remember:

- a. Limit exposure to pressurized systems to minimize risk.
- b. Identify and assess all hazards and consequences prior to beginning operations.
- c. Use remote manipulations whenever possible.
- d. Minimize pressure, volume, and temperature.
- e. Design pressurized systems conservatively relative to the operating temperature and pressure.
- f. Use material with a predictably safe failure mode.
- g. Ensure that the components of the pressurized system will maintain structural integrity at the maximum allowable working pressure.

IMPORTANT: *Do not use glass containers for pressurization, unless the glass item is designed to be pressurized and is rated for pressurization by the manufacturer.*

- h. Only use equipment designed for use under pressure. Avoid material that may become brittle at extreme temperatures.
- i. Operate within the original design parameters.
- j. Ensure safety mechanisms (e.g., pressure relief valves, fail-safe devices) are in place.
- k. Use quality hardware.
- l. Use protective shield or enclosures.
- m. Use tie-downs to secure tubing and other equipment.
- n. Do not leave a pressurized system unattended.

7.8.10 Reduced Pressure Operations

The university is using FM Global Hot Work Permit program as an essential tool in preventing fires in our buildings. The permit is just a tool and it does not disclose all precautions for every hot work application. All hot work on campus shall be **strictly supervised** while the work is being performed.

- a. Glass vacuum containers, such as desiccators and flasks, should be wrapped with tape to prevent glass from flying in the event of an implosion or explosion.
- b. When carrying out filtration or distillation procedures under reduced pressure, the heavy-walled glassware and tubing must be undamaged and able to withstand the conditions of reduced pressure. Cold traps should be used to prevent leaking of vapours from the experiment to the oil of the vacuum pump or the water passing through a water aspirator.
- c. Rotary evaporation of solvents using a water aspirator is not appropriate where the vapour being removed is highly odorous or toxic unless a suitable cold trap is available to capture them. Alternative enclosed systems are recommended.

7.8.11 Hot Work – Welding – Brazing

The university is using FM Global Hot Work Permit program as an essential tool in preventing fires in our buildings. The permit is just a tool and it does not disclose all precautions for every hot work application. All hot work on campus shall be **strictly supervised** while the work is being performed.



- d. Any operation producing flames, sparks or heat including cutting, welding, brazing, grinding, sawing, torch soldering, thawing frozen pipes, applying roof covering etc. have the potential to cause a fire, fire alarm activation, smoke or burning odors.
- e. When these activities are performed inside of a building, they require a special permit, which authorizes “hot work” activities at a specific location and time.
- f. The permit should be obtained from EHS at least 24 hours in advance of the planned work. A request to perform “hot work” should be emailed to EHS. This email should include the date, time, location, person performing work and description of the work to be performed.
- g. Permits will be picked up from the Public Safety parking and transportation front counter located on the first floor of the Public Safety building or may be dropped at your location
- h. The permit should be displayed on site during the work, completed and returned to EHS when the hot work is complete.
- i. Permits contain a checklist to be completed prior to commencing hot work activities and also at the conclusion of the hot work.
- j. Normally hot work will require the use of a “fire watch”. This is a trained individual stationed in the hot work area who monitors the work area for the beginning of potential, unwanted fires both during and after hot work. Individuals must be trained and familiar with the operation of portable fire extinguishers and methods to activate building fire alarm systems.
- k. Unless we are under a fire restriction or ban, hot work permits are not required for work performed outside of buildings.
- l. Once the work is completed, complete the hot work permit process by signing off on who did the work and that the fire watch requirement was completed
- m. Please return the completed hot work permit to Public Safety for their recordkeeping

7.9 Equipment Safety

7.9.1 Vacuum Systems

All vacuum equipment is subject to possible implosion resulting in possible flying glass leading to cuts and lacerations. Any piece of glassware under vacuum e.g. rotary evaporators, vacuum desiccators, Schlenk lines and storage bulbs on vacuum lines has the potential to do harm following implosion.

The energy imparted to flying fragments is directly proportional to the volume of the glass vessel evacuated. It follows that the potential to do harm is also directly proportional to the volume of the glass vessel and a rotary evaporator with its associated flasks is a greater hazard than a small Schlenk tube.

Take precautions to minimize damage and injuries that can result from an implosion. When using a vacuum system, follow these guidelines and requirements to ensure system safety:

- a. Laboratory coats and safety glasses must be worn. In certain circumstances e.g. when introducing liquid nitrogen or other cryogenic material or when warming storage tubes from low temperature, a face shield and appropriate cryogenic gloves should be worn.
- b. Ensure that pumps have belt guards in place during operation.
- c. Ensure that service cords and switches are free from defects.
- d. Ensure that all associated equipment and apparatus to be used are rated for the vacuum pressures that will be achieved.
- e. Always use a trap on vacuum lines to prevent liquids from being drawn into the pump, vacuum line, or water drain. An in-line High Efficiency Particulate Air (HEPA) filter is

required whenever biohazardous or recombinant DNA materials are used in a vacuum system.

- f. Always close the valve between the vacuum vessel and the pump before shutting off the pump to avoid sucking vacuum oil into the system
- g. Replace and properly dispose of vacuum pump oil that is contaminated with condensate. Used pump oil must be disposed of as hazardous waste.
- h. Place a pan under pumps to catch oil drips.
- i. Do not operate pumps near containers of flammable chemicals.
- j. Do not place pumps in an enclosed, unventilated cabinet. Dangerous carbon monoxide gas and heat can build up in enclosed spaces.
- k. Conduct all vacuum operations behind a table shield or in a fume hood. Also, glassware may be wrapped with tape to minimize the effects of an implosion.
- l. Use only heavy-walled round-bottomed glassware for vacuum operations. The only exception to this rule is glassware specifically designed for vacuum operations, such as an Erlenmeyer filtration flask.
- m. Volumes of 1 liter or larger must be enclosed in tape or plastic mesh to restrain fragments in case of implosion. This will normally apply to rotary evaporators, vacuum desiccators and storage bulbs on glass lines. Schlenk lines and tubes are generally of small volume and are quite robust in nature and do not require extra protection in the shape of tape or plastic mesh.
- n. Carefully inspect vacuum glassware before and after each use. Discard any glass that is chipped, scratched, broken, or otherwise stressed.
- o. Wear appropriate PPE, including safety goggles and a face shield when approaching a system under pressure.
- p. Glass desiccators often have a slight vacuum due to contents cooling. When possible, use molded plastic desiccators with high tensile strength. For glass desiccators, use a perforated metal desiccator guard.

CAUTION: Do not underestimate the pressure differential across the walls of glassware that can be created by a water aspirator.

Cold Trap

A cold trap is a condensing device used to prevent moisture contamination in a vacuum line. Follow these guidelines for using a cold trap:

- a. Locate the cold trap between the system and vacuum pump.
- b. Ensure that the cold trap is of sufficient size and cold enough to condense vapors present in the system.
- c. Check frequently for blockages in the cold trap.
- d. Use isopropanol/dry ice or ethanol/dry ice instead of acetone/dry ice to create a cold trap. Isopropanol and ethanol are cheaper, less toxic, and less prone to foam.
- e. Do not use dry ice or a liquefied gas refrigerant bath as a closed system. These can create uncontrolled and dangerously high pressures.

7.9.2 Centrifuges

A centrifuge is a common piece of laboratory equipment, and using a centrifuge properly is essential to preventing accidents which could result in serious injury or destruction of the equipment. The hazards associated with centrifuges can be related to the equipment itself, the materials used in the centrifuge, or improper use of the centrifuge. It is vital that the centrifuge



operator has been thoroughly trained on how to safely use the centrifuge and on how to properly maintain it.

Guidelines for Centrifuge Use

Centrifuge operators must be trained in the proper use, handling, storage, and maintenance of the equipment.

- a. Use a centrifuge only if it has a disconnect switch that deactivates the rotor when the lid is open. Replace older models that do not have this safety feature.
- b. Always keep the lid closed and locked during operation and shut down. Do not open the lid until the rotor is completely stopped or attempt to brake the head rotation by hand;

IMPORTANT: Attempting to defeat safety mechanisms and/or to brake the rotor by hand could result in severe injury!

- c. Use the centrifuge in a well-ventilated area.
- d. Low-speed and small portable centrifuges that do not have aerosol-tight chambers may allow aerosols to escape. Use a safety bucket to prevent aerosols from escaping or use the centrifuge in a biological safety cabinet or fume hood.

Safe Operating Techniques

The following safe operating techniques should be followed for proper centrifuge operation:

- a. Inspect the inside of each tube cavity or bucket prior to using the centrifuge. The rotor and tubes should be clean and dry. Remove any glass or other debris from the rubber cushion.
- b. Before loading the rotor, examine the tubes for signs of stress, and discard any tubes that are damaged.
- c. Ensure that centrifuge tubes are not filled more than three-fourths full. Overfilling can result in leaks or spills. Also, do not fill tubes to the point where the rim, cap, or cotton plug becomes wet.
- d. When balancing the rotors, match the tubes, buckets, adapters, and inserts against each other, and consider any added solution. Tubes, etc. should be spaced or distributed evenly around the rotor, and the density of the contents of the tubes should also be similar.
- e. Do not use aluminum foil to cap a centrifuge tube. Foil may rupture or detach.
- f. Ensure that the centrifuge has adequate shielding to guard against accidental ejection.
- g. Stop the rotor and discontinue operation if you notice anything abnormal such as a noise or vibration.

High Speed Centrifuges

High-speed centrifuges pose additional hazards due to the higher stress and force applied to their rotors and tubes. It is necessary to understand the basic mechanics of the equipment and to know how to maintain it properly to ensure overall safety and reduce risk. In addition to the safety guidelines outlined above, follow these guidelines for high-speed centrifuges:

- a. Be sure the centrifuge rotor and tubes are clean and dry prior to use.
- b. The centrifuge should be cleaned periodically to help prevent corrosion or other damage. Routinely wash rotors with a mild dish soap to prolong rotor life. Rinse and let air dry.
- c. Clean any spills in the centrifuge immediately, especially if the materials are corrosive.

- d. Frequently inspect the rotor and other parts for corrosion, wear, or other damage; turn the spindle by hand. Rotors or parts exhibiting corrosion or other damage should be removed from use and evaluated by a service technician.
- e. Check the expiration date of both the rotor and centrifuge. Always follow the manufacturer's retirement date for rotors and other centrifuge parts.
- f. Do not exceed manufacturer recommendations for safe operating speeds.
- g. Keep a record of rotor usage and follow the manufacturer's recommendations on when to replace the rotor.
- h. For centrifuges that have been refrigerated, wipe away any excess moisture and allow the open unit to dry.
- i. Filter the air exhausted from the vacuum lines.

7.9.3 Electrophoresis

Electrophoresis is a separation technique that involves the migration of charged molecules through fluid medium under the influence of an electrical field. The apparatus must be designed and maintained so that electrical current is shut off when the cover is opened. A label must warn workers of the electrical hazard. Always follow the manufacturer's operational instructions and safety guidelines.

Electrophoresis equipment may be a major source of electrical hazard in the laboratory. The presence of high voltage and conductive fluid in this apparatus presents a potentially lethal combination.

Many people are unaware of the hazards associated with this apparatus; even a standard electrophoresis operating at 100 volts can deliver a lethal shock at 25 milliamps. In addition, even a slight leak in the device tank can result in a serious shock.

Protect yourself from the hazards of electrophoresis and electrical shock by taking these precautions:

- a. Use physical barriers to prevent inadvertent contact with the apparatus.
- b. Use electrical interlocks.
- c. Frequently check the physical integrity of the electrophoresis equipment.
- d. Use warning signs to alert others of the potential electrical hazard.
- e. Use only insulated lead connectors.
- f. Turn the power off before connecting the electrical leads.
- g. Connect one lead at a time using one hand only.
- h. Ensure that your hands are dry when connecting the leads.
- i. Keep the apparatus away from water and water sources.
- j. Turn the power off before opening the lid or reaching into the chamber.
- k. Do not disable safety devices.
- l. Follow the equipment operating instructions.

7.9.4 Heating Systems

Common hazards associated with laboratory heating devices include electrical hazards, fire hazards, and hot surfaces. Devices that supply heat for reactions or separations include the following:

- a. Open flame burners



- b. Hot plates
- c. Heating mantles
- d. Oil , steam, sand and air baths
- e. Flask heaters
- f. Hot air guns
- g. Ovens
- h. Furnaces
- i. Ashing systems

Follow these guidelines when using heating devices:

- a. Before using any electrical heating device:
 - i. Ensure that heating units have an automatic shutoff to protect against overheating.
 - ii. Ensure that heating devices and all connecting components are in good working condition.
- b. Use caution when heating chemicals, as heated chemicals can cause more damage more quickly than would the same chemicals at a lower temperature.

RULE OF THUMB: Generally, reaction rates double for each 10° C increase in temperature.

- c. Use heating baths equipped with timers to ensure that they turn on and off at appropriate times.
- d. Use a chemical fume hood when heating flammable or combustible solvents. Arrange the equipment so that escaping vapors do not contact heated or sparking surfaces.
- e. Use non-asbestos thermal-heat resistant gloves to handle heated materials and equipment.
- f. Perchloric acid digestions must be conducted in a perchloric fume hood.
- g. Minimize the use of open flames. Never leave an open flame unattended.

Ovens

- a. With the exception of vacuum drying ovens, laboratory ovens rarely have any means of preventing the discharge of material volatilized within them. It should be assumed that these substances will escape into the laboratory atmosphere but may also be present in sufficient concentration to form explosive mixtures within the oven itself. This hazard may be reduced by venting the oven to the laboratory exhaust system.
- b. Ovens should not be used to dry any chemical sample that has moderate volatility and might pose a hazard because of acute or chronic toxicity unless the oven is constantly vented to a safe exhaust.
- c. Glassware rinsed in solvent poses a danger of explosion if dried in an un-vented oven. Do not dry or place any flammable liquids in an oven.
- d. Plastic, paper products or other organic materials may combust if the temperature of the oven is set above the materials combustion point. Avoid drying or heating these materials. If these materials must be used in the oven, assure that the temperature cannot exceed the ignition point.
- e. Ovens may ignite combustible material that is touching or in close proximity to the unit or the exhaust ductwork. Assure that there is nothing touching the ductwork and that the ductwork is non-combustible. Maintain an air space around the unit based on the manufacturers requirements.
- f. Proper protective equipment must be worn i.e. laboratory coat, safety glasses and gloves. Use tongs to handle hot materials.



Bunsen Burners

- a. Bunsen burners are not widely used in laboratories.
- b. A flame is a particularly hazardous ignition source and must never be used near open containers of flammable liquid or in environments where appreciable concentrations of flammable vapor may be present.
- c. Safer, alternative equipment should be reviewed and implemented prior to using Bunsen Burners and other open flames. Purchase sterilized equipment in lieu of flame sterilization. Consider using a “Bacti-Cinerator” or a glass bead sterilizer.
- d. Consider using Bunsen burner equipment with a pilot light and a button that activates gas flow.
- e. A Bunsen flame may be difficult to see in bright sunlight. Blinds should be drawn to shade the flame.
- f. The tubing should be in good condition and specifically designed and approved for the use with Bunsen burner operations. Use braided steel line with a flame protective wrapping. Do not use Tygon or rubber tubing.
- g. Proper protective equipment must be worn i.e. laboratory coat, safety glasses and gloves. Use tongs to handle hot materials.
- h. Assure that reaction flasks and beakers are firmly held in place with a ring stand or other means.
- i. Assure that the fire extinguisher is in close proximity and ready for use. Attend Fire Extinguisher Training, provided by EHS.

Bunsen burner safety guidelines:

- **PLACE** the Bunsen burner away from any overhead shelving, equipment or light fixtures.
- **REMOVE** all papers, notebooks, combustible materials and excess chemicals from the area.
- **TIE-BACK** any long hair, dangling jewelry, or loose clothing.
- **INSPECT** hose for cracks, holes, pinched points, or any other defect and ensure that the hose fits securely on the gas valve and the Bunsen burner.
- **REPLACE** all hoses found to have a defect before using.
- **NOTIFY** others in the laboratory that the burner will be in use.
- **UTILIZE** a sparker / lighter with extended nozzle to ignite the Bunsen burner. Never use a match to ignite burner.
- **HAVE** the sparker / lighter available before turning on gas.
- **ADJUST** the flame by turning the collar to regulate air flow and produce an appropriate flame for the experiment (typically a medium blue flame).
- **DO NOT** leave open flames unattended and never leave laboratory while burner is on.
- **SHUT-OFF** gas when its use is complete.
- **ALLOW** the burner to cool before handling. **ENSURE** that the main gas valve is off before leaving the laboratory.

Hot Plates, Heating Mantles, Flask Heaters

- a. The condition of the heating element should be checked. Do not use a unit that is damaged in any way.
- b. If the covering is broken or worn the equipment must not be used.
- c. If water or other liquid has been spilled onto the element, the equipment must be electrically checked before use.



- d. These units can still be a source of ignition if used in a flammable environment or if flammable liquids are spilled onto the unit.
- e. The unit must have a light that warns the operator when the unit is hot. If a light is not available, a "HOT" sign must be placed in front of the unit to warn of the hazard.

7.9.5 Refrigerators/Freezers

Using a household refrigerator to store laboratory chemicals is extremely hazardous for several reasons. Many flammable solvents are still volatile at refrigerator temperatures. Refrigerator temperatures are typically higher than the flashpoint of most flammable liquids. In addition, the storage compartment of a household refrigerator contains numerous ignition sources including thermostats, light switches, heater strips, and light bulbs. Furthermore, the compressor and electrical circuits, located at the bottom of the unit where chemical vapors are likely to accumulate, are not sealed.

Laboratory-safe and explosion-proof refrigerators typically provide adequate protection for chemical storage in the laboratory. Laboratory-safe refrigerators, for example, are specifically designed for use with flammables since the sparking components are located on the exterior of the refrigerator. Explosion-proof refrigerators are required in areas that may contain high levels of flammable vapors (e.g., chemical storage rooms with large quantities of flammables).

Follow these rules for using refrigerators and freezers in the laboratory:

- a. Never store flammable chemicals in a household refrigerator.
- b. Do not store food or drink in a laboratory refrigerator/freezer.
- c. Ensure that all refrigerators are clearly labeled to indicate suitable usage.
 - i. Laboratory-safe and explosion-proof refrigerators should be identified by a manufacturer label.
 - ii. A "Not Safe for Flammable Storage" labels must be applied to any household style refrigerator or freezer used in a laboratory.
 - iii. Refrigerators used to hold food should be labeled "For Food Only" and should be located outside of the laboratory.

7.9.6 Grinders

There are two basic types of grinders: stationary grinders, such as bench or pedestal grinders; and portable hand grinders.

General Safety Considerations

- a. Keep the floor and work area clean. Store flammable and combustible materials a safe distance (e.g., a minimum of 35 feet) away from the grinding operation. Sparks can ignite debris and flammable vapors. In some cases, a hot work permit (see 7.7.10) may be required.
- b. Before working with a grinder, secure or remove loose clothing (i.e., snap, button, zip, tie, etc.) and confine long hair, scarves, ties, and dangling jewelry, which can be snagged by the grinder and wrap around the shaft quickly.
- c. Always wear eye protection. At a minimum, goggles are required. Safety glasses with side shields are acceptable only when combined with a faceshield. Wear gloves to protect hands from flying particles and sharp edges created during the grinding operation. Other PPE may also be needed based on circumstances (e.g., respirator, hearing protectors, etc.).
- d. Keep hands, fingers, and other body parts from coming into contact with



- the revolving wheel.
- e. When installing a new wheel, observe all instructions provided by the manufacturer. Ensure the recommended speed (as posted on the wheel) is compatible with the grinder, and that the type of wheel is compatible with the material being ground. An improperly installed or incompatible wheel can break or explode and cause injury. All wheels must be sound (ring) tested before use. Grinding wheels should fit freely on the spindle and remain free under all grinding conditions. The spindle nut must be tightened enough to hold the wheel in place without distorting the flange. When a bushing is used in the wheel hole it should not exceed the width of the wheel and or contact the flanges.
 - f. Avoid grinding aluminum and steel on the same wheel to prevent residual aluminum particles from heating up and flying back at the operator when harder surfaces such as steel are being ground later.
 - g. To avoid burring, loading, and uneven wear on the wheel, use the minimum pressure necessary and keep work in motion evenly across the face of wheel.
 - h. Never grind on the side of the wheel.
 - i. Use vise-grip pliers or a clamp to handle/secure work pieces.
 - j. All contact surfaces of wheels, blotters and flanges must be flat and free of foreign matter.

Bench and Pedestal Grinders

- a. The grinder should be positioned by height and location to eliminate the need to overreach while grinding; and securely anchored.
- b. The transmission cover and outer wheel guard must be secured in the proper position prior to operation. In addition, adjustable guards must be properly secured before use. Do not make adjustments with the wheel in motion.
 - Side guards should cover the spindle, nut, flange, and seventy-five percent of the wheel diameter.
 - Adjust the tongue guard on the top side of the grinder to within 1/4-inch (0.6350cm) of the wheel.
 - Adjust the tool rest to within 1/8- inch of the grinding wheel.
- c. Before starting the grinder, inspect the wheel to make sure it is not cracked or broken. Never use a wheel that has been dropped or received a heavy blow, even if there is no apparent damage. To minimize hazards from undetected defects or imbalance, stand to one side of the wheel until it has reached full speed. Do not begin grinding until the wheel has reached full speed.
- d. As the wheel wears down, readjust the tool rest and tongue guard. When you can no longer adjust them, replace the wheel. Visually inspect the wheel for cracks before mounting.
- e. All flanges must be maintained in good condition. When the bearing surfaces become worn, warped, sprung, or damaged they should be trued, refaced, or replaced, in accordance with manufacturer recommendations.

Portable Hand Grinders

- a. Guards must be in place and properly positioned such that sparks fly away from the operator.
 - The clearance between the wheel side and the guard shall not exceed one-sixteenth inch.
 - Safety guards used on machines known as right angle head or vertical portable grinders shall have a maximum exposure angle of 180 deg., and the guard shall be located so as to be between the operator and the wheel during

use. Adjustment of guard shall be such that pieces of an accidentally broken wheel will be deflected away from the operator.

- The maximum angular exposure of the grinding wheel periphery and sides for safety guards used on other portable grinding machines shall not exceed 180 deg. and the top half of the wheel shall be enclosed at all times
- b. Before using the tool on a workpiece, let it run for several minutes. Watch for flutter or excessive vibration that might be caused by poor installation or a poorly balanced wheel. Do not stand in the plane of rotation of the wheel as it accelerates to full operating speed.
- c. Never use a grinding wheel on an air sander. Pistol-grip, high speed air sanders operate at speeds exceeding the maximum-rated speeds for grinding wheels.
- d. Never clamp a hand-held grinder in a vise.
- e. Always engage the OFF switch and wait for the wheel to come to a complete stop before adjusting or removing the wheel or changing its work position or angle.

7.9.7 Power Tools

Hand operated tools often pose risk of lacerations, contusions, and muscle strain. Obviously, power tools pose higher risk of severe injury because points of contact can transfer a large amount of mechanical energy from the tool to small areas on the body. The risk of laceration becomes risk of amputation with power tools; risk of contusion becomes risk of crushing. In addition, users of hand and power tools may also be exposed to hazardous airborne contaminants, flying debris, and electrocution, among others risks

General Tool Safety

- a. Use the right tool for the job. For example, do not use a screwdriver as a chisel. Do not attempt to modify or adapt a tool to extend its capabilities.
- b. Inspect every tool before use and remove damaged or defective tools from service. Do not use tools with defective, broken, or compromised handles, guards, or ancillary parts (e.g., warped, dull, or cracked blades, marred or chipped drill bits, checked hoses, frayed cords, sprung gripping surfaces, mushroomed heads, etc.). Most power tools must be equipped with guards and positive pressure switches (or other safety controls).
- c. Operate and maintain tools in accordance with manufacturer recommendations. Store tools in a clean and dry location.
- d. Use the proper apparel and Personal Protective Equipment. Avoid loose clothing and jewelry. Minimum PPE will generally consist of protective eyewear, sturdy shoes, and gloves. Depending on the task or tool, additional or specialized PPE may be needed (e.g., hearing protectors, face shields, special helmets or goggles, respirators, cotton clothing, leather chaps, steel toed boots or shoes, etc.).
- e. Take action to minimize ancillary hazards posed by the work place. For example, remove accumulated debris or tools to prevent trips; dry or clean up slippery surfaces; use portable lighting in poorly lit areas, etc. Non-sparking or intrinsically safe tools may be required in the presence of flammable vapors.

Portable Power Tools

- a. Use only with properly placed, adjusted, and functioning guards. In general, the exposed moving parts of power tools need to be safeguarded.
- b. Do not carry a tool by the hose or cord.
- c. Do not yank on a cord to disconnect the tool from the receptacle. Firmly grasp the plug.
- d. Avoid accidental starting. Do not hold fingers on the switch button while carrying a



- plugged-in tool.
- e. Keep hoses and cords away from heat, oil, and sharp edges.
- f. Disconnect tools from their power source before servicing, cleaning, when changing accessories, and when not in use/attended.
- g. When a temporary power source is used for construction a ground-fault circuit interrupter should be used.
- h. To protect the user from shock and burns, electric tools must have a three-wire cord with a ground and be plugged into a grounded receptacle, be double insulated, or be powered by a low-voltage isolation transformer.
- i. Do not use electric tools in damp or wet locations unless they are approved for that purpose.
- j. Keep all people not involved with the work at a safe distance from the work area.
- k. Secure work with clamps or a vise, freeing both hands to operate the tool.
- l. When using pneumatic tools, a safety clip or retainer must be installed to prevent attachments from being ejected during tool operation.
- m. Compressed air guns should never be pointed toward anyone. Workers should never "dead-end" them against themselves or anyone else. A chip guard must be used when compressed air is used for cleaning.
- n. Compressed air used for cleaning. Compressed air shall not be used for cleaning purposes except where reduced to less than 30 p.s.i. and then only with effective chip guarding and personal protective equipment.
- o. Handle, transport, and store gas or fuel only in approved flammable liquid containers, according to proper procedures for flammable liquids. Allow a hot engine to cool before refueling a tool. Use fuel-powered tools only when there is sufficient ventilation for removal of fumes.
- p. If using nail guns, read and adhere to the content of OSHA's publication titled "[Nail Gun Safety: A Guide for Construction Contractors.](#)"

Exposure to dusts created by the use of tools can present respiratory hazards. Reduce dust hazards to the extent feasible by:

- a. Utilizing local engineering controls to minimize exposures, including enclosures, tools equipped with dust collection devices, and local ventilation/dust collection systems, and maintain these systems so that they function effectively.
- b. Avoid dry sweeping of dusts. Use a vacuum system or wet method.
- c. Do not use compressed air to clean dusty surfaces.
- d. Avoid inadvertent transport of dusts on equipment or work pieces. Clean them before they are removed from the work area. Keep the general work area clean of dust accumulations.
- e. Contact EHS if you conduct dust-generating activities without the benefit of engineering controls so that an exposure evaluation can be completed to assess the need for respiratory protection.
- f. Do not eat or drink in work areas.
- g. Use protective outer garments to avoid contaminating clothing and transporting dusts out of the work area. Eye protection is also required when conducting work that could result in creation of flying debris or dust.
- h. Wash hands and exposed skin thoroughly after conducting dust producing operations.



7.10 Biological and Animal Safety

Many laboratories on campus use biological materials, including biological pathogens, toxins and allergens derived from biological agents, and recombinant DNA materials. Some laboratories work with animals in their research or in clinical settings. In these laboratories, Biological and/or Animal Safety is integral to overall laboratory safety.

Three committees within the Office of Sponsored Programs oversee and grant approval for conducting such research.

- The Institutional Review Board (IRB) manages research involving human subjects.
- The Institutional Animal Care and Use Committee (IACUC) oversees any research involving the use of animals.
- The Institutional Biosafety Committee (IBC) manages research involving recombinant DNA materials, biological pathogens, and biological toxins (including those on the Select Agent List).

Some research may be subject to more than one of these boards. Information regarding all three of these boards is available on the OSP website.

UCCS has developed a Biosafety Management Plan which is included as Appendix E to this plan.

7.11 Laser Safety

The primary authoritative sources regarding hazard controls for the types of lasers commonly used at UCCS are:

- ANSI Z136.1: 2000, Safe Use of Lasers
- ANSI Z136.5: 2000, Safe Use of Lasers in Educational Institutions, and
- NFPA 115, Standard for Laser Fire Protection.

Overview of Hazard Controls

In general, the following control measures are required for Class IIIb and IV lasers:

- a. Access restrictions including key master switch, interlocked entry or beam enclosure.
- b. Training of operators and personnel working on or near lasers (on site or general).
- c. Posting and labeling of rooms and equipment, to include a warning light in the hallway or access entrance.
- d. Protective eye wear and clothing.
- e. Engineering controls such as beam stops, curtains, and enclosures.

The exact combination of these control measures depends on the power and type of laser, laser environment, and procedures conducted with laser equipment. The LSO approves control measures prior to operation of lasers.

Training

All personnel working with Class III and IV open-beam lasers used for research and teaching must be trained on the safe use of the laser including the manufacturer's literature, operating manual, and control measures. All people that enter a room with an operating Class III and IV open beam laser used for research or teaching must be trained on how to prevent a personal injury and provided with the appropriate personal protective equipment.



Medical Evaluation

Medical surveillance and evaluations of laser workers may be necessary for chronic laser exposure or for accidental exposures. The primary concern is an accidental exposure to the eyes. Any suspected over-exposure from laser radiation to the eyes should immediately prompt an eye examination by a qualified physician. Subsequent re-examinations and follow-ups may be necessary.

Laser Program Administration

UCCS supports a centralized laser safety program. Principal Investigators and other persons with authority for laser operations are responsible to assist in complying with the campus Laser Safety Program including registration of their lasers on the lab safety registration form..

7.12 Administrative Controls

Administrative controls are procedural measures which should be taken to reduce or eliminate hazards associated with the use of hazardous materials or physical hazards. Administrative controls include the following:

- a. Careful planning of experiments and procedures with safety in mind. Planning includes the development of written work procedures for safe performance of the work.
- b. Restricting access to areas in which hazardous materials are used.
- c. Using signs or placards to identify hazardous areas (designated areas).
- d. Use of labels on hazardous materials.
- e. Substitution of less toxic materials for toxic materials.
- f. Good housekeeping. Do not limit egress with clutter. Maintain a 36" aisle space throughout the laboratory. Do not stockpile chemicals
- g. Good hygiene (e.g., Decontaminate before eating, drinking, smoking, applying cosmetics, lip balm, or going to the bathroom)
- h. Prohibiting eating, drinking, and smoking in areas of chemical use, and providing break areas for this purpose.
- i. No mouth pipetting.
- j. Adding acid to water, never water to acid.
- k. Assuring employees are provided adequate training for safe work with hazardous materials.
- l. Adhering to safe lab practices as taught by instructors
- m. Disposing of waste in designated containers
- n. Do not block lab windows.
- o. Use secondary containers during storage of liquids
- p. Store chemicals by hazard class in appropriate cabinets. Do not store liquids above eye level
- q. Restrict access to laboratory. Lock laboratory doors when no one is present in the laboratory. Challenge all visitors, maintenance staff to assure that they are permitted in the laboratory.
- r. Do not work alone with hazardous materials. Do not perform hazardous operations alone. Assure that another trained researcher is available in the same laboratory or adjacent room to provide emergency assistance as needed.
- s. DO NOT wear contact lenses. Contact lenses may pose a special hazard; soft contact lenses may absorb and concentrate irritants. Wear eye protection that is designed to go over prescription glasses. EHS recommends that researchers purchase prescription safety glasses or splash goggles or utilize eye protection with prescription inserts

7.12.1 Administrative Actions

Departments are expected to enforce safety standards through administrative actions in a variety of ways. For instance, employee performance evaluations should reflect that laboratory personnel are following UCCS safety standards and protocols in their work areas. Also, it is each department's responsibility to establish whether safety performance should be included in the grading criteria for laboratory courses.

Appropriate safety signage is another way departments can promote safety in laboratories. Signs indicating the hazards present in the laboratory can be posted on laboratory doors. Signs pointing to the location of safety equipment in or near the laboratory can minimize the consequences of an incident by enabling employees to quickly locate needed equipment. Emergency contact information should be posted outside each laboratory door to make it easier for emergency responders to obtain needed information quickly. A template for emergency contact information may be found on the EHS website.

7.12.2 Pre-Planning

Many laboratory hazards can be minimized by pre-planning. Before beginning work on a new project, the associated hazards should be considered carefully. What are the sources of danger? Are there chemical, equipment, or electrical hazards? Consider also the risk of an accident or exposure occurring, and what the impact of that incident would be. Also, conduct a thorough safety review of new apparatus.

Once the hazards have been identified, steps to minimize risk should be implemented. This includes utilizing engineering controls (such as fume hoods) and personal protective equipment. If the hazard is chemical, another option would be to substitute a less hazardous chemical. Or perhaps the project can be designed in such a way as to separate incompatibles, such as electrical equipment and water.

Careful planning is essential to a safe laboratory

7.12.3 Minors Involved in Laboratory Research and Teaching Activities

Persons under 18 years of age are not allowed in University laboratories where hazardous materials are present or hazardous activities take place except under the following circumstances:

- a. The minor is employed by the University or has been formally accepted as a volunteer worker; and
 - has been trained in safe laboratory procedures; and
 - has adult supervision at all times; and
 - has a parental hazard-acknowledgement form on file with the host department; or
- b. The minor is enrolled in a University class with a laboratory component; or
- c. The minor is participating in a University-sponsored program; and
 - has been trained in safe laboratory procedures; and
 - has adult supervision at all times; and
 - has a parental hazard-acknowledgement form on file with the host department.



- d. Tours involving minors may occur provided that all unnecessary experiments and procedures must be stopped and the laboratory or area be made safe for the duration of the tour or visit.
- e. Under no circumstances shall infants, toddlers, or children too young to understand safety training be permitted in UCCS laboratories except as research study participants with the signed consent of a parent or legal guardian.
- f. In all circumstances the minor must have a completed Consent for Minors in Labs NIH Format on file prior to entering the laboratory.
<https://www.cu.edu/risk/services/volunteer-trainee-and-minor-participants>

7.12.4 Volunteers Involved in Laboratory Research and Teaching Activities

University volunteers are individuals who are uncompensated by the University of Colorado Colorado Springs and who perform services directly related to the business of the University to support the research, teaching or public service activities of the University or to gain experience in specific endeavors.

Volunteer workers are permitted to perform research and teaching activities at the UCCS provided the following requirements are met:

- Faculty Members or Principal Investigators must notify and receive documented approval from the Chair of the Department or Director of the Program.
- The volunteer worker must attend all applicable safety training sessions prior to commencing to working in the laboratory
- The volunteer worker is under the supervision of a faculty member in the laboratory or area where the work will occur.
- The volunteer worker must use all required personal protective equipment. Each college, school, department, division or unit should make available to each volunteer required to wear personal protective equipment the devices appropriate for the activity and hazards involved. The volunteer may be required to purchase certain individualized items of personal protective equipment.
- The volunteer worker must be monitored and supervised by a knowledgeable and experienced adult employee until the principal investigator is comfortable that the volunteer can work independently. They must not work alone while performing hazardous operations or while working with hazardous materials.
- The volunteer must follow all Departmental and University safety procedures and policies.
- The volunteer must sign and submit an Authorized Volunteer Agreement, Notice of Risk, and Waiver of Responsibility <https://www.cu.edu/risk/services/volunteer-trainee-and-minor-participants>
- Refer to Use of Volunteers Guidelines for any additional guidance <https://www.cu.edu/risk/services/volunteer-trainee-and-minor-participants>

7.13 Training

Departments should ensure that all laboratory employees receive proper training for the hazards in their work areas and that such training is properly documented and filed. Appendix R and W provides a Laboratory Employee Safety Training Checklist which guides the employee and Principal Investigator in the types of training that may apply to a particular employee.

7.13.1 Employee Hazard Communication Training

Before entering a laboratory, all new laboratory employees, including teaching assistants, must receive training on the hazards they will encounter in their work area. This training includes both general and work area specific Hazard Communication Training. This employee training will contain at least the following topics:

- Details of the Laboratory Safety Manual
- Identification of personnel responsible for certain aspects of the LSM
- Information to help employees understand and read labels and SDSs
- Locations of the SDSs, lab procedures and other mandated documents
- Physical and health hazards of common chemicals
- Physical hazards associated with the equipment in the laboratory
- Protective procedures from the hazards, e.g., work practices, PPE and emergency procedures
- Methods and procedures to detect the presence of or release of a chemical in the work area (CO monitors etc.)
- Methods and procedures for reporting accidents.

General Training

General hazard communication training is provided by EHS through the Introduction to Laboratory Safety Training class. The Laboratory Safety class is available through the EHS website or it is offered each fall at the start of the school year.

All faculty and staff who work with hazardous materials or hazardous equipment are required to have an annual refresher training. EHS offers a classroom course each fall prior to the start of the school year. The course is also offered on-line. The on-line course may be taken to satisfy the general hazard communication training requirement. However, the classroom course covers much more safety information than the on-line course does, and EHS recommends that whenever possible all employees take the classroom course

Work Area Specific Training

Work area specific training is provided by the principal investigator, laboratory manager and/or laboratory supervisor. This training should focus on the specific hazards in the employee's work area, such as chemical hazards, equipment hazards, biological hazards, etc. Work area specific training should also include the location of SDSs, the proper use of personal protective equipment, the location and proper use of safety equipment (fume hoods, biological safety cabinets, etc.), the location and use of emergency equipment (showers, eyewashes, fire extinguishers, spill kits, etc.), and the proper response to emergency situations (fires, chemical spills, etc.).

Training should also be provided for new hazards that are introduced into the work area. If new information becomes available for an existing hazard, additional training on that information should be provided.

Training Documentation

Employee safety training must be documented and records maintained for at least five years. Completion of both the Introduction to Laboratory Safety Training course and the on-line Hazard



Communication Training course is documented in EHS. Also, a Hazard Communication Training Record is provided to each person who completes either of these courses. A copy of this record should be maintained in the employee's personnel records. This document lists the specific topics covered in the training and is the document which state auditors will ask for as proof that Hazard Communication Training has been provided to the employee.

Documentation of Work Area Specific Training should include the date of training, specific topics covered, the name of the person providing the training, and the signature of the trainee. Appendix Q provides an example Safety Training Log which can be utilized to

7.13.2 Hazardous Waste Training

Training is required for any UCCS employee or student that generates or handles hazardous materials. Generators and/or handlers of hazardous waste must receive, at a minimum, Hazardous Communication training based on OSHA 29 CFR 1920.1200 and 29 CFR 1910.1450. Hazardous Communication training will include an introduction to the Laboratory Safety Guidelines.

Additional training should be received by generators and handlers of waste. This training shall consist of emergency procedures, emergency system, and a review of the hazardous materials regulatory requirements set forth by EPA, OSHA and CDPHE. The training will also include details of the UCCS Waste Management Plan as described in this document.

All training records must include the dates of training sessions, contents or a summary of the training session, names of persons conducting the training and names of persons attending the training session. Each department will be responsible for assuring everyone who works with chemicals (lab instructors, teaching assistants, professors, etc.) are trained. Each department will also be responsible for keeping individual training records. The EHS office will assist with record keeping.

Initial Chemical Safety Training is required within six months of hire and then annually after that.

7.13.3 Bloodborne Pathogen Training

All University employees, including full-time, part-time, and work study who provide first aid services, work with or have the potential to contact human blood, body fluids, or tissues as a part of their normal work scope are required to participate in blood-borne pathogen training.

This course provides employees with information and training on precautions with dealing with blood, infectious materials and other biohazards. Employees are informed of the need and requirement to comply with state and federal regulations, as well as with University Safety program.

- The class covers the following :
- introduction to Federal and State regulations
- discussion of the regulatory standard and explanation of its contents,
- information on bloodborne diseases and their transmission,
- UCCS model exposure control plan,
- engineering and work practice controls,
- personal protective equipment,
- hepatitis B vaccine,



- response to emergencies involving blood,
- how to handle exposure incidents,
- the post-exposure evaluation and
- follow-up program, signs/labels/color-coding.

7.13.4 Additional Training Options

In addition to Hazard Communication Training, EHS provides a variety of other training opportunities for laboratory employees. Some training may be required, such as training for employees who will be working with radioactive materials. A list of training courses provided by EHS is available on the EHS website.

7.13.5 Student Safety

Student Training and Acknowledgement Forms

Students enrolled in Laboratory Courses will receive appropriate safety information and instruction if class work involves hazardous chemicals. Each student enrolled in a laboratory class involving the use of chemicals or biohazards shall successfully complete an on-line safety training course.

Students who have not successfully completed the course by the deadline shall not be permitted in the laboratory. Instruction on safe and proper use of laboratory equipment should also be provided to students as needed.

Departmental Oversight of Student Safety

Departments with teaching laboratories should periodically conduct self-evaluations to ensure teaching assistants are enforcing safety rules and students are complying with them. These evaluations should be documented, as should any discrepancies found and steps taken to correct them.

7.14 Engineering Controls

Exposure to hazardous materials must be controlled to the greatest extent feasible by use of engineering controls. Engineering controls to reduce or eliminate exposures to hazardous chemicals include:

- Substitution of less hazardous equipment, chemicals or processes (e.g. safety cans for glass bottles)
- Isolation of the operator or the process (e.g. use of barriers when handling explosives, or completely enclosing the process in a glove box or other enclosure)
- Local and general exhaust ventilation (e.g. use of chemical fume hoods)

7.14.1 Laboratory Sign Program

EHS has developed an ongoing program to label all laboratories and areas where hazardous operations occur or where hazardous materials are used with a uniform laboratory hazard warning sign (generally an NFPA diamond). These signs assist in communicating to emergency responders the hazards present in the area. All areas, rooms or laboratories where hazardous materials are used or hazardous operations occur shall be labeled with an approved laboratory warning sign.

7.15 Laboratory Ventilation Equipment

Ventilation in a laboratory is a very important aspect of laboratory safety. General room exhaust is not sufficient to protect the laboratory worker who uses hazardous chemicals, works with biological agents or uses equipment that generates excess heat. Additional engineering controls are required. This chapter discusses different types of laboratory ventilation.

7.15.1 Chemical Fume Hoods

Chemical fume hoods provide primary containment in a chemical laboratory. They exhaust toxic, flammable, noxious, or hazardous fumes and vapors by capturing, diluting, and removing these materials. Fume hoods also provide physical protection against fire, spills, and explosions.

For optimum performance and most effective protection, chemical fume hoods should be located away from doorways, supply air vents, and high-traffic areas. Air currents created by passers-by can cause turbulence in a fume hood, which can result in contaminated air being drawn back out of the hood and into the room.

Similarly, a supply air vent located directly above a fume hood can also cause turbulence in the hood.

UCCS requires that all chemical fume hoods be ducted to the outside of the building and operate with an average face velocity that is consistent with industry standards. The acceptable range for the average face velocity of a general purpose chemical hood is 95 – 120 feet per minute (fpm). The minimum face velocity at any one measuring point should be at least 80 fpm. (The face of the hood is the opening created when the hood sash – the movable glass window at the front of the hood – is in the open position.)

Types of Fume Hoods

Standard Fume Hoods (aka Constant Air Volume (CAV) fume hoods)

These hoods exhaust a constant volume of air. The velocity of the air passing through the face of a standard fume hood is inversely related to the open face area. Thus, if the sash is lowered, the inflow air velocity increases.

IMPORTANT: Face velocity that is too high may cause turbulence, disturb sensitive apparatus, or extinguish Bunsen burners.

Bypass Fume Hoods

Bypass fume hoods are also constant air volume hoods, but with an improved design. These hoods are designed with a grille-covered opening above the sash. When opened, the sash blocks the grille and does not allow air through. However, as the sash is lowered, air is drawn through the grille, allowing a constant exhaust volume without increasing the velocity of air at the face of the hood. This design helps keep the room ventilation system balanced and helps eliminate the problems with turbulence that high face velocity can cause.



Auxiliary Air Fume Hoods

Auxiliary air fume hoods are also known as "supplied air" or "make-up air" hoods. They use an outside air supply for 50% to 70% of the hood's exhaust requirements. This type of hood is designed to reduce utility costs and conserve energy by reducing the amount of conditioned room air that is pulled through the hood. One disadvantage, however, is that additional ductwork and fans increase the overall cost of these hoods. Also, if the supplied air is tempered, the energy savings is negated, while if it is not tempered, the user may be working under hot or cold air, depending on the season. Untempered air may also cause condensation in the hood, which can lead to rusting of the hood. The face velocity of an auxiliary air fume hood may vary.

Variable Air Volume Fume Hoods

Just as their name suggests, variable air volume (VAV) hoods are designed to vary the amount of air being exhausted from the fume hood based on the sash position. By varying the exhausted air, these hoods are able to maintain a constant face velocity, no matter where the sash is positioned. VAV hoods are often equipped with an audio/visual alarm to notify the user if the hood is not operating properly.

Special Fume Hoods

Special fume hoods are necessary when working with certain chemicals and operations.

Examples of special fume hoods include the following:

Perchloric acid fume hoods: Anyone working with perchloric acid must use a perchloric acid fume hood. These special fume hoods are equipped with a water spray system to wash down the entire length of the exhaust duct, the baffle, and the wall of the hood. Perchloric acid vapors can condense on the hood ductwork, forming dangerous, explosive metal perchlorates. Also, perchloric acid can react with organic materials to form organic perchlorates, which are also explosive. For this reason, organic solvents should never be used or stored in a perchloric acid fume hood, and the hood should be labeled "Perchloric Acid Use Only; No Organic Chemicals". The water wash down system, used periodically or after each use of the hood, removes any perchlorates or organic materials that may have accumulated in the hood exhaust system. The wash down system should be activated only when the exhaust fan has been turned off, so that complete coverage can be achieved.

Walk-in hoods: These fume hoods have single vertical sashes or double vertical sashes and an opening that extends to the floor. These hoods are typically used to accommodate large pieces of equipment.

Radioisotope hoods: These hoods are labeled for use with radioactive materials. The interiors of these hoods are resistant to decontamination chemicals. These hoods are also often equipped with High Efficiency Particulate Air (HEPA) filtration.

Ductless hoods:

Ductless hoods are designed with a filtration system. Generally, however the filters are not appropriate for use with all chemicals. Also, it is difficult to know when the filters need to be replaced, even if a strict change-out schedule is followed. UCCS and EHS do NOT approve of ductless fume hoods.

Fume Hood Safety Considerations

The potential for glass breakage, spills, fires, and explosions is great within a fume hood. To ensure safety and proper fume hood performance, follow these guidelines:

- a. Know how to properly operate a fume hood before beginning work.
- b. Fume hoods provide the best protection when the fume hood sash is in the closed position.
- c. Inspect the fume hood before starting each operation, including any airflow monitors. Do not use the hood if it is not functioning properly; call Facility Services to have it checked.
- d. Keep traffic in front of the fume hood to a minimum and walk slowly when passing by the hood, especially when work is being conducted in the hood. This will reduce the likelihood of creating turbulence in the hood.
- e. Use the appropriate type of hood for the work being conducted. For example, when using perchloric acid, use a perchloric acid fume hood.
- f. Keep the area in front of the hood clear of obstructions. This will allow room for laboratory workers to move about and will allow sufficient airflow to the hood.
- g. Place equipment and chemicals at least six inches behind the fume hood sash. This practice reduces the chance of exposure to hazardous vapors.
- h. Do not allow equipment and chemicals to block baffle openings. Blocking these openings will prevent the hood from operating properly.
- i. Keep loose paper out of the fume hood. Paper or other debris that enter the exhaust duct of the hood can interfere with the hood's ventilation.
- j. Do not store excess chemicals or equipment in fume hoods.
- k. Elevate any large equipment within the hood at least three inches to allow proper ventilation under the equipment.
- l. When working in a fume hood, set the sash at the lowest working height, about 12 – 15 inches from the base of the hood opening. Close the sash completely when no one is standing at the hood working in it. The only time the sash should be completely open is while setting up equipment.

IMPORTANT: *A fume hood's sash is designed to protect the user from dangerous chemical gases and vapors, chemical splashes and potentially flying debris. The sash should be positioned to protect the user's face, neck and upper body. The lower the sash position, the more area of the user's body will be protected.*

- m. Do not defeat sash stops by removing them or altering their design or function.
- n. Wear personal protective equipment, including protective eyewear, as appropriate. The hood does not replace PPE.
- o. Keep laboratory doors closed. Laboratory ventilation systems are designed to operate with the doors closed.
- p. Do not alter/modify the fume hood or associated duct work. If additional equipment needs to be ventilated, contact EHS for an evaluation.
- q. Clean up spills in the hood immediately.

IMPORTANT: *If a power failure or other emergency occurs (e.g., building fire or fire within the fume hood), close the fume hood sash and ensure safe shutdown of the lab, paying special attention to equipment that may be reenergized when power is restored.*

Work Practices

- a. Conduct all operations, which generate air-borne contaminants, inside a fume hood.



- b. Always wear appropriate eye protection and a lab coat when working near a fume hood.
- c. If the hood is used for long-term experiments, post the name and phone number of the person in charge, experiment title and potential hazards.
- d. Keep your head outside the face of the hood with the sash lower than your face.
- e. Keep apparatus at least 15 cm from the face of the hood to minimize turbulence at entrance to hood as this can cause some of the contaminants to be swirled out of the hood.
- f. Avoid blocking the rear ventilation slot. Material stored at the back of the hood should be stored on an elevated shelf so that the slot airflow is not impeded.
- g. Avoid storing chemicals or gas cylinders inside the hood. Hazardous chemicals should be stored in approved safety cabinets.
- h. Do not place electrical receptacles or other ignition sources inside the hood when flammable liquids or gases are present. No permanent electrical receptacles are permitted in the hood (current design criteria).
- i. Avoid cross drafts at the face of the hood. Minimize foot traffic past the hood and position windows and supply air diffusers to direct air away from the hood.
- j. Do not raise the sash higher than the labeled height as this will reduce the hood efficiency.
- k. Leave the sash lowered when the experiment is unattended.
- l. Keep the bypass grill clean.

Fume Hood Airflow Failure Response

The abrupt and complete loss of airflow to a laboratory fume hood may create significant hazards or cause injury to maintenance and laboratory staff. The purpose of this procedure is to ensure that the hazards associated with hood system failure are minimized.

Fume hood users need to develop a plan of action to follow if the fume hood fails. This planned procedure should include the following steps:

If Fume Hood Air Flow Stops:

- a. Note pressure gauge reading, if one is provided.
- b. Shut off experiments, turn off heat, relieve system pressure.
- c. Seal containers; remove compressed gas cylinders from the hood.
- d. Ensure no other lab equipment is vented into the hood.
- e. Place —Do Not Use; Hood Out of Order sign on the fume hood.
- f. Where radioisotopes are used, contact the Radiation Officer at 2-7052.
- g. Call Trouble Calls @ 2-2173.
- h. Advise your departmental administrator

Fume Hood Inspections

Fume hoods should be tested at least annually by the Chemical Hygiene Officer or other trained individual. Fume hoods should also be tested in the following circumstances:

- When an employee requests an inspection.
- After major repair work.
- After a fume hood is moved.

Fume hood testing includes measuring the velocity of airflow through the face of the hood as well as a general inspection of the hood's condition (sash, lighting, noise level, etc.). If you



suspect a problem with your fume hood, contact Environmental Health & Safety. Appendix K is a form which can be used to document fume hood function,

7.15.2 Other Laboratory Ventilation Systems

Biological Safety Cabinets (BSCs)

BSCs provide containment for pathogenic materials and are not intended for use as a chemical fume hood. When used and maintained correctly, Class II biosafety cabinets protect the user from exposure to harmful biological agents and also protect the product from contamination by filtering the air inside the cabinet through High Efficiency Particulate Air (HEPA) filters. Before using a biological safety cabinet, laboratory personnel should be thoroughly trained on how to properly use and maintain the cabinet.

Follow these instructions for safe use of a biological safety cabinet:

- a. Only biosafety cabinets that are certified according to National Sanitation Foundation (NSF) Standard # 49 may be used with pathogenic or recombinant DNA materials. BSCs must be certified upon installation, upon being moved, after major repair, and at least annually.
 - i. It is each department's responsibility to have the BSCs certified
 - ii. BSCs that are not certified annually or that fail certification will be tagged "Not Safe For Use With Pathogens."
- b. Locate biosafety cabinets away from doorways and high traffic areas. As with chemical fume hoods, rapid movement in or near the cabinet can create turbulence, causing contaminants to be drawn out of the cabinet and into the general laboratory area.
- c. Restrict entry into the laboratory when work is being conducted in the BSC.
- d. Turn off UV light before beginning work in a BSC.
- e. Disinfect the biosafety cabinet prior to beginning and after completing work in the cabinet.
- f. Allow cabinet to operate without activity at least 15-20 minutes before and after use. This will allow all the air in the cabinet to circulate through the HEPA filters, removing any contaminants that may be present.
- g. Keep the BSC clear of clutter and loose paper. Only place items that are needed in the cabinet.
- h. Keep clean items and dirty items segregated in the BSC.
 - i. Provide a waste container inside of the cabinet and keep it covered.
- j. Always wear appropriate personal protective equipment.
- k. Keep face away from the BSC opening.
- l. Never use a Bunsen burner in a biosafety cabinet. Dangerous levels of gas can build up in the cabinet. Also, heat from the open flame can damage the HEPA filters.
- m. Clean up spills in the BSC immediately.

Canopy Hoods

These hoods capture upward moving contaminants and are good for heat-producing operations only. Canopy hoods should not be used as chemical fume hoods, as workers may be exposed to contaminants if they work under the hood.



Glove Boxes

Glove boxes are designed to be leak-tight and can be used with highly toxic or air-reactive chemicals and materials. Some glove boxes may also be appropriate for use with some radioactive materials. The leak-tight design provides a controlled atmosphere, protecting both the product and the worker by preventing vapors/moisture, gases, and particulates from entering or leaving the box.

Laminar Flow Hoods

Also known as clean benches, laminar flow hoods provide a continuous flow of HEPA filtered air across the work surface. This design helps prevent contamination of the product, but does not offer any protection to the worker. Laminar flow hoods should only be used with non-hazardous materials.

Laminar flow hoods may be certified at the user's discretion..

Snorkel Hoods

Snorkel hoods are small fume exhaust duct connections. They are designed with flexible ducts and are able to be positioned directly over a work area at the bench. For best performance, the snorkel hood should be placed within six inches of the item needing ventilation. Snorkel hoods should only be used to exhaust heat and nuisance odors. They should never be used with highly toxic or flammable chemicals.

7.16 Personal Protective Equipment

Personal Protective Equipment (PPE) includes all clothing and work accessories designed to protect employees from workplace hazards. Protective equipment should not replace engineering, administrative, or procedural controls for safety — it should be used in conjunction with these controls. Employees must wear protective equipment as required and when instructed by a supervisor.

IMPORTANT: Personal protective equipment is used to prevent exposure or contamination. PPE should always be removed before coming in contact with other individuals or before going in or near elevators, break rooms, classrooms, bathrooms, etc.

Principal Investigators (PIs) or laboratory supervisors are required to assess the hazards based on the procedures performed in the laboratory and the controls in use. The PI or laboratory supervisor should determine if additional PPE or specific PPE beyond the minimum is required. Required PPE should be detailed as a laboratory-wide requirement (e.g., lab coats) or in Standard Operating Procedures for specific laboratory procedure(s). PPE for some types of hazards are shown in the following table.

Hazards and PPE

| HAZARD | PERSONAL PROTECTIVE EQUIPMENT |
|---------------------|--|
| Biohazards (Germs) | Splash goggles, respirators, gloves, surgical masks, lab coats, aprons, sleeves, shoe covers, head covers |
| Chemicals | Gloves, chemical-resistant clothing, aprons, sleeves and shoe covers, vapor-proof or splash goggles, respirators |
| Cuts/Abrasions | Cut-resistant gloves (leather, Kevlar, chain-mail) |
| Dust | Dust goggles, respirators |
| Electricity | Electrically-resistive gloves, mats, hard hats |
| Falling Objects | Hard hats, steel-toe shoes, metatarsal guards |
| Falls | Fall harness, strap-on hard hat |
| Flying Particles | Safety glasses w/ side shields, goggles, face shields |
| Hot Environments | Cooling vests, reflective suits |
| Hot or Cold Objects | Gloves (Note: Asbestos gloves are prohibited and must be turned in as hazardous waste.) |
| Intense Light | Opaque glasses, goggles, welding hoods |
| Kneeling | Knee pads |
| Lifting | No PPE available, use engineering controls/training |
| Low Overhead | Bump cap, hard hat |
| Noise | Hearing protectors |
| Over-Water Work | Life vests, flotation devices |
| Radiation | Lead apron, lead gloves, thyroid collar, lead glasses for X-ray, lab coats/gloves for radioactive materials |
| Repetitive Motion | No PPE available, use engineering controls/training |
| Slipping | Non-skid shoes |
| Splashes | Splash goggles, face shields, chemical-resistant clothing, gloves, aprons, sleeves and shoe covers |
| Traffic | Reflective vest |

7.16.1 General Apparel and Appearance

- a. Inadequate Clothing
In the laboratory, do not wear open-toed shoes, sandals, shorts, cropped tops, or any other apparel that leaves skin exposed and unprotected. All loose clothing should be confined to avoid easily catching fire, dipping into chemicals, or becoming entangled in moving machinery.

- b. Jewelry
Remove jewelry to prevent chemicals from collecting underneath, contacting electrical sources, catching on laboratory equipment, and/or damaging the jewelry itself.

- c. Hair
Long hair should be tied back or confined to avoid easily catching fire, dipping into chemicals, or becoming entangled in moving machinery.



7.16.2 Arm and Hand Protection

Arms and hands are vulnerable to cuts, punctures, burns, bruises, electrical shock, chemical spills, and amputation. Forms of hand protection available to employees include but are not limited to

- Disposable exam gloves
- Chemical resistant gloves (rubber, nitrile, neoprene, etc.)
- Non-asbestos heat-resistant gloves
- Kevlar or Dynema gloves for cut resistance
- Bite-resistant gloves

Always wear the appropriate hand and arm protection. Appendix H provides guidance on chemical resistance of various glove materials.

Double your hand protection by wearing multiple gloves when necessary (e.g., two pairs of disposable gloves for work involving biological hazards). For arm protection, wear a long-sleeved shirt, a laboratory coat, chemical-resistant sleeves, or gauntlet-length gloves.

Follow these guidelines to ensure arm and hand safety:

- a. Inspect and test new gloves for defects.
- a. Always wash your hands before and after using gloves.
- b. Wash reusable chemical-protective gloves with soap and water before removing them.
- c. Do not reuse disposable gloves. Turn disposable gloves inside-out as you remove them to avoid contaminating your hands.
- d. Do not wear gloves near moving machinery; the gloves may become caught.
- e. Do not wear gloves with metal parts near electrical equipment.

IMPORTANT: *Gloves are easily contaminated. Avoid touching surfaces such as telephones, door knobs, etc. when wearing gloves.*

7.16.3 Body Protection

Hazards that threaten the torso tend to threaten the entire body. A variety of protective clothing, including laboratory coats, long pants, rubber aprons, coveralls, and disposable body suits are available for specific work conditions, including the following:

- Rubber, neoprene, and plastic clothing protect employees from most acids and chemical splashes.
- Laboratory coats, coveralls, and disposable body suits protect employees and everyday clothing from contamination by chemicals, biological materials, dirt and grime, etc.
- Welding aprons provide protection from sparks.

Launder reusable protective clothing separate from other clothing

7.16.4 Hearing Conservation

If you work in a high noise area, preventing hearing loss is of utmost importance. Whenever possible, attempts should be made to control noise levels through engineering controls or operational changes before resorting to hearing protection. Equipment that is operating more loudly than usual may just need maintenance. Also, installing noise attenuating devices in an



inherently noisy environment may alleviate noise levels. If, however, the noise level cannot be controlled sufficiently, hearing protection should be employed.

If you suspect that your laboratory environment exceeds acceptable noise levels, contact EHS for help. EHS has instruments for measuring decibel levels and can make recommendations on possible ways to reduce the noise level or on types of hearing protection that would be appropriate for the situation.

7.16.5 Eye and Face Protection

Employees must wear protection if hazards exist that could cause eye or face injury. Eye and face protection should be used in conjunction with equipment guards, engineering controls, and safe practices.

NOTE: *Unless it is documented that there is no potential for eye injury to occur, safety glasses are required in laboratories. Chemical splash goggles should be worn when handling chemical materials.*

Always wear adequate eye and face protection when performing tasks such as grinding, buffing, welding, chipping, cutting, pouring chemicals or pipetting. Safety glasses or goggles should be worn in case of impact hazard. Chemical splash goggles provide the most effective eye protection against chemical splashes as well as protection against impact.

Follow the information below regarding eye protection:

- a. If you wear prescription glasses, goggles or other safety protection should be worn over the glasses.
- b. Safety glasses with side-shields provide protection to eyes and are four times as resistant as prescription glasses to impact injuries.
- c. Goggles protect against impacts, sparks, chemical splashes, dust, etc., but not all goggles provide the same type of protection. There are specific goggles for:
 - i. Wood-working or other impact hazards
 - ii. Chemical splash hazards
 - iii. Laser hazards
 - iv. UV hazards
 - v. Welding hazards
- d. A face shield is designed to protect the face from some splashes or projectiles, but does not eliminate exposure to vapors.

NOTE: *Goggles or safety glasses with side shields must be worn under a face shield.*

7.16.6 Foot Protection

To protect feet and legs from falling objects, moving machinery, sharp objects, hot materials, chemicals, or slippery surfaces, employees should wear closed-toed shoes, boots, foot-guards, leggings, or safety shoes as appropriate. Safety shoes are designed to protect people from the most common causes of foot injuries — impact, compression, and puncture. Foot protection is particularly important in laboratory work.

IMPORTANT: *Do not wear sandals, open-toed shoes, open-backed shoes, or Crocs in laboratories, shops, or other potentially hazardous areas.*



Chemically resistant shoes may be necessary when working with certain materials, such as corrosives. Special foot protection is also available for protection against static electricity, sparks, live electricity, and slipping.

7.16.7 Head Protection

Accidents that cause head injuries are difficult to anticipate or control. With some exceptions, head protection is generally not needed in a laboratory environment. However, if hazards exist in the laboratory that could cause head injury, employees should try to eliminate the hazards, but they should also wear head protection.

7.16.8 Respiratory Protection Program

UCCS uses engineering, administrative, and procedural controls to protect people from dangerous atmospheres, including harmful mists, smoke, vapors, oxygen deficient environments, and animal dander. When these controls cannot provide adequate protection, respiratory protection is necessary.

People who use respiratory protection must be physically capable of using and wearing the equipment. In some cases, a physician must determine if an employee is healthy enough to use a respirator. In addition, all people required to wear respirators must be formally trained and instructed in proper equipment usage.

Choosing the right respirator for the job is equally important to knowing how to use it. There are many types of respirators and each type protects against different hazards. EHS will help individuals select the best respirator for their needs.

IMPORTANT: *Respirators are available in different sizes. Always fit test a respirator to select the correct size.*

Environmental Health & Safety can provide training and fit testing for personnel who need respiratory protection.

7.17 Safe Experiment Design

7.17.1 Introduction

A comprehensive experimental design process is an essential step in running safe laboratory operation. This process should review the potential hazards associated with each experiment over its life cycle. It is instrumental in maintaining safe laboratory operations, minimizing exposure to potential hazards, minimizing waste generation and ensuring regulatory compliance.

In this process, the whole range of experimental steps should be considered. From the development of clear experiment goals and objectives, through acquisition, setup and handling of materials and equipment, detailed assessment of chemicals and reactions, all the way to storage and disposal practices, each step should be examined to determine safety issues and environmental concerns.



Detailed information related to potential hazards identified and safety measures to be implemented should be incorporated to the experimental protocol and be an integral part of it! A guide on job hazard analysis is provided in Appendix AC.

7.17.2 Responsibility

Principal Investigators and supervisors are responsible for ensuring that effective pre-experiment review is implemented for each laboratory protocol prepared by a lab worker.

7.17.3 Procedure

1. State the goals and objectives of your experiment
2. Consider and state all the fundamental steps of the experiment
3. Perform hazard assessment for each step of the experiment or process. Consider the following elements:
 - a. Hazard evaluation of materials and chemicals to be used:
Complete hazard assessment for all materials and products associated with experiment. If risks are determined to be unacceptable, redesign the experiment, minimize quantities, reduce concentrations, reduce volume or use less hazardous chemical alternatives. Consider the chemical amount, volume, flow rate, physical properties, and the potential for exposure. Address emergency response for unexpected events. Special attention should be given to new materials produced whose physical properties and toxicity are unknown.
 - b. Management of chemicals and equipment:
Include provisions for acquiring and storing chemical reagents and equipment, proper equipment set up, handling and operation, inventory management, source reduction, material sharing, monitoring of reactive chemicals, compound shelf life, and storage incompatibility. Consider the potential impact of loss of air, water or power, on your experiment. Assess additional equipment hazard (noise, radiation, electrical hazard, ergonomics).
 - c. Working with chemicals:
Include steps such as sample preparation, equipment assembly and commissioning, equipment startup and calibration, product isolation and characterization, storage and disposal of materials after work is completed. Special consideration should be given to planning unattended operations, introduction of new equipment, and significant process scale up.
 - d. Types of reactions:
Know the chemistry of your reactions. Be prepared for exothermic reactions, runaway reactions, bumping, pressure build up, generation of hazardous gases or interaction between incompatible materials. Know the physical conditions required for the reaction (e.g. high pressure, vacuum, extremely cold temperature, high temperature, high voltage) and conditions that may develop over the course of the reaction. Consider the potential associated hazards.
 - e. Equipment, area cleaning and decontamination:
Develop a procedure for equipment and area decontamination. Make sure you are using the proper decontamination procedures and cleaning materials and know how to properly dispose of any residue or waste. Special caution should be taken with



reactive materials (air/moisture/water reactive) and when cleaning with solvents. Review compatibility information of cleaning and decontamination agents.

f. Proper disposal and deactivation procedures:

Consider waste minimization and recycling of materials. Evaluate the properties of all waste products to be generated by the experiment and develop written disposal instructions for each waste stream. Consider the amount and frequency of waste generated and methods to neutralize the waste or render it non-hazardous. Have a procedure in place to deal with unstable waste or wastes that require special storage and handling. Review the compatibility of materials being accumulated. Minimize the generation of multi-hazard waste. Minimize the release of hazardous chemicals to the environment. Do not use the fume hood to dispose of volatile hazardous materials (use filters, scrubbers or other control equipment). Do not discharge hazardous chemicals into the sewer system.

g. Provide a contingency plan to deal with the unexpected:

Be prepared for emergencies. Include information regarding emergency response in each procedure:

- i. the location and type of spill control equipment and materials
- ii. the location and type of fire extinguisher required (D type for combustible metals)
- iii. the type and location of antidotes to special hazardous chemicals (HF, cyanide)

h. Laboratory facilities:

Assess the area proposed for the experiment. Identify any potential hazards. Consider the location of equipment relative to the location of emergency response facilities. Work with hazardous materials should be carried out in the fume hood, glove box or biosafety cabinets. Special needs for bench space, ventilation or shielding may affect experimental planning and should be stated.

i. Personal protective equipment (PPE) and industrial hygiene monitoring:

Review the need for PPE and determine the type of PPE required for each step of the experiment. Incorporate this information to your protocol. Work with certain materials may require industrial hygiene monitoring or a special occupational health review.

7.18 Activities Requiring Prior Approval

Appendix P goes into detail about specific chemicals and/or hazards which require prior approval.

7.18.1 Activities Requiring Prior Approval

OSHA requires each employer to identify those activities which the employer believes to be of a sufficiently hazardous nature to warrant prior "employer approval" before implementation. Departments need to identify activities which involve extremely toxic chemicals, select carcinogens and reproductive hazards, and those activities with a high potential for personal injury and property damage. Departments will also need to identify existing activities subject to the requirements of this section.

Except for the most hazardous activities, "employer approval" will occur at the local level (e.g. Principal Investigator, Department Chemical Hygiene Officer). The EHS staff is available for assistance. Examples of activities requiring prior approval of the Principal Investigator or Department Chemical Hygiene Officer:

- Large scale operations (e.g. 22 liter volume or greater)
- Unattended operations, or longer than a normal eight-hour shift
- High pressure/low pressure operations (explosion/implosion hazards)
- After-hours work (before 7:00 am or after 6:00 pm)

7.18.2 Activities Requiring Approval of Environmental Health and Safety

- Reactions using highly toxic, radioactive or carcinogenic chemicals
- Installation, removal, moving or changes to a laboratory exhaust ventilation unit (chemical fume hood, exhaust trunk, canopy hood, etc.)
- Purchase of a Class 3B or IV Laser
- Potentially explosive laboratory reactions
- Experiment or process that impact building or laboratory design, i.e. a large piece of equipment or apparatus that blocks sprinkler heads.
- Purchase or use of a respirator.

7.18.3 Process Hazard Analysis

A hazard analysis is a step-by-step review of the procedures used by a laboratory and functions to predict hazards and risks to personnel and property and the environment. The hazard analysis also assists in defining control methods to prevent exposures to hazards.

The analysis should include the following:

- Laboratory Use Evaluation
- Chemical Use Evaluation
- Personal Protective Equipment Evaluation
- Pollution Prevention Analysis
- Evaluation for the need of a Prior Approval form
-

Process Hazard Analysis should take place during the laboratory registration process or may be scheduled as part of the laboratory inspection. Process Hazard Analysis should be based on information provided during laboratory safety training. EH&S is available to assist with this endeavor. PIs and Lab Managers should conduct Process Hazard Analysis on any new process or procedure. Hazard Analysis reviews should be reviewed with the employees involved in the process.

7.19 Restricted Use/Designated Areas

7.19.1 Designated Areas

Facilities placarded with the following warning signs are restricted access, designated areas:

- DANGER – BIOHAZARDS



- CANCER HAZARD
 - DANGER – RADIOACTIVE MATERIAL
 - DANGER – RADIATION AREA
 - DANGER – HIGH RADIATION AREA
 - DANGER – ACUTELY TOXICITY
 - CAUTION – REPRODUCTIVE TOXIN
 - DANGER – X-RAY
 - DANGER – LASER
- a. A list with names and phone numbers of responsible personnel shall be on file with Public Safety Dispatch
 - b. Students, faculty, staff and administrators shall not enter a restricted area, except when accompanied by an authorized user of the facility.
 - c. In general, all support personnel must have a minimal level of training (Right-to-Know) to enter any laboratory. Additional awareness training must be given by the Principle Investigator, Department Chemical Hygiene Officer or Environmental Health and Safety for support personnel to enter restricted areas.
 - d. Custodians are permitted to enter restricted areas to perform routine tasks; however, custodians must not touch labeled waste containers, other research equipment or materials.
 - e. Other support personnel, such as University Police, are permitted to enter restricted areas provided the work to be performed does not involve disturbing a use area within the facility, equipment, or materials. Examples include:
 - i. Fume hoods
 - ii. Biological safety cabinets
 - iii. Sinks
 - iv. Placarded equipment
 - v. Chemicals or materials on lab benches

7.19.2 Restricted Use of Chemicals

Chemicals purchased with University funds, grants or otherwise procured through and by the University of Colorado are specifically for use in University business on University property. In no case are chemicals to be transported in personal vehicles, taken home or used for non-University operations. Proper authorization must be obtained from the Department Chair, Dean or Director prior to transporting University chemicals off campus, including chemical sharing between organizations for research or training.

Chemical use shall be limited to University academic facilities or facilities use (including facilities operations in auxiliary units). Offices and residential facilities are not designed or intended for the use of chemicals and such use is specifically prohibited. This prohibition does not apply to the use of medicinal chemicals, including oxygen cylinders or to normal office or cleaning supplies.

7.19.3 Materials Transfer Agreement

Research involving biological agents and/or hazardous materials can sometimes also involve transfer of the physical material and/or intellectual property between various entities. CU's [Technology Transfer Office](#) (TTO) can assist you with issues related to intellectual property (IP); patents/ licensing/copyrights/ trademarks for discoveries/inventions/educational materials and software; start-up company development; materials or tissue transfer agreements.



Per UCCS Policy 100-011 only identified individuals may sign these agreements.

[Policy 100-011](http://www.uccs.edu/Documents/vcaf/policies/2014/100-011Contracts10-14.pdf): <http://www.uccs.edu/Documents/vcaf/policies/2014/100-011Contracts10-14.pdf>

the 100-011 [signature matrix](http://www.uccs.edu/~Documents/vcaf/policies/2014/100-011ApprovalMatrix10-14.pdf): <http://www.uccs.edu/~Documents/vcaf/policies/2014/100-011ApprovalMatrix10-14.pdf>

MTA sample templates are available on the CU [Technology Transfer Office Website](#)

- UBMTA: Document created by the NIH which simplifies the transfer of materials to other academic institutions already authorized to sign UBMTAs. CU is able to sign UBMTA's without any additional negotiation.
- Academic MTA: CU template to transfer materials to or from other academic institutions. Reasonable intellectual property terms with a focus on academic collaboration.
- Commercial MTA: Transfers material to or from a company.

For help transferring materials, send an email to MTA@cu.edu.

8 Laboratory Emergency Response

Be prepared for hazardous material emergencies and know what action to take in the event of an emergency. Examples of emergencies are power failure, exhaust ventilation failures, spills, fires, explosions, etc. Assure necessary equipment and supplies are available for handling small spills of hazardous materials.

Know the location of safety equipment: emergency shower, eyewash, fire extinguisher, fire alarm pull station.

Plan in advance for an emergency.

- What possible emergencies could occur during your work, e.g., fire, spill, high level chemical exposure, ventilation failure?
- Are systems available to indicate an emergency situation, e.g., chemical exposure monitoring systems, chemical fume hood audible/visual alarms?
- What supplies and equipment should be maintained in the area to assist emergency response personnel in the event of an emergency, e.g., eyewash and safety shower, spill control materials, personal protective clothing?
- What training is required to handle an emergency in the area, e.g., emergency first aid or respirator use training?
- Is it safe for you to work alone?

Help prevent emergencies in laboratories by doing the following:

1. Post emergency phone numbers and floor plans
2. Know locations of shutoffs for equipment including electrical, gas, water
3. Train personnel to retrieve SDSs for laboratory chemicals.
4. Separate incompatible chemicals and put them in secondary containment
5. Frequently dispose of chemical wastes, and clean out unneeded chemicals and surplus or dispose of unneeded items
6. Ensure electrical wires and equipment are in good condition
7. Discuss accidents and near misses to prevent future accidents
8. Complete the laboratory inspection checklist periodically
9. Discuss safety topics periodically in staff meetings



Develop a written plan for each experiment or process, detailing the steps to take should an emergency occur. This plan should reference and answer the questions listed above. This plan can be integrated into an experiment procedure document.

8.1 Fire Safety Procedures

Fire in a university building is the most likely campus emergency that could result in loss of property and threat to lives. It is, therefore, most critical that individuals react quickly and responsibly to any indication of fire in their surroundings.

PROCEDURES

If you SMELL smoke or gas

- From the nearest phone call the Department of Public Safety, at ext. 3111 or 255-3111.

If you OBSERVE fire or smoke

- Do not shout "Fire!" Remain calm.
- Pull the nearest fire alarm. Notify those in immediate danger.
- From the nearest phone call the Department of Public Safety at ext. 3111 or 255-3111 to notify the department of the exact location of the fire.
- If possible and safe to do so after initiating the fire alarm, attempt to extinguish the fire with a fire extinguisher.
 - Never use a fire extinguisher on a fire that is large enough to frighten you or when you do not have a way of escape.
 - No matter how small the fire, never use an extinguisher without sounding the fire alarm, in case you are overcome.
 - If you cannot extinguish the fire by yourself with one extinguisher, leave the area and let the professionals handle it.
- Do not prop open any fire doors. (Fire doors have automatic closers on them.)
- Evacuate, using appropriate exits and escape routes (do NOT use elevators). Provide assistance to those who need it.

If the fire alarm sounds

- All alarms should be treated as a valid fire alarm until Public Safety personnel verify that it is a false alarm.
- Stop what you are doing immediately, remain calm and follow instructions.
- Do not look for other people or attempt to take along belongings (other than your purse or backpack) - don't take the time to gather up your "stuff," your life is more important!
- Do not prop open any fire doors.
- Using the nearest exit or escape route (do NOT use the elevators), leave the building quickly and calmly.
- Persons with disabilities should be assisted out of the building or removed to a safe area to await evacuation by emergency responders.
- Proceed to safe ground at least 25 feet away from the building and out of the fire lane(s). The Director of Emergency Management should notify emergency response personnel of missing or disabled persons.
- Do not obstruct fire hydrants or any fire/rescue workers.
- Do not re-enter the building until informed by a uniformed officer (fire or police).

Reporting

After contacting Public Safety, and after meeting with the University Police, contact your supervisor.

Acting

If fire is observed or smoke smelled, **DO NOT HESITATE** to pull the fire alarm to evacuate the building. Notify Public Safety immediately as to the specific problem and its location.

If the fire appears no larger than a trash can, and there is an extinguisher nearby, **AND** you feel confident about putting the fire out, use the following instructions remembering the acronym PASS.



Pull the plastic tab off the fire extinguisher handle

Aim the nozzle at the base of the fire

Squeeze and hold the handle to discharge the dry chemical inside the extinguisher toward the **BASE** of the fire



Sweep the nozzle back and forth at the **BASE** of the fire

Use the entire contents of the extinguisher or stop when the fire is out. If the fire continues after emptying the extinguisher, evacuate **IMMEDIATELY**.

8.2 Ventilation Failure/Power Failure

Develop a written plan for each experiment or process, detailing the steps to make the operation safe should a ventilation or power failure occur. The chance of a power or ventilation failure occurring is much higher especially during the summer months. It is a prudent measure to have a separate plan to handle these types of emergencies

Be sure after a power outage, that the fan units in the ventilation system are operational before starting or resuming work.

8.3 Gas Leaks and Unknown Odors

All staff need to know what gases and volatile chemicals in their laboratory may produce an odor. Identify contents of pipes, hoses or gas lines with labels. Staff should know the location of control valves used to shut off gas flow. Previous incidents with odors as well as possible odors from adjacent laboratories should be discussed during staff meetings if they are issues.

8.3.1 Natural Gas Leaks

1. Natural gas leaks are a potential cause of explosions. Natural gas contains an odorant that enables recognition even at low concentrations. If you smell natural gas in the laboratory, do the following:
 - Turn off all sources of ignition (open flames, electrical equipment.)
 - Check laboratory gas outlets for open valves.
 - Call Facilities Services to have the location of the gas leak identified.



2. For strong, widespread and/or quickly worsening odor:
 - Pull the emergency alarm at a pull station.
 - Turn off all sources of ignition (open flames, electrical equipment).
 - Close the emergency gas valve for your floor or area if one exists.
 - Evacuate the building immediately and go to your assembly area.
 - If your assembly area is downwind of the building, move to an alternate assembly area up wind at least 300 feet from the building.
 - Do not return to an evacuated building unless told to do so by the on-scene authority (fire department, police department or other personnel).
 - Submit an incident report

8.3.2 Leaking Gas Cylinders

Do not over-tighten the valve in an attempt to stop the leak. If the valve continues to leak, consider whether room evacuation and building evacuation is necessary. Take the following actions as appropriate:

1. Flammable, oxidizing or inert gases – Wear PPE as necessary. If possible, allow the cylinder to exhaust into a well-ventilated area (such as a fume hood) with few or no combustible absorbent materials in the vicinity (such as cardboard). Post a sign warning of the leaking cylinder. Avoid sparks and open flames.
2. Toxic or corrosive gases – Wear PPE as necessary. Exhaust cylinder into an absorbent or neutralizer if possible. If no absorbent or neutralizing system is available, exhaust the cylinder into an operating fume hood. If escaping gas is leaking out of the control device or no control device is available, evacuate the area. Post a sign warning of the leaking cylinder.

8.3.3 Unknown Odors

Check with co-workers to determine if they are doing something to produce an odor. If not, check adjacent labs to determine if the odor is widespread or if the source is obvious. Try to relate the odor to possible causes – such as whether it smells like a sewer, or rotting food, or over-heating electronics, or a distinct chemical. If the source is obvious, take action if possible to eliminate the cause or control the odor, such as taking a chemical reaction off the bench top and putting it into a working fume hood.

If the odor isn't immediately found but appears to be appreciably stronger in one location, there is likely a source nearby, which can be a dried sink drain or floor drain (if a sewer-like or chemical-like odor), a chemical process gone wrong (if a rotting or unknown chemical odor), over-heating electronics (if devices are over-heating), or a chemical spill or a leaking process (if a distinct chemical). There are an unlimited number of potential sources, but familiarity with the lab's activities should help narrow the possibilities.

If the source of the odor continues to unknown and appears to be having adverse effects on workers, be sure to evacuate the area and notify Campus Police at x3111. If the source is known and exposure to the odor does not create an unhealthy or dangerous situation, then you may attempt to mitigate the source. Do not attempt to mitigate the source until you have notified someone else about the odor. If it is not safe, you do not feel comfortable mitigating the source, or the source continues to remain unknown then evacuate the area and contact Campus Police at x3111.

8.4 Exposure Evaluations

EHS will conduct or ensure sampling and monitoring activities are conducted to measure employee exposure to any hazardous chemical if there is any reason to believe exposure levels for the chemical routinely exceeds established acceptable levels. The decision to conduct monitoring is based on review of procedures conducted in individual laboratories in response to requests received from deans, directors, chairs, departmental chemical hygiene officers, Laboratory Manager and employees, or on information obtained during the laboratory registration or inspection process.

OSHA has specific mandates for several substances that may pose serious health risks to employees. For any laboratory use of a chemical for which there is a specific OSHA health standard, EHS may monitor for potential exposures if:

- There is a reason to believe that the exposure levels for that substance routinely exceed the action level or, in the absence of an action level, the permissible exposure limit.
- A request for monitoring is made by the laboratory or employee when there is reason to believe that the exposure levels for that substance routinely exceed the action level, or in the absence of an action level, the permissible exposure limit.

EH&S may recommend or conduct initial exposure monitoring when:

- When there is reason to believe that the maximum airborne concentration of a specific chemical could be above the short term exposure limit (STEL) action level or PEL; and
- The combination of chemicals could be above the STEL, action level or PEL.

Initial monitoring by direct reading methods may be conducted by EHS. These methods include, but are not limited to, colorimetric tubes, test paper strips and direct reading vapor monitors. Active monitoring may be performed for materials which there are no direct monitoring methods. If initial monitoring reveals employee exposure over the STEL, action level or PEL, EH&S must immediately comply with OSHA exposure monitoring provisions established for the specific contaminant.

If direct measurements indicate exposures may exceed the acceptable limits, additional monitoring may be required and active testing of individual breathing zones will be conducted using accepted OSHA methods and AIHA accredited laboratories.

EHS may not recommend monitoring if or when:

- Initial monitoring does not indicate any exposure above the action levels;
- There is no source of contamination;
- Monitoring does not demonstrate exposures above the ceiling or short-term action levels;
- The source is noncontiguous;
- If engineering and/or administrative controls have maintained exposures below action levels.

The employee must be notified in writing by posting the test results in an appropriate location within 15 working days after the receipt of results. Notification and posting will be completed by EHS.



8.5 Medical Consultation and Examination

- All employees who work with hazardous chemicals shall be provided an opportunity to receive medical attention under the following circumstances:
 - When the employee develops signs and/or symptoms that may be associated with a hazardous chemical to which the employee was exposed in the laboratory;
 - When routine monitoring reveals an exposure above the PEL or action level;
 - When an event takes place in the work area such as a spill or leak, explosion or other occurrence resulting in the likelihood of a hazardous exposure.
- All medical examinations and consultations shall be performed by a licensed physician or under his/her direct supervision.
- The employer shall provide the following information to the physician:
 - The identity of the hazardous chemicals to which the employee may have been exposed;
 - A description of the conditions under which the exposure occurred; and
 - A description of the signs and symptoms of exposure the employee is experiencing, if any.
- The Physician shall provide a written opinion which shall include
 - Any recommendation for further medical follow-up;
 - The results of the examination and any associated tests;
 - Any medical condition which may be revealed in the course of the examination which may place the employee at increased risk; and
 - A statement that the employee has been informed by the physician of the results of the examination and any medical condition that may require further examination or treatment.
 - The written opinion shall not reveal specific findings of diagnoses unrelated to occupational exposure.
- All medical consultations shall be coordinated by the University Risk Management.
- Appendix J is a form which can be utilized for medical consultation documentation.

8.6 Spill Clean-up Procedures

The Laboratory Chemical Spill Clean Up Procedures were created to give researchers and laboratory personnel a starting point for developing a chemical spill kit and providing guidance for cleaning up chemical spills. Chemical spills and accidents need to be minimized as much as possible. If a chemical spill should occur, a quick response with a stocked chemical spill kit will help minimize potential harm to personnel, equipment and laboratory space. Listed herein is the minimal equipment required for a spill kit. You may add equipment to the kit, provided all personnel are proficient in its use.

Recommended chemical spill kit contents

- Universal Chemical Absorbent Pads
 - High Capacity
 - Chemically Inert
 - Absorbs aggressive chemicals as well as non-aggressive compounds such as water
 - Good for all chemicals; acids, bases, flammable liquids, formaldehyde
- Universal Chemical Absorbent Powder
 - High Capacity
 - Chemically Inert



- Absorbs aggressive chemicals as well as non-aggressive compounds such as water
- Good for all chemicals; acids, bases, flammable liquids, formaldehyde
- Polyethylene Bags
 - Strong Construction
 - Leak Proof
 - At least 7-gallon capacity
 - 4 mm in thickness
- Anti-Static Polypropylene Plastic Scoop
- Nitrile/Silver Shield Combination Gloves
 - .011 thick Nitrile Gloves under Silver Shield Gloves
 - At least two pairs
- Two Pairs Indirect Venting Chemical Splash Goggles
- Hazardous Waste Labels

Note that the majority of chemical spills can be prevented or minimized by:

- Maintaining a neat and organized work area;
- Performing a laboratory procedure review prior to conducting new experimental procedures;
- Storing liquid chemicals in secondary containment bins;
- Keeping reagent chemical containers sealed or closed at all times, except when removing contents;
- Ordering reagent chemicals in plastic or plastic coated glass containers whenever possible;
- Using secondary containment to store and move chemicals.

8.6.1 Large Spill Protocol

If the spill is too large for you to handle, involves materials listed in the table below; is a threat to personnel, students or the public; involves radioactive material; involves an infectious agent; or involves a corrosive, highly toxic, or reactive chemical, call for assistance.

| Chemical Class | Example |
|--|--|
| Strong Acids - Any acid that is concentrated enough to fume or emit acid gases | Fuming Sulfuric Acid Red Nitric Acid Hydrofluoric Acid Perchloric Acid |
| Strong Bases - Any base that is concentrated enough to emit vapors | Ammonium Hydroxide |
| Poison by Inhalation - Any chemical that readily emits vapors / gases at normal temperature and pressure that are extremely toxic by inhalation | Phosphorous Oxychloride Titanium Tetrachloride Formates Isocyanates |
| Reactive - Any chemical that is sensitive to air, water, shock, friction and/or temperature | Dry Picric Acid Lithium Aluminum Hydride Sodium Borohydride Phosphorus Metal Organic Peroxides |



| | |
|---|---|
| <p>Mercury - Any mercury compound. Do not use a domestic or commercial vacuum cleaner. Uses of powder sulfur or mercury spill clean up kits are not as effective as the specialized equipment EHS has on hand. These spill clean up methods also increase the disposal cost.</p> | <p>Metallic Mercury Mercury Salts Aqueous Mercury Solutions</p> |
| <p>Extremely Toxic - Any chemical that is readily absorbed through the skin and is extremely toxic at small concentrations</p> | <p>Benzene Sodium Cyanide</p> |

- If the spill occurs in the laboratory, evacuate the room and call on DPS at 255-3111. Follow the University Police’s directions and stay by the laboratory until EHS responders arrive.
- If the spill occurs in a public space (hallway, stairwell, elevator, etc.) or involves a large amount of flammable liquids (greater than four liters), flammable gas, or has the potential to threaten people outside of the laboratory, pull the building fire alarm and evacuate the building. Follow the University Police’s directions and stay by the facility until EHS responders arrive.
- For specific spill clean-up information, contact your supervisor, instructor or Environmental Health and Safety.

8.6.2 Low Hazard Material Spills

Laboratory workers who have had the proper training and possess the appropriate equipment can safely and effectively handle the majority of chemical spills that occur in the laboratory. In addition, spills involving multiple chemicals may pose various hazards. Always contact EHS if multiple chemicals are involved in a spill. Except for the chemical classes listed in the previous table, labs can handle spills involving one liter or less of liquid and one pound or less of a solid. If the spill is large, contact EHS to assist with the cleanup. The following procedures are specific guidelines for using the recommended spill cleanup materials. Contact EHS with any questions or concerns about proper spill clean-up practices.

- a. In the event of a chemical spill, first decide if you are trained, knowledgeable and equipped to handle the incident. Immediately evacuate the lab and notify DPS if there is a possibility of an acute respiratory hazard present or if you need assistance to clean up the spill. Never proceed to clean up a spill if you do not know the hazards associated with the chemical or if you are unsure of how to clean up the spill. If anyone is injured or contaminated, immediately notify DPS and begin decontamination measures or first aid, if trained.
- b. Don the personal protective equipment from the spill kit; splash goggles and nitrile/Silver Shield combination gloves. Always ask a fellow researcher for assistance. They should also don splash goggles and nitrile/Silver Shield combination gloves. Make sure that all forms of local exhaust, i.e. fume hoods, are operating. It is normally not advisable to open the windows. If broken glass is involved, do not pick it up with your gloved hands. Use the scoop or tongs to place it in the bag, then place the bag in a strong cardboard box or plastic container. Follow the procedures provided below based on the class and type of chemical.
- c. All tools used in the cleanup need to be decontaminated (plastic scoop, tongs, etc.). Remove all gross contamination with a wet paper towel. Dispose of the contaminated

paper towels as hazardous waste. Rinse the tools off with copious amounts of water. Dispose of the gloves as waste. Dry the tools off and place back into the spill kit along with the splash goggles

- d. Liquid Spills other than flammable liquids - Spread the chemical spill powder over the spill starting with the edges first. This will help to confine the spill to a smaller area. Spread enough powder over the spill to completely cover the liquid. There should be no free liquid. Use plastic scoop to ensure that the liquid was completely absorbed by the powder. Pick up the powder with scoop and place in the polyethylene bag. Wipe the area down with a wet paper towel. Dispose of paper towel with the waste generated from the spill cleanup. Seal bag with tape and attach a completed orange hazardous waste sticker on the bag.
- e. Flammable Liquid Spills - Control all sources of ignition. Lay the chemical spill pads over the spill. These pads are design to suppress the vapors emitted by a volatile liquid. Allow pads to completely soak up liquid. Pick up pads with tongs or other device that minimizes direct contact with a gloved hand. Place in the polyethylene bag. Wipe the area down with a wet paper towel. Dispose of paper towel with the waste generated from the spill cleanup. Seal bag with tape and attach a completed orange hazardous waste sticker on the bag.
- f. Solid Spills - Use the plastic scoop to place the spilled material into the polyethylene bag. Care should be taken so as not to create dust or cause the contaminated powder to become airborne. After the bulk of the material is cleaned up, wet a spill pad and wipe the area down. Place the pads into the polyethylene bag. Wipe the area down with a wet paper towel. Dispose of paper towel with the waste generated from the spill cleanup. Seal bag with tape and attach a completed orange hazardous waste sticker on the bag.

Note: Precautions must be taken to minimize exposure to the spilled chemical. Be careful not to step in the spilled material and track it around. Contact EHS and DPS if an exposure to a chemical occurs.

8.6.3 Mercury Spills

Most mercury spills at UCCS are small, and can be readily cleaned up by personnel working in the area where the spill occurs. All work areas that use mercury must have mercury spill kits available, and train workers in their proper use.

Commercial Mercury Spill Response Kits and Devices

- **Amalgamating kits:** sold by safety and lab supply vendors, amalgamating powder is sprinkled over the droplets of mercury, wetted to initiate the amalgamating reaction; the mixture is scooped up and placed in a container for disposal. Some kits are equipped with a small hand pump for collecting large mercury droplets before amalgamating and for difficult to reach areas.
- **Sponges:** specially designed sponges that pick up mercury droplets when firmly pressed against the surface of the spill, work best on non-porous, smooth surfaces. **Use of a sponge alone is not recommended** -- the area should also be treated with an amalgamating powder to reduce any mercury vapors from residual mercury.
- **Mercury vacuum:** essential only for responding to large mercury spills and not an economical choice for minor spills resulting from broken thermometers or other small mercury-containing items. These devices are specially designed to purify exhaust air and capture the elemental mercury for recycling. A HEPA vacuum is not suitable for mercury spill cleanup.



Small Mercury Spills (5 ml's or less from small devices such as thermometers)

- If the spill is onto or within a heated surface, do not attempt to clean it up.
 - Turn off the heat-producing device,
 - Turn on fume hoods or open windows to ventilate the area,
 - Isolate the room from others by shutting connecting doors,
 - Evacuate the room, and shut the door,
 - Placard the door(s) to the room "Mercury Spill - Do Not Enter.",
 - Contact Environmental Safety for assistance.
- If the spill is not onto a heated surface, access the spill kit and follow the enclosed instructions. In general, this should include:
 - Turn on fume hoods or open windows to ventilate the area,
 - Isolate the room by shutting all doors,
 - Wear protective latex or nitrile gloves,
 - Consolidate the mercury droplets using the scrapers provided, two small pieces of stiff cardboard, index cards or plastic "credit cards",
 - Collect droplets using hand pump, mercury sponge, or amalgamating powder,
 - Place the recovered mercury and other contaminated materials in a heavy-walled, polyethylene screw-cap bottle; labeled "MERCURY SPILL RESIDUE."
 - Remove gloves and place them in the mercury spill residue bottle.
 - Wash hands, arms and face thoroughly.
 - Tag the spill residue bottle for collection as a hazardous waste.

Large Mercury Spills

IF MORE THAN 5 ML OF MERCURY IS INVOLVED IN THE SPILL CONTACT [EH&S](#) @ 255-311

8.7 Safety Showers and Eye Wash Stations

Most of the laboratories where extensive chemicals are utilized are equipped with eye wash and/or emergency showers. The eye wash/showers need to remain unobstructed. The eye washes should be run at least weekly by laboratory personnel. This helps to ensure that the unit is operational and that the water is not stagnant.

Be aware that emergency showers do not have drains. If one is activated, besides assisting the victim, you also need to put down barriers (from your spill kit) to help contain the water. Likewise be aware of electrical sources or other equipment which may be impacted by the water.

8.8 Injury, Illness, Personal Contamination, Minor First Aid

8.8.1 Serious Injuries, Serious Illnesses or Hazardous Materials Exposures

- a. For serious injuries, serious illnesses or chemical exposures, call 911 or DPS 255-3111. Unless otherwise specified by Environmental Health & Safety, all injuries, regardless of severity, involving chemical or other hazardous materials will be reported. The University Police will contact EHS staff
- b. Tell emergency and medical personnel:
 - i. Your name, location and nature of the emergency
 - ii. Name of the chemical involved



- iii. The amount involved
 - iv. Area of the body effected
 - v. Symptoms
 - vi. If you have any questions regarding injury and illness procedures, contact your supervisor, instructor, or the Department of Environmental Health and Safety.
- c. Do not move a seriously injured person unless they are in further danger.
 - d. Follow the appropriate steps outlined in section

8.8.2 Non-life threatening injuries, illness or non-serious issues

- a. Undergraduate Students should report to the Student Health Service, if medical attention is required. Students should be accompanied by a friend, teaching assistant, or instructor.
- b. Employees and graduate students, should consult with Risk Management regarding medical services
- c. When in doubt as to what should be done, telephone the University Police for assistance.

8.8.3 Personal Contamination

Chemicals Spilled Over a Large Area of the Body

- a. The “buddy” or lab partner should assist the person to a safety shower and contact x3111 immediately.
- b. Remove potentially contaminated clothing, jewelry, and other items while in the safety shower. Flush the affected area in the safety shower with water for at least 15 minutes unless otherwise specified. Wash off chemical with water but do not use neutralizing chemicals, unguents, creams, lotions, or salves, unless indicated and approved by Environmental Health and Safety
- c. The “buddy” or lab partner should retrieve the SDS and provide to EMS
- d. Seek medical attention promptly.
- e. Localized spills can be flushed under a faucet. Call Public Safety at x3111
- f. Notify your supervisor, teaching assistant or principal investigator.

Chemicals in the Eyes

- a. The “buddy” or lab partner should assist the person to an eyewash and contact x3111
- b. Flush eyes with water for at least 15 minutes using an eyewash station unless otherwise instructed. Hold your eyelids open when using the eyewash. Remove contact lenses if not already removed by the water.
- c. The “buddy” or lab partner should retrieve the SDS and provide to EMS.
- d. Seek medical attention promptly.
- e. Notify your supervisor, teaching assistant or principal investigator.

Inhalation of Vapors, Mists, Fumes or Smoke

- a. The “buddy” or lab partner should assist the person to fresh air and contact
- b. In the event of an inhalation exposure, remove victim to fresh air only if it is safe to do so. Do not enter the area if a life threatening condition still exists:
 - Oxygen depletion
 - Explosive vapors
 - Cyanide gas, hydrogen sulfide, nitrogen oxides, carbon monoxide or other toxic gases, mists, vapors or fumes



- c. Utilize the safety shower or eyewash and flush affected areas as needed for 15 minutes if applicable
- d. If trained and necessary, provide Rescue Breathing or CPR
- e. The “buddy” or lab partner should retrieve the SDS and provide to EMS.
- f. Notify your supervisor, teaching assistant or principal investigator.

Burning Chemicals on Clothing

- a. Extinguish burning clothing by using the drop-and-roll technique or by dousing with cold water or use an emergency shower.
- b. Remove contaminated clothing; however, avoid further damage to the burned area. Do not remove any clothing or material that is stuck to the victim
- c. The “buddy” or lab partner should assist as necessary and when safe contact
- d. Cover injured person to prevent shock.
- e. Get medical attention promptly.

Ingestion of Hazardous Chemicals

- a. Identify the chemical ingested and obtain the SDS
- b. The “buddy” or lab partner should contact
- c. Call the Poison Information Center (1-800-722-7112).
- d. Provide the ambulance crew and physician with the Safety Data Sheet, the chemical name and any other relevant information. If possible, send the container or the label with the victim.

8.8.4 Minor First Aid

First Aid Kits

- a. Departments should obtain a first aid kit for treatment of minor first aid cases (cuts, scratches, minor burns).
- b. First aid kits must be readily accessible. If the kit is not visible, the area where it is stored must be clearly marked.
- c. First aid kits must be fully stocked at all times.
- d. Do not dispense or administer any medications, including aspirin.
- e. Do not put any ointments or creams on wounds or burns. Use ice, cold pack or cold water.
- f. The SDS contains special first aid information.
- g. After giving first aid, direct or transport the victim to a medical facility for evaluation.
- h. Non-emergent undergraduate student first aid cases are treated at the Student Health Services
- i. Non-emergent employee, including graduate and postdoctoral students, first aid cases are treated at the designated facilities after consultation with Risk Management
- j. Visitors, regardless of the extent of the injury should be transported to the nearest hospital by ambulance.
- k. Seriously injured individuals (employees or students) should be transported to the nearest appropriate hospital by ambulance
- l. For specific first aid information, contact your supervisor, instructor, or the Department of Environmental Health and Safety

8.9 Laboratory Floods

If your laboratory is flooded, find the source of the water. Shut the water off. If safe, also shut down any equipment that could cause a dangerous electrical situation during a flood. Cover



equipment and desks if water is dripping onto them. Then, get help quickly. During work hours, contact your building coordinator. After hours, call UCCS Police at x3111. Also, notify the supervisor, principal investigator or department administrator in charge of the flooding laboratory as soon as possible.

If the water is contaminated by chemicals, call EHS through UCCS Police at x3111.

The best method to clean up uncontaminated water is by using one water vacuum on the scene of the flood and another on the affected area below. Saturated materials (fabrics and cardboard, for example) need to be dried within 48 hours or will need to be discarded to prevent mold growth.

After the cleanup, submit an accident report.

8.10 Accident and Near Miss Reporting

Principal Investigators or Lab Managers must submit accident reports to Risk Management and near miss reports to EHS for any accident or near miss situation. Employees will be free from any reprisals for reporting accidents. Accident/Near Miss Reports, corrective actions and suggestions regarding possible improvements can help UCCS as they strive to improve future laboratory safety.

To report an incident related to an employee in regards to an injury or illnesses refer to <https://www.cu.edu/risk/workers-compensation> . For incidents involving volunteers or students, please complete the Report of Injury form (Appendix Y). For near misses refer to the EHS website and fill out the Near Miss Report (Appendix S).

9 Inspections

It is the aim of the Chemical Management Team to work cooperatively with principal investigators and laboratory workers to achieve compliance with University safety policies, the Laboratory Safety Manual and governmental regulations. From time to time, however, it may be necessary when cooperation fails to impose sanctions to achieve compliance. This policy is designed to ensure compliance through a system of phases that applies increasing pressure on a principal investigator to make the appropriate corrective actions..

9.1 Laboratory

Periodically Environmental Health and Safety will conduct inspections of the laboratories on campus. The frequency of the inspections will depend upon the hazards present in each lab, These inspections are not intended to be punitive in nature but rather educational by assisting Principal Investigators to identify areas where they may not be up to standard and assisting them in correcting those areas. A copy of the laboratory inspection sheet is available in Appendix D.

A report identifying deficiencies and areas for improvement will be directed to the laboratory's Principal Investigator, and any applicable department designee. These items must be corrected within 30 days of receipt of the laboratory inspection report. If the items cannot be corrected in that timeframe, the Principal Investigator must submit a written corrective action plan detailing the expected corrections and estimated date of completion within the same 30 days. The Principal Investigator may designate a responsible party to submit the report. Any inspection



finding posing eminent danger (likely to cause a serious hazard, injury, disability or death) must be corrected immediately

In addition to the inspections conducted by EHS, the departmental Chemical Hygiene Officer may also conduct periodic inspections especially during instructional labs to ensure that students are working in a safe environment.

9.2 Emergency Equipment

EHS routinely checks some emergency equipment such as fire extinguishers, emergency showers and eye wash stations. Principal Investigators are responsible for ensuring that first aid, spill equipment and appropriate PPE are available in their laboratories.

9.3 Regulatory Inspections

On occasion the University may be visited by federal, state, county or city regulatory inspectors. Some of these groups may contact Environmental Health and Safety (EHS) or the Research Office to initiate an inspection, but others may just present themselves at a lab or building. If this occurs, it is recommended that you follow these procedures:

- Request identification or credentials from the inspector. Write down the inspector's name and affiliation. If satisfactory credentials are not provided, do not offer any further assistance and contact Public Safety immediately.
- Contact EHS at x3201 to inform them of the inspection. Provide the affiliation of the inspector when calling to assure the proper response from EHS.
- As per your lab or department's policy, contact your PI, department chair and/or building manager to inform them of the inspector's presence. The department chair and the director of EHS should advise the administration that the inspector is on site and arrange for any close-out conferences requested.
- Do not decline the inspection, however ask the inspector if they can wait until one or more of the above individuals can join the inspection. At a minimum, the PI or EHS representative should be present before proceeding. If EHS is not present before the inspection starts, please take notes of what is said and/or visited until they arrive.
- Answer the inspector's questions, but only provide the information or files that are specifically requested. Do not volunteer information. If the inspector asks to take pictures, do not allow it unless you are able to also take the same pictures for the university's records or verify that they will make them available to the university as well.
- The inspector's status does not authorize him/her to handle any hazardous material in your facility so do not permit this.
- The inspector must always be accompanied by you or other University personnel during the inspection so do not allow them unescorted access to your facility.
- Assure that the inspector wears all appropriate or required personal protective equipment.

If you are contacted to schedule an inspection, please inform EHS and allow the appropriate personnel to be present to assist with the inspection.

If you have any questions regarding these procedures, please contact EHS at x3201 or x3212

10 Waste Management

Disposal of hazardous materials is regulated by various federal and state agencies. Laboratory waste very often includes hazardous chemical, biological, or radiological materials. Thus, proper disposal of laboratory waste is not only prudent, it is mandatory. Environmentally sound disposal methods prevent harm to the water, land, and air and by extension, to people as well. Proper disposal techniques also protect waste handlers from harm.

Laboratory waste disposal can be broken down into five categories – hazardous (chemical) waste, biological waste, radioactive waste, glass waste, and metal (sharps) waste – which are discussed below.

Laboratory personnel can ensure compliance with the Hazardous Waste Management Program by following a few simple steps:

- a. Never dispose of chemicals improperly. Improper disposal includes
 - i. Pouring chemicals down the drain;
 - ii. Leaving uncapped chemical containers in the fume hood to evaporate off the chemical; and
 - iii. Disposing of chemicals in the regular trash.
- b. Collect waste in a leak proof container that is in good condition, that can be securely closed, and that is appropriate for the given chemical.

NOTE: *If a large waste container (>10 gallons) is warranted, contact EHS for assistance.*

- c. When reusing a container to collect chemical waste, completely deface or remove the original label.
- d. Label the container:
 - i. The words “Hazardous Waste” must be written on the container
 - ii. Identify the contents of the waste container on the container itself and on the tag (if attached). Example: Nitric Acid Waste, or Phenol Waste.
- e. Do not mix incompatible waste chemicals in a single container. Use separate waste containers for different waste streams.
- f. Do not overfill the waste container.
 - i. For liquid hazardous waste:
 - a. Do not fill jugs and bottles past the shoulder of the container.
 - b. Fill closed head cans (5 gallons or less), leaving approximately two inches of space between the liquid level and the top of the container.
 - c. Fill closed head drums (larger than 5 gallons), leaving approximately four inches of space.
 - ii. For solid hazardous waste materials, do not fill beyond the weight capacity of the container, and leave at least two inches head space for closure.
- g. Keep waste containers closed. Waste containers should only be open when adding or removing material.

10.1 Hazardous Waste

The term “hazardous waste” refers to hazardous chemical waste. If waste chemicals contain infectious materials or biological hazards, the waste must be treated first as biological waste.

Once the biological hazard has been eliminated, then the waste can be treated as hazardous waste. Any waste containing radioactive materials must be treated as radiological waste.

Disposal of hazardous waste is governed by the Environmental Protection Agency (EPA) and by the Colorado Department of Public Health and Environment (CDPHE) through Federal and State regulations.

Hazardous waste must not be:

- Disposed or recycled with other forms of trash or waste
- Burned or allowed to evaporate into the air
- Disposed or diluted in water (i.e. down the drain)
- Disposed on or buried in the land.

10.1.1 Hazardous Waste Determination

EPA's RCRA has established authority and control of handling and disposing of all solid chemical wastes and discarded liquids and gases in containers. All generators of RCRA regulated waste are required to determine if the waste is hazardous. This is accomplished by determining if any of the constituents of the waste are specifically "listed" hazardous waste constituents or if the waste has a regulated characteristic of hazardous waste.

"Listed" Chemical wastes are broken down into the following lists:

"K" listed waste from specific sources.

"F" listed waste from non-specific sources.

"U" listed wastes from off-spec or discarded commercial chemicals.

"P" listed wastes from off-spec or discarded commercial chemicals which have been designated as acutely hazardous.

Under the Hazardous and Solid Waste Amendments (HSWA) of 1984, additional substances were incorporated into the hazardous waste regulations by having characteristics of hazardous waste. A generator must determine if a waste possesses one or more of the following characteristics: ignitability, corrosivity, reactivity or toxicity. A waste known to be contaminated with constituents having one or more of the four characteristics must be handled by the generator as hazardous waste, unless the generator develops the detailed waste analysis required to establish the absence of regulated characteristics to the point specified in the regulations.

Characteristics of Hazardous Wastes

Ignitability – A chemical waste is ignitable if it has a flash point below 140 degrees Fahrenheit, if it is an ignitable compressed gas, or if it is a substance that readily yields oxygen to stimulate combustion. EPA hazardous waste number D001.

Corrosivity – Chemical solutions with a pH less than or equal to 2 or greater than or equal to 12.5 are considered corrosive. EPA hazardous waste number D002.

Reactivity – Chemicals that are normally unstable or react violently with water. EPA hazardous waste number D003.



Toxicity – Toxicity Characteristic Leaching Procedure (TCLP) toxic chemicals are waste in which extracts contain high concentration of heavy metals or pesticides that could be released into the groundwater.

Other types of Hazardous Waste Include:

- **Universal Wastes:** Aerosols, Batteries, Electronics (devices and components), Oils, Lamps and Pesticides. Disposal of electronics and lamps must be arranged through the Facilities Department. Batteries can be recycled through the Office of Sustainability. Used oil is managed between Transportation, Facilities and Environmental Health and Safety. The Environmental Health and Safety Office handles all others essentially as regulated hazardous waste.
- **Designated Wastes:** Asbestos Containing Material, CFC's, PCB containing materials, Silver-rich photographic waste. Contact the Environmental Health and Safety Office for disposal information.
- **Biohazard (Biomedical) Waste:** Human and animal tissue, blood, and blood products, cultures and stocks of etiologic agents and associated biologicals, laboratory waste that has come in contact with a biohazard, sharps, animal waste, animal carcasses, body parts, and human pathological waste. Disposal of these materials must comply with the UCCS policy on Biosafety Management (Appendix E).
- **Radioactive Waste:** Radioactive materials, including wastes are controlled through the Radiation Safety Office in the Environmental Health and Safety Department at the University of Colorado Boulder.

Federal, state and local laws regulate the disposal of hazardous materials. The disposal of any hazardous material in the sewer system, storm water system, on the ground, or in the regular trash is strictly forbidden. Improper disposal of Hazardous Waste is subject to criminal and civil penalties.

Once solid waste is identified as hazardous waste by the generator, it must be handled in accordance with this Manual. This includes hazardous materials that are:

- No longer used
- In excess of what is needed
- Have exceeded their shelf life
- Have been used in a process
- No longer useable
- A product of a process

10.1.2 F listed Wastes

The EPA has established F listed wastes which are wastes from nonspecific sources. These include:

Spent solvents (F001-F005)

Electroplating and metal finishing waste (F006-F012, F019)

Dioxin-bearing wastes (F020-F023 and F026-F028)

Wood preserving waste (F032, F034 and F035)



Many of the chemicals used in UCCS laboratories are F001-F005 wastes. If the before use concentration of the listed constituent was 10% or more and the material was used as a solvent, then it is a listed waste. If the waste consists of a mixture of constituents and the total concentration of all of the listed constituents is greater than 10% and it was used as a solvent then it is a F listed waste.

10.1.3 P and U listed Wastes

The EPA has compiled a list of P-coded (acute hazardous wastes) and U-coded (toxic wastes) hazardous chemical wastes (see lists below) that are commonly used in industrial settings in very large quantities. If you are using any chemicals identified in either the P or U lists, the waste generated from these products are likely to be regulated.

Laboratories are not allowed to accumulate more than a total of one quart of P-coded waste (e.g. sodium azide) at any time. If you ever generate more than a total of one quart of P-coded chemical waste at any time, the waste must be immediately disposed through EHS (x3212).

Laboratories are not allowed to accumulate more than a total of 55 gallons of all U-listed (e.g. methanol) chemical waste at any time. If you ever generate more than a total of 55 gallons of U-coded chemical waste at any time, the waste must be immediately disposed through EHS (x3212).

The following rules apply to chemicals found on either the P or U lists of hazardous chemical waste:

- a. Any commercial chemical products or off-spec materials (or intermediates) that are waste products or have no legitimate use are considered regulated chemical waste. Please be aware that any listed unused commercial chemical product that still has a practical use or may be legitimately recycled, is not a regulated chemical waste.
- b. All spill residues or contaminated water or other debris resulting from a spill cleanup is a regulated chemical waste.
- c. Spill debris must be properly disposed through EHS.
- d. All formulations and dilutions of chemicals found on either of these lists is a regulated chemical waste. Please be aware that many column chromatography reagents and biological test kits have small amounts sodium azide present to prevent bacteria from growing, these types of materials maybe regulated P-coded hazardous waste because of the presence of the sodium azide.
- e. Empty chemical containers that held U-listed chemicals are unregulated as long as the entire product has been removed by normal pouring or scraping procedures. Any empty U-listed container cannot have more than 3% of the original product remaining in it; otherwise, the "empty" container is a regulated hazardous waste. Dispose of all empty chemical containers through EHS.
- f. Empty P-listed chemical containers are unregulated as long as the entire product has been removed by normal pouring or scraping procedures and the container has been triple rinsed with an appropriate solvent. P-coded waste containers which have been triple rinsed may be discarded in the regular garbage but remember the rinsate must be collected and disposed of through EHS.
- g. Unrinsed P-listed chemical containers, packaging, syringes, pipettes, etc. must be collected and treated as hazardous waste.
- h. Appendix L-1 and L-2 provide lists of P and U wastes.



10.1.4 Hazardous Waste Segregation

When collecting hazardous waste in a laboratory, please follow these general guidelines for segregation:

- a. Clean flammable solvents (alcohols, acetone, acetonitrile, xylene, etc.) may be collected together inside the same waste container.
- b. Acids must be collected separately.
- c. Bases or caustics must be collected separately.
- d. Halogenated solvents (chloroform, methylene chloride, carbon tetrachloride) must be collected separately.
- e. Heavy metals (arsenic, barium, cadmium, chromium, lead, mercury, selenium, silver) must be collected separately. Do not mix heavy metal wastes with organic solvents.
- f. Toxic liquids (phenol, acrylamide, formaldehyde) must be collected separately.
- g. Solid chemical wastes are collected separately from liquid chemical wastes.
- h. Solid debris that is contaminated with highly toxic or carcinogenic chemicals must be collected separately.

10.1.5 Hazardous Waste Collection

An appropriate container (bottle, jar, drum, etc.) must be used to accumulate waste. It must be properly labeled. Hazardous waste containers must be kept closed except when adding or transferring waste and the contents of the containers must be compatible with the container material.

Steps to take with chemical waste collection:

- An identified area within the unit must be designated as a Satellite Accumulation Area for hazardous material disposal. Access to this area must be controlled to ensure that materials are properly identified, handled, and maintained.
- Individual containers for each chemical category must be identified and labeled. Containers must be placed in secondary containment, unless specifically exempted by EHS.
- A label must be placed on each container and clearly marked with what materials are placed in each accumulation container, the individual generator's name and the full name of the chemical waste (not just chemical formulas). Except when physically placing materials in containers, lids must be in place and tightened.

IMPORTANT: EHS will provide assistance in management of chemical wastes and will collect all identified wastes for disposal, by arrangement. Unidentified chemicals or wastes will be the responsibility of the generator until properly identified and labeled for disposal. Transporting hazardous waste by vehicle on campus shall be conducted by the EHS department or his/her designee (contracted waste hauler, etc.).

When the waste container is ready for disposal, the generator should complete a Waste Removal Request (available on the EHS website) and send it to EHS. The generator should ensure the following:

- a. Completely fill out Waste Removal Request Form. (This information is essential for record keeping.)
- b. The "REQUESTOR" is the person in charge of the laboratory.



- c. Use full chemical names or common names. Chemical formulas or abbreviations are not acceptable.
- d. List all chemical components, including water. Long lists may be continued on the back of the form.
- e. Indicate the percent concentration of potentially explosive materials such as picric acid and nitro compounds.
- f. Place additional hazard information in REMARKS.
- g. Date the full container with the date the EHS was notified that the container was full and/or ready for pick-up.

10.1.6 Disposing of Empty Chemical Containers

Empty chemical containers may be disposed of in the regular trash provided the following EPA requirements are met:

- a. Containers must not contain free liquid or solid residue.
- b. Containers must be triple rinsed. Confirm with EHS what to do with the rinsate. The chemical and which building you are located in will affect your disposal options for the rinsate. The rinsate from all solvent containers must be collected and treated as hazardous waste.
- c. Product labels must be defaced or removed.
- d. Container lids or caps must be removed.
- e. Render metal containers and plastic jugs unusable by punching holes in the bottom of the containers before disposing of them in the regular trash. (It is not necessary to break empty glass containers.)

IMPORTANT: Containers that do not meet the requirements mentioned here must be treated as hazardous waste.

We are also working with the Office of Sustainability to be able to recycle many of our empty chemical containers.

10.1.7 Labeling of Hazardous Waste

A chemical container must be labeled as hazardous waste at the time its content is designated as a hazardous waste. When a hazardous waste is added to a container, it must be labeled as hazardous waste at the time the first drop of hazardous waste is added to the container. The label should not be dated until such time as the container is ready for pick-up by EHS. Hazardous waste labels are available in the chemistry department, biology department and in the EHS.

The Hazardous Waste labels will be used on all waste containers. The container must clearly be labeled with the fully written chemical name and generator's name. If the collection container contents contain a mixture, all components must be listed by percent or volume on the hazardous waste label.

Containers will not be reused once designated for hazardous waste disposal.

Once a container is ready for pickup, fill out a Hazardous Waste Removal Request Form (located under the forms tab on the EHS website) and call the EHS 255-3212.



10.1.8 Packaging of Hazardous Waste

U.S. Department of Transportation (DOT) regulates the proper packaging of waste containers. DOT regulation 49 CFR 172 provides information on the proper container selection for hazardous waste. In addition, waste storage containers must be non-leaking, chemically compatible, safe, and clearly labeled. Hazardous waste must be kept in appropriate closed containers at all times, except when adding or removing material. The following guidelines must be followed when packaging hazardous waste:

- Use a leak-proof container that will safely contain the contents.
- Do not mix incompatible chemicals.
- Do not overfill a container with liquid waste.
- Do not mix hazardous materials with non-hazardous materials.
- Allow an empty space of approximately five percent of the container volume for thermal expansion.
- Be suspicious of any pressure build-up inside the container.
- Hazardous waste must be stored based on compatibility. Store materials of the same hazard class together.
- Loose solid materials must be placed in a sealed container.
- Do not leave funnels in the collection container (unless the funnel has a lid and then the lid must be kept closed at all times except when adding waste material).
- Place waste containers into secondary containment when needed.

10.1.9 Hazardous Waste Storage Areas

Hazardous wastes must be stored in designated satellite accumulation areas. Accumulation areas must be located next to or near the point of waste generation, and the individual who operates that process or area must manage and control the hazardous waste container.

Satellite accumulation areas can be in a laboratory fume hood or on a countertop. They should not be positioned in front of or behind doors or windows, blocking means of egress or suspended from equipment.

It is the responsibility of the Principal Investigator/Lab Supervisor to inspect the Satellite accumulation area (SAA) on a weekly basis. This needs to be documented on the SAA inspection log form (Appendix V). It is best practice to have the satellite accumulation containers in secondary containment or placed in some other manner so that a spill would be contained/controlled.

Aisle space must be maintained to allow the unobstructed movement of emergency equipment and personnel into all areas where waste is stored.

UCCS has a designated Hazardous Waste Storage Room on campus in the Osborne Center room LD-301A. Once waste containers are full, they are then transferred to the Hazardous Waste Storage Room.

Proper labeling must be used when placing containers in the waste storage room.

Once waste has been moved to the Hazardous Waste Storage Room, it must not be stored for more than 180 days per Colorado Hazardous Waste Regulations. All waste containers must



also be inspected monthly for leaks, deterioration, etc. Hazardous Materials/Hazardous Waste Inspection forms are available under the forms tab on the EHS website.

Pick-up Schedule

EHS coordinates hazardous waste pick-ups 2 times per year (January and August) for all campus departments that generate hazardous waste. It is the responsibility of the generator / manager of the hazardous waste to notify EHS of hazardous waste to be disposed.

A contracted hazardous waste disposal company provides waste pick-ups to the UCCS campus.

10.1.10 Hazardous Waste Management Recordkeeping

All waste management activities shall be documented and records are kept in the EHS. The following are documentation requirements and will be maintained by EHS:

- All hazardous waste documentation (manifests, etc.) related to transportation, shipment, regulatory reporting, land disposal, etc.
- Hazardous Waste Removal Request Forms
- Hazardous Waste Inspections (storage area – OCSE room LD-301A)
- Initial / Annual hazardous waste management training. (Training conducted by departments separately – send a copy of the training roster to EHS.)
- All other hazardous materials documentation

All waste management documents must be maintained for a minimum of three years.

10.1.11 On-site treatment

"Treatment" when used in connection with an operation involved in hazardous waste management, means any method, technique, or process, including neutralization or incineration, designed to change the physical, chemical, or biological character or composition of a hazardous waste, so as to neutralize such waste or to render such waste less hazardous, safer for transport, amenable for recovery or reuse, amenable for storage, or reduced in volume. [6 CCR 1007-3 Section 260.10]

Generally speaking a permit is required in order to treat hazardous waste. Under a limited set of circumstances, however, generators are allowed to treat their own hazardous wastes without first going through the complex regulatory process of getting a hazardous waste permit. The broadness of the definition of "treatment" creates many areas of confusion about when a hazardous waste treatment permit is required and when a particular activity is exempted from requiring a treatment permit.

The exceptions from the hazardous waste treatment permit requirements include:

- Generators adding absorbent material to waste in a container and generators adding waste to absorbent material in a container.
- Owners and operators of elementary neutralization units.
- Owners and operators of wastewater treatment units.
- Owners and operators of totally enclosed treatment facilities.

- Conditionally exempt small quantity generators treating their own hazardous wastes and persons who own or operate facilities solely for the treatment of hazardous waste from conditionally exempt small quantity generators.
- Persons recycling certain hazardous wastes in specific ways.
- Persons conducting treatability studies to determine the appropriateness of potential treatment processes.
- Persons managing batteries, pesticides, mercury-containing devices, mercury-containing lamps, electronic devices and aerosol cans under the Universal Waste Rule of CHWR Part 273.

Labs on campus are permitted to practice elementary neutralization under select circumstances. Prior notification to EHS is required. The permit exemption for elementary neutralization units is very narrow in scope and is limited to wastes that are only hazardous for the corrosivity characteristic. Don't let the terms acid or caustic mislead you – many acidic and caustic wastes are not eligible for this exemption. For example, neutralization of chromic acid would not be covered by this exemption because chromic acid also fails the toxicity test for chromium (D007). Similarly, unused hydrofluoric acid is listed as a hazardous waste (U134) due to corrosivity and toxicity and therefore would not be covered by this exemption. This is why prior notification to EHS is required.

Other “treatment” needs to be pre-authorized by EHS to prevent a violation of this regulation.

10.2 Biomedical Waste

Biohazardous materials include organisms or substances derived from biological materials or organisms that may be harmful to humans, animals, plants, or the environment. Biohazardous waste includes any waste materials that contain biohazardous materials, such as

- a. Waste (including blood) from and bedding or litter used by infectious animals
- b. Bulk human blood or blood products and waste materials contaminated with human blood
- c. Microbiological waste (including pathogen-contaminated disposable culture dishes and disposable devices used to transfer, inoculate, and mix pathogenic cultures)
- d. Biological pathogens
- e. Sharps
- f. Any recombinant (rDNA) materials and products of genetic manipulation

IMPORTANT: *All biohazardous material must be decontaminated prior to disposal.*

Biohazardous waste mixed with hazardous chemical or radioactive waste must be treated to eliminate the biohazard prior to disposal. After treatment, the waste can be managed as either hazardous chemical waste or as radiological waste.

There are strict safety requirements regarding segregation, labeling, packaging, treatment (including documentation), and transportation of biohazardous waste. The guidelines below should be followed:

- a. Do not mix biological waste with chemical waste or other laboratory trash.
- b. Segregate hazardous biological waste from nonhazardous biological waste.





- c. Clearly label each container of untreated biohazardous waste and mark it with the Biohazard Symbol.
- d. It is recommended to label nonhazardous biological waste as "NONHAZARDOUS BIOLOGICAL WASTE."

Refer to Appendix E for additional requirements regarding biomedical waste management.

10.3 Nanotechnology Waste

Under current regulations, nanoparticles are not in and of themselves a regulated waste; however, they may be regulated based on the compounds used to create the engineered nanoparticles or because of the solvents in which they are suspended. Therefore, the following waste management guidance applies to potentially contaminated nonmaterial waste streams consisting of:

- Pure nanomaterials (e.g., carbon nanotubes)
- Items contaminated with nanomaterials (e.g., wipes, pipettes, culture plates, PPE, etc.)
- Liquid suspensions containing nanomaterials
- Solid matrices with nanomaterials that are loosely attached to the surface such that they can reasonably be expected to break free or leach out when in contact with air or water, or when subjected to reasonably foreseeable mechanical forces.

Dispose of nanomaterial liquids, powders, and contaminated papers, wipes, disposable PPE, etc. via EHS. Containerize all waste in double plastic bags that are sealed, or other sturdy, impervious, screw-cap containers. Consult EHS on proper disposal of nanomaterials embedded in a solid matrix that cannot reasonably be expected to be released

Recommended Nanomaterial waste management methods by stream.

| Waste Stream | Management Method |
|---|--|
| Solid <ul style="list-style-type: none"> • Dry ENM product • Filter media containing ENMs • Debris / dust from ENMs bound in matrix | <ol style="list-style-type: none"> 1. Follow <i>General Nanomaterial Waste Management Practices</i> 2. Collect waste in rigid container with tight fitting lid. |
| Liquid <ul style="list-style-type: none"> • Suspensions containing ENMs | <ol style="list-style-type: none"> 1. Follow <i>General Nanomaterial Waste Management Practices</i>. 2. Indicate both the chemical constituents of the solution and their hazard characteristics, and the identity and approximate percentage of ENMs on container labels. 3. Use leak proof containers that are compatible with all contents. 4. Place liquid waste containers in secondary containment and segregate from incompatible chemicals during storage. |
| Laboratory trash with trace nanomaterials <ul style="list-style-type: none"> • PPE | <ol style="list-style-type: none"> 1. Follow <i>General Nanomaterial Waste</i> |



| | |
|---|---|
| <ul style="list-style-type: none"> • Tacki mats • Spill clean-up materials | <p><i>Management Practices.</i></p> <ol style="list-style-type: none"> 2. Dispose of in double clear plastic bags, folded over and taped at the neck. 3. Avoid rupturing the bags during storage and transport. |
| <p>Solid Matrix</p> <ul style="list-style-type: none"> • embedded with nanomaterials (intact and in good condition) | <ol style="list-style-type: none"> 1. Consult with your EH&S department, as these materials may be non-hazardous. |

10.4 Solid Waste

10.4.1 Glass Waste

Glassware should never be disposed of in the regular trash. Pasteur pipettes and broken glass can break through trash bags and cut individuals who handle trash. Follow these guidelines when disposing of broken glass:

- Do not pick up broken glass with bare or unprotected hands. Use a brush and dust pan to clean up broken glass. Remove broken glass in sinks by using tongs for large pieces and cotton held by tongs for small pieces and slivers.
- Glass contaminated with biological agents must be decontaminated by thermal or chemical treatment before disposal.
- Glassware contaminated with chemical or radiological materials must also be decontaminated prior to disposal. If decontamination is not possible, the glass should be disposed of as hazardous or radioactive waste. Place non-contaminated broken glass in a rigid, puncture resistant container such as a sturdy cardboard box. Mark the box "Non-contaminated Broken Glass." Once the box is three-quarters full, seal it shut. The box should then be placed in the dumpster by laboratory personnel. Custodial staff are not responsible for disposing of glass waste containers.

NOTE: *If broken glass is commingled with metal sharps, it must be treated as sharps waste and encapsulated before for disposal.*

10.4.2 Metal Sharps

All materials that could cause cuts or punctures, must be contained, encapsulated, and disposed of in a manner that does not endanger other workers. Needles, blades, etc. are considered biohazardous even if they are sterile, capped, and in the original container. The following guidelines apply to handling and disposing of sharps:

- Metal sharps must be segregated from all other waste.
- Sharps that have been used with chemical or biological materials should be placed in a designated sharps container for disposal by a licensed contractor. This can be coordinated through the student health center.
- Sharps that have radiological contamination must be disposed of as radiological waste.
- Dispose of sharps in a rigid container, such as a sturdy plastic jar or a metal can.
- When the container is three-quarters full, encapsulate the sharps with Plaster of Paris or some other solidifying medium.
- Once the contents are encapsulated, seal the sharps container, label it "Encapsulated Sharps," and take it to the dumpster.



NOTE: *Laboratory personnel are responsible for sharps disposal. Custodial staff are not responsible for encapsulating and/or disposing of metal sharps waste.*

10.5 Universal Wastes

10.5.1 Aerosol Cans

Aerosol cans may also be hazardous wastes depending on their contents. Aerosol cans in storage also present a hazard to occupants and emergency responders in case of fire. The Colorado Department of Public Health and Environment (CDPHE) regulates disposal of aerosol cans as Universal Waste.

- a. Aerosol cans sometimes need to be discarded before they are completely empty. This occurs for a variety of reasons, including when the spray mechanism no longer operates as designed, the propellant is spent, or the product is no longer used. In these cases, the aerosol can should be collected and turned over to EHS for disposal.
- b. Do not discard aerosol cans in the garbage if they still contain any product.
- c. Completely empty aerosol cans may be placed in the dumpster.
- d. This includes everything that comes in an aerosol can, (e.g., paints, hairspray, deodorizer, contact cleaner, “clean air”, etc.)
- e. All unwanted aerosol cans must be properly disposed via EHS **THEY MUST NOT BE THROWN INTO THE GARBAGE.**

10.5.2 Batteries

The Office of Sustainability recycles all battery types on campus. No batteries should be going into domestic trash. Recycle containers are located around campus. Refer to UCCS.SOP4 Batteries

<http://www.uccs.edu/Documents/pusafety/safe%20operating/UCCS.SOP4%20Batteries.pdf> for exact locations.

10.5.3 Electronics (devices and components)

The Office of Sustainability recycles/disposes of all electronic devices and components on campus. No electronic devices/components should be going into domestic trash. Utilize a work order from Facilities to dispose of excess electronics or contact the Office of Sustainability for additional assistance. There is a specific UCCS policy on e-wastes.

10.5.4 Lamps/Fluorescent Bulbs, CFLs

Facilities collects and manages all fluorescent bulbs, CFL bulbs, etc. on campus. These can be delivered to the Campus Services Building for management/disposal. No fluorescent/CFL bulbs should be going into the domestic trash. This includes green-tipped lamps.

10.5.5 Used Oil

Federal, State, and local regulations and ordinances govern the disposal of used oil, filters, and other lubricating fluids or associated devices. For oils contaminated with polychlorinated biphenyls (PCBs) – contact EHS.

- **Oil is a serious environmental pollutant** in lakes and streams. POTENTIAL RELEASES MUST BE PREVENTED FROM REACHING DRAINAGE SYSTEMS LEADING TO WATERWAYS (STORM DRAINS) OR THE WATER TREATMENT PLANT (SANITARY SEWER SYSTEM).
- It is important to segregate used oil which is from a closed system (i.e. vacuum pumps) where the potential for the oil to be contaminated with process chemicals is minimal from used oil generated in an open system (i.e. diffusion pump) where the potential exists for the oil to be contaminated with process chemicals. One can be managed as a universal waste for recycling and the other may have to be managed as a hazardous waste.
- **Create a segregated storage area** for used oil collection:
 - **Indoor storage or areas protected from the weather** are strongly recommended.
 - Collection container **must be metal or plastic**, not glass
 - Collection container **MUST BE LABELED "USED OIL ONLY"**.
 - Collection container **must have tight fitting lid** that is in place except when adding used oil
 - **A funnel should always be used** to minimize spills when transferring used oil to the collection container. **THE FUNNEL MUST BE REMOVED AND THE CONTAINER CLOSED WHEN NOT ACTIVELY BEING USED FOR OIL TRANSFER.**
 - **Suitable spill containment and cleanup material** must be on hand to ensure spills are not released to drainage systems or penetrate soils. Secondary containment or berm sufficient for the entire volume in the area must be used.
 - A screw-in funnel **WITH A LID** can be used for a collection drum
 - Collection container **limited to 5 gallons** or less except in the designated facility's collection location
 - Collection container must have **adequate spill protection**
 - **Secondary containment** sufficient to hold full container volume if it fails or leaks
 - Indoor storage locations kept **away from floor drains and flammable materials**
 - Outside storage areas **away from storm sewers, street gutters, waterways, etc.**
 - **Appropriate absorbents, pads and cleanup materials** on hand in vicinity
 - Contact [EH&S](#) for assistance in evaluating prior to use
 - Collection container must be **within secondary containment**
 - Collection container **access must be controlled** to ensure only used oil is added
 - Do not mix used (lubricating) oil with other automotive fluids (transmission fluids, brake fluids, anti-freeze, etc.), solvents, solvent-contaminated oil, PCBs, non-petroleum based oils, or any other material in the collection container.
- When container is full contact [EHS](#) for proper disposal .
- **Do not burn used oil** on-site or give it to others to burn – this is a specific violation of federal and state regulations.
- **A service contractor services the majority of UCCS's motorized vehicles.** In this process, they collect and manage the used oil from these vehicles. For those vehicles maintained by Facilities, the used oil is collected in drums in a designated storage shed.
- Oil filters need to be drained and managed as a "used oil" waste stream separate from the actual oil. It is important the filters are drained and the oil collected for recycling. Depending upon the type of filter, the filters can be recycled or managed as a waste stream. Contact EHS for disposal.

10.6 Special Wastes

10.6.1 Radioactive Waste

Radioactive materials, depending upon the license, are regulated by the State of Colorado or the Nuclear Regulatory Commission, and these regulations/rules are enforced by UC Boulder's Radiological Safety Program. All radioactive wastes shall be disposed through UC Boulder's EHS or via written procedures approved by EHS. See the Radionuclide Procedure Manual or contact EHS for more information on proper disposal of radiological waste.

10.6.2 Ethidium Bromide

Ethidium bromide is a nucleic acid stain. It fluoresces under ultraviolet light, especially when bound to double-stranded DNA. It is also a strong mutagen and a possible carcinogen, so must be managed correctly. While it is not specifically regulated as a hazardous waste, the mutagenic properties may present a hazard if it is not managed properly in the laboratory.

Ethidium bromide (EtBr) is a strong mutagen that requires special handling and disposal procedures, as described follows:

- When handling EtBr always wear a lab coat, nitrile gloves, and chemical splash goggles. Proper skin and eye protection are needed when a ultraviolet (UV) light source is used while working with EtBr. Avoid exposing unprotected skin and eyes to intense UV sources. Wear a face shield if UV source is pointing upwards. When working with a UV source for a long time, wrap up lab coat sleeves with tape or other means where the wrist could be exposed
- Unused excess EtBr must be tagged for collection by EHS.
- Solutions of EtBr containing heavy metals, organics, cyanides or sulfides, or other toxic constituents must be tagged for collection by EHS.
- pH neutral, aqueous solutions containing greater than 5 ppm EtBr may be discharged to the sanitary sewer following decontamination or deactivation as listed below.
- Solvent solutions containing any amount of EtBr must be tagged for collection by EHS.
- EtBr mixed with a radioactive isotope must be processed for collection by CU Boulder Health Physics.
- Gels that contain ethidium bromide may be double-bagged, labeled "non-hazardous" and placed in the trash if they contain less than 0.1% ethidium bromide. If the gel is pink or red, the ethidium concentration is higher than 0.1%. In this case, the gel is handled as hazardous waste.
- Concentrated solutions (10 mg/ml) of ethidium bromide must be handled as hazardous waste. They will quickly saturate the treatment tea bags.
- Disposable equipment/consumables (i.e., gloves, pipette tips, etc.) minimally contaminated with EtBr may be bagged and disposed as regular trash. Materials with gross contamination must be bagged in sealed heavyweight plastic bags weighing less than 20 pounds and tagged for collection by EHS.
- Clean spills of ethidium bromide carefully with soap and water. Collect the soap, water and ethidium bromide mixture onto absorbent material. If concentrated or powdered ethidium bromide was spilled, place it in a sturdy screw top container and dispose of as hazardous waste. All other materials may go in the trash after you double bag it and label it "non-hazardous".
- Other nucleic acid dyes and stains are also mutagens and possible carcinogens. They should be treated like ethidium bromide with the methods above.

Decontamination or Deactivation

Charcoal Filtration

Filtering the aqueous EtBr waste solutions (free of other contaminants) through a bed of activated charcoal is a relatively simple and effective method for removal of EtBr. The filtrate may be poured down the drain.

There are two kits available for charcoal filtration.

Funnel Kit:

Commercial filter funnel kits are available that use a packaged charcoal disk that is graduated for easily tracking the amount of aqueous solution that can be run through it. This is particularly useful for labs that generate large amounts of solutions at a time. The kit is available through Schleicher and Schuell or VWR.

- Filter the EtBr solution through the charcoal filter.
- Pour filtrate down the drain.
- Place charcoal filter in a sealed container (mayonnaise jar) and label as a hazardous waste.

[GreenBags](#) Kit:

Another simple charcoal filtration method is the Green Bag, manufactured by BIO 101; The [GreenBags](#) Kit allows rapid and trouble-free concentration of EtBr from large volumes of solutions into a small "tea" bag containing activated carbon, which is then conveniently disposed along with other solid (contaminated debris) hazardous wastes. One kit has the capacity to remove 500 mg of ethidium bromide from solutions (10 mg EtBr/bag).

- Place the Green Bag into the EtBr solution.
- Allow to sit for the allotted time.
- Pour filtrate down the drain.
- Dispose of the Green Bag in a sealed container (mayonnaise jar) and label as a hazardous waste.

EtBr Chemical Degradation Procedure

Solutions containing EtBr can be deactivated and rendered nonhazardous by using one of three methods. Deactivation may be confirmed using UV light to detect fluorescence. The three methods are as follows:

➤ Armour Method:

This is the simplest method, but is somewhat controversial. One study found traces of mutagenic reaction mixtures using this method. (Lunn, G. and E. Sansone, Analytical Biochemistry, vol. 162, pp. 453-458, 1987)

- Combine equal amounts of EtBr solution and household bleach.
- Stir constantly for four hours or let sit for 2-3 days.
- Adjust pH to 4-9 with sodium hydroxide.
- Pour down drain with copious amounts of water.

➤ Lunn and Sansone Method:

For each 100 ml of EtBr solution:

- Add 5% hypophosphorus acid.



- Add 12 ml of 0.5 M sodium nitrite.
- Stir briefly and let stand for 20 hours.
- Adjust pH to 4-9 using sodium hydroxide.
- Pour down drain with copious amounts of water.

➤ **Quillardet and Hoffnung Method:**

This method uses 0.5 M potassium permanganate and 2.5 M hydrochloric acid. Since chlorine gas may be released in significant concentration, EH&S does not recommend using this method.

Contaminated Debris:

Contaminated debris includes gloves, bench paper and other non-labware items. Place contaminated debris into an appropriate containers for hazardous waste disposal. All containers used for collection must have a top or cover that can be secured. Hazardous waste labels must be used and EH&S contacted when the material is ready for disposal. Bags must not be used unless they are doubled up and kept sealed.

Contaminated Labware:

Contaminated labware includes needles, pipettes, test tubes, etc. that are contaminated with EtBr. Depending on the waste you generate, follow the procedures below.

Needles, scalpels, Pasteur pipettes, and other sharps contaminated with EtBr should be disposed of directly into a sharps container. These will be disposed of like other sharps waste.

Volumetric or transfer pipettes, and other disposable glassware incidentally contaminated with EtBr should be disposed of in a sharps container. Grossly contaminated (visibly contaminated) glassware should be washed with bleach before disposal in a sharps container.

Test tubes and centrifuge tubes contaminated with EtBr should first be emptied, with the liquid disposed of according to the procedures given above. Empty incidentally contaminated tubes can be disposed of in the trash. Grossly contaminated (visibly contaminated) tubes should be collected with other laboratory debris, labeled and disposed of as a hazardous waste.

Most other disposable labware (e.g. sample vials, disposable beakers, etc.) incidentally contaminated with EtBr may be disposed of in the normal trash. Grossly contaminated (visibly contaminated) disposable labware should be labeled and managed as a hazardous waste.

Accident Procedures:

Be very careful when using EtBr. Call EH&S at 255-3212 for assistance with spills. Below are procedures to follow in case of contact:

- In the case of eye contact, flush eye(s) with water for at least 15 minutes lifting upper and lower eyelids occasionally.
- If skin is exposed, remove contaminated clothing and wash skin with soap and water immediately.
- If EtBr vapors are inhaled, remove to fresh air.
- If swallowed, get medical attention immediately.

Spill Clean-up:

In case of a small spill, absorb freestanding liquid. Use ultraviolet light to locate the spill. Then prepare decontamination solution by mixing of 4.2 grams of sodium nitrite and 20 mL of hypophosphorous acid (50%) in 300 mL of water. To decontaminate the spill area, wash it with a paper towel soaked in the



decontamination solution. Wash the spill area with wet paper towels (soaked in the decontamination solution) an additional 5 times (using fresh paper towel each time). After cleaning up the area put all the used towels in the decontamination solution for 1 hour. Check the completeness of decontamination using the ultraviolet light. If satisfied, put all the decontamination solution in a bottle, label it with a hazardous waste label and call EH&S for waste pick-up.

In case of large spill notify all the people in the laboratory. Evacuate the laboratory immediately. Call EH&S for assistance with a clean up. Post warning signs on all laboratory doors notifying others of the spill. Prevent unnecessary entry into the room until the EH&S personnel arrive. Explain all the details to the EH&S personnel.

Contaminated Equipment:

Laboratory equipment (e.g. transilluminators, laboratory floors and countertops, etc.) contaminated with aqueous solutions of more than 10 mg/L (0.01 %) EtBr should be decontaminated using the spill clean-up procedures listed above.

11 Transportation and Receiving of Hazardous Materials

The transportation of dangerous goods (i.e. hazardous materials) is highly regulated by the Department of Transportation. Persons who ship, carry or receive such goods must have current certification of training.

Receiving Dangerous Goods

Receivers must be trained to examine packages, check documentation and respond to emergencies such as spills. This is to ensure that materials are received in safe, intact containers and accompanying hazard information and documentation is complete.

11.1 Receiving Procedures

Receiving dangerous goods (DG) involves the following steps:




1. Each package containing DG must be examined to ensure the packaging is intact and the DG have not leaked or spilled from the container.
2. Each package should have the appropriate safety symbols and labels attached.
3. The labels and shipping documents should match. Any errors on classification should be corrected.
4. The package must be stored safely until used.
5. File shipping documents for a minimum of two years.
6. Respond to and report any dangerous occurrences.

11.2 Dangerous Goods Hazard Categories

There are nine hazards classes recognized under DOT. The following table lists the classes and their hazard symbols.

Anyone receiving goods classified as explosive must contact EHS to determine appropriate procedures and storage facilities required.

Anyone receiving a good classified as a radioisotope must obtain certification through the UC Boulder Radiation Safety Program.

| DOT Class | Label Symbol | Comments |
|-----------------------|---|--|
| Explosives [1] |  | Anyone receiving explosives must consult with Risk Management Services |
| Compressed Gasses [2] |  | Flammable gases include propane or hydrogen Toxic gases include hydrogen sulphide or chlorine |
| Flammable Liquids [3] | | Flammable liquids have flash points below 61°C. |
| Flammable Solid [4] |  | These symbols are required on large quantities. |
| Oxidizers [5] | | Examples include nitric acid, and osmium tetroxide |
| Toxic/infectious [6] | | These materials are acutely toxic causing immediate health risk. Example sodium cyanide |
| Radioactive [7] | | Question on the safe handling of radioisotopes must be referred to the Risk Management Services Radiation Safety Program |
| Corrosive [8] | | Examples include acids and |

11.3 Shipping Description

Each package must display the following information:

- The name of the material in the package. For example —hydrochloric acid
- The TDG hazard class name and subsidiary classes. For example —Class 8 corrosive
- A four-digit material identification number. For example, —UN 1789 is the number
- for hydrochloric acid.
- The packing group designation; I, II, III
- Special handling information such as —Keep from freezing or —Keep upright

11.4 Safety Symbols and Labels

Each package must display the appropriate safety symbols. Examples are provided in the above table.



Symbols and labels may not be removed until the goods are removed from the packaging. Empty containers must have labels defaced or removed, or the boxes flattened. The symbols are to be placed on the packages in a diamond orientation with the corner of the labels pointing upwards. Reduced size labels may be used on compressed gas cylinders and are often located on a reinforced tag attached to the neck of the cylinder.

11.5 Documentation Required

All dangerous goods shipments must be accompanied by DOT shipping papers and must be retained by the receiver for at least two years. DOT shipping papers may be combined with commercial documents such as a Bill of Lading for convenience.

A receiver is responsible for ensuring that information on the document matches the safety marks and label information on the packages. A diligent receiver may also object to poorly prepared shipping papers.

11.6 Handling and Transporting

Transportation of dangerous goods, loading, unloading, or storage should be in a way that could not cause the discharge, emission or escape of the dangerous goods from the means of containment that could constitute a danger to health, life property or the environment.

Handlers and transporters must follow any special instructions relating to safe handling and storage, e.g. —Refrigeration required; keep away from heat and flames. ll

Received materials must be segregated by hazard classes in accordance with the University's chemical storage guidelines (see Section VI of this manual).

11.7 Dangerous Occurrences

If any of the following incidents occur:

1. Any transportation accident involving infectious or radioactive substance;
2. Any unintentional explosion or fire involving dangerous goods; or
3. A spill of a dangerous goods

Immediately contact Public Safety at 719-255-3111

11.8 Packaging Damaged in Transport

Damaged gas cylinders can be extremely dangerous if rapid release occurs. Leaking cylinders must be returned and may be handled and transported in a road vehicle. Keep the cylinder in a safe (outdoor) location. Contact the supplier immediately to arrange for its return.

Damaged packages containing solid materials of hazard classes 4, 5, 6.1, 8, or 9 may be handled and transported in a road vehicle provided the damage package is repaired. Packages will be marked with the words —FOR SALVAGEll and are transported directly to the consignee or to a point for repackaging or disposal.

Damaged packages containing liquid materials of hazard classes 3, 5, 6.1, 8 or 9 may be handled and transported in a road vehicle provided the damaged package is placed in a steel or plastic drum over-pack.



12 Laboratory Close Out and Decommissioning Procedures

Research scientists and science instructors at the UCCS are responsible for the safe operation of their laboratories. If you are relocating, renovating or vacating your laboratory, you are also responsible for leaving your laboratory in a state suitable for re-occupancy or renovation. Environmental Health and Safety must be notified of all moves in laboratory spaces. A Laboratory Decontamination/Decommissioning Procedures and Checklist (Appendix F) should be completed and forwarded to EHS at least 45 days prior to exiting a laboratory due to renovation, moving to another laboratory, or separation from the University

In General, the following steps must be followed if a laboratory needs to be decommissioned for renovation, transfer to another principle investigator or decontaminated for any reason. The Department requesting the cleaning must contact EHS at x3212 to evaluate the laboratory. This can be completed by submitting a Laboratory Decontamination/Decommissioning Procedures and Checklist;

- a. EHS will review the historical use of chemical, biological and radioactive materials within the laboratory;
- b. EHS will inspect the laboratory;
- c. EHS will determine whether the area needs to be decontaminated by a qualified contractor or simply cleaned by custodial services. Custodial Service personnel are not trained or equipped to clean areas that are contaminated with chemical, biological and radiological residues; therefore, they cannot clean contaminated areas;
- d. If it is determined that the area needs to be decontaminated by a qualified contractor, then EHS will coordinate with the department to arrange for a qualified contractor to schedule and perform the cleaning, if needed;
- e. EHS will confirm that the contractor adequately cleaned the laboratory and will provide written confirmation to the requesting Department contact;
- f. Laboratories may not be renovated or reoccupied until the EHS has confirmed that the area is adequately cleaned; and
- g. All costs associated with the cleaning of a laboratory will be charged back to the requesting Department if it is necessary to hire a qualified contractor.

It is important that researchers properly decontaminate their laboratory equipment from hazardous materials (flammable, corrosive, reactive, toxic, radioactive, biological) prior to allowing sending the equipment off for repair or service. It is important to check every piece of laboratory equipment that once held hazardous samples to insure that any remaining samples or standards have been removed. If any laboratory equipment has appreciable chemical, radiological or biological contamination on the outside surface, which would present a hazard to anyone handling it, the equipment, needs to be properly decontaminated by the researchers. Instruments, equipment or work areas must be certified as being free from potentially hazardous contamination prior to maintenance or repair by untrained, unprotected personnel or appropriate safeguards must be established and communicated to those involved with the operation. The means to protect personnel must be included on a decontamination certification form when decontamination is not reasonably possible.

A decontamination form a must be included with all surplus containers and equipment whenever hazardous material contamination was a factor.

In general, the following must occur prior to service or repair:



- a. The item/area to be serviced must be cleaned of all visible residue and encrusted material whenever reasonably possible. The decontamination must be completed by a train laboratory worker.
- b. Where there is the potential for hazardous non-visible chemical contamination, it may be necessary to use pH test strips, peroxide test strips or other indicating mechanism to verify that no contamination is present.
- c. For items used with radioactive materials, no radioactivity must be detected with survey equipment or swipe tests. Contact the UC Boulder Radiation Safety Officer.
- d. Where infectious materials were used, disinfect all surfaces with an effective disinfectant.
- e. Remove or deface all hazard warning labels or signs once hazards have been successfully removed by decontamination. Remove gross contamination and maintain appropriate hazard warnings when decontamination is not reasonably possible. The word "residue" may be added to indicate that only residue remains.
- f. A Decontamination Statement (Appendix G) must be completed and attached to the item/area. If service is requested and initiated on an item/area and it appears that decontamination or other measures are not adequate to protect involved persons, the requestor will be contacted to rectify the remaining hazard(s). Costs associated with decontamination or other protective action will be the responsibility of the requestor.
- g. Adequate protection may be provided by decontaminating only the part of an item needing service or by packaging items so that persons handling the equipment will not come into contact with contamination.
- h. Items that have been in contact with hazardous chemicals, radioactive substances or infectious materials and are intended for sale as surplus property must be decontaminated and a Decontamination Statement form must be attached to the item(s).
- i. Items that cannot be decontaminated should not be sold as surplus property.
- j. Exception: Items of high surplus value that cannot be decontaminated may be sold under certain conditions. An example of such an item would be the sale of laboratory equipment to another laboratory.

Certain equipment and systems require other special precautions prior to sending out for service and repair. The following must be accounted for. This is not an exclusive list.

If you intend to discard your refrigerator or freezer, the Freon must be properly recycled from the coils by Facilities personnel prior to the unit being disposed. Remove all contents, to include mercury thermometers, chemical reagents, radioactive isotopes. Decontaminate the refrigerator if it held radioactive isotopes, infectious agents or toxic chemicals. Contact the Radiation Safety Officer for guidance for surveying refrigerators which stored radioactive isotopes. The refrigerator must be completely empty prior to being handled by Campus Movers or Facilities. Defrost the refrigerator/freezer if there is a buildup of ice around the freezer compartment.

- a. Ovens - Remove all mercury thermometers or containers holding samples or liquids. For outdated ovens, check the lining for the presence of asbestos (inhalation hazard). If the oven lining appears to be constructed of asbestos, contact EHS (x3212) for assistance.
- b. Incubators - Remove any remaining samples and drain the water from the jacket. Remove mercury thermometers.
- c. Centrifuges - Inspect for centrifuge tubes holding water or samples to insure they have been removed from the rotor system.
- d. Water baths - Drain the water from the unit and remove any remaining samples or mercury thermometers.
- e. Balances or scales - Wipe clean to remove any remaining chemical contamination inside the balance or on the scale.



- f. Chemical storage cabinets such as flammable or corrosive cabinets must have all the chemical containers removed prior to moving the cabinet. Decontaminate the chemical storage cabinet of any remaining spills or residues.
- g. Vacuum pumps contain vacuum pump oil. Vacuum oil, which is grossly contaminated with toxic chemicals or other hazardous materials, should be removed prior to repair. Discard all spent vacuum pump oil through EHS as chemical waste.
- h. Heating blocks need to have samples and mercury thermometers removed. If necessary, decontaminate the heating block. Set all mercury thermometers aside for management as chemical waste. Do not use mercury thermometers with heating blocks, as it is an unnecessary inhalation hazard (use alcohol thermometer).
- i. Mercury containing sphygmomanometers & blood pressure cuffs may contain metallic mercury, which is an inhalation hazard when spilled. Seal the units inside clear plastic bags and set them aside for management through the chemical waste program.
- j. Mercury barometers contain metallic mercury which is an inhalation hazard when spilled. Completely drain the metallic mercury from the barometer into sealed plastic bottles. Set aside empty barometer and plastic bottles holding metallic mercury for management through the chemical waste program.
- k. Photo-processing equipment usually has three storage tanks holding caustic developer, acidic photographic fixer and rinse water. Drain the storage tanks (also supply and drain hoses). Discard the photo-processing chemicals through EHS as chemical waste.
- l. Silver recovery cartridges, which are connected to photo-processing units, contain slightly acidic photographic fixer and silver salts. Have the silver recovery cartridge recycled through your supplier.
- m. Gas chromatographs (GC) which have electron capture detectors contain a radioactive source. Contact the Radiation Safety Officer.
- n. High Performance Liquid Chromatography (HPLC) may have columns that contain organic solvents. Drain the columns and waste lines prior to shipping the HPLC. Dispose the organic solvent wastes through EHS.
- o. Tissue dehydrating units - Remove or drain all the ethanol and xylene from the storage tanks. Dispose the solvents through EHS as chemical waste. Paraffin wax and tissue samples may also need to be removed from the tissue dehydrating unit.
- p. Colorimeters may contain cuvettes holding liquids (remove them).
- q. Spectrophotometers may have automatic sample feeders holding sample containers or standards (remove them).
- r. Desiccators may contain drying agents (Drierite, NaOH, phosphorus pentoxide). Discard the spent drying agents through EHS as chemical waste.
- s. Transformers or high voltage regulators may contain oil. Outdated transformers may hold toxic PCB contaminated oil. Contact EHS whenever oil containing transformers or high voltage regulators are discovered. Do not ship oil containing transformers or high voltage regulators without approval from EHS.
- t. Water purification systems - Remove all the free standing water from the water purification cartridges.
- u. pH electrodes & other chemical electrode systems may contain water and possibly other hazardous chemicals. Set aside electrodes containing liquids for management through the chemical waste program.

12.1.1 Recommended Decontamination Solutions

- a. For biological and infectious material contamination use a fresh 10% bleach solution in water. Other commercially available disinfectants may be used provided the manufacturer

- b. Use clean water to decontaminate equipment contaminated with low-chain compounds, salts, organic acids and other polar compounds. Follow up with a secondary decontamination using a dilute basic solution of a detergent or soap.
- c. Use a dilute basic solution of a detergent or soap to decontaminate equipment and areas contaminated with acidic compounds, phenol, thiols and nitro and sulfonic compounds.
- d. Use an organic solvent such as ethanol or acetone to decontaminate equipment and areas contaminated with non-polar compounds such as organic chemicals. Follow up with a secondary decontamination using a dilute basic solution of a detergent or soap.

All applicable personal protective equipment must be worn during the decontamination and servicing of the equipment. A job hazard analysis should be completed to help determine the type of PPE required.

All waste materials, decontamination solutions and other discard products or materials must be handled through the appropriate waste disposal program.

Engineering controls, such as fume hoods and elephant trunks should be used when decontaminating and servicing all laboratory equipment

13 Resources – Available at the Websites Listed

Occupational Safety and Health Administration References

- Laboratory Standard - 29 CFR 1910.1450 –
http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=10106
- National Research Council Recommendations Concerning Chemical Hygiene in Laboratories (Non-Mandatory) – 29 CFR 1910.1450 App A –
http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=10107
- References (Non-Mandatory) – 29 CFR 1910.1450 App B –
http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=10108
- OSHA Permissible Exposure Limits (PEL) – 29 CFR 1910.1450 subpart Z –
http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=10147
- Limits for Air Contaminants – 29 CFR 1910.1000 –
http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=9991
- TABLE Z-2 – 29 CFR 1910.1000 TABLE Z-2 –
http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=9993
- TABLE Z-3 Mineral Dusts – 29 CFR 1910.1000 TABLE Z-3 –
http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=9994

List of Substances Known to be Human Carcinogens, Reasonably Anticipated to be Human Carcinogens and Highly Toxic Substances

- National Toxicology Program (NTP)(latest edition) –
<http://ntp.niehs.nih.gov/index.cfm?objectid=72016262-BDB7-CEBA->

[FA60E922B18C2540](#)

- International Agency for research on Cancer Monographs (IARC) (latest editions) – <http://monographs.iarc.fr/ENG/Classification/index.php>

ACGIH Guide to Occupational Exposure Values – Request from the Department of

Environmental Health & Safety or order online at <http://acgih.org/store/>

Prudent Practices in the Laboratory – <http://www.nap.edu/readingroom/books/prudent/>