Environmental Health and Safety
UNIVERSITY OF COLORADO
COLORADO SPRINGS

Lab Safety Manual

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Appendix:

1 Introduction

The purpose of the ***Lab Safety Program (LSP)*** 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 regulations in 29 CFR 1910.1450 "Occupational Exposure to Hazardous Chemicals in Laboratories".

This Lab Safety Manual (LSM) is only one portion of the LSP. The LSP also requires compliance with the following:

- Waste Management Plan
- Personal Protective Equipment
- Physical Safety Requirements
- Biosafety Requirements
- Fire Protection
- Training
- Emergency Response
- Export Controls

Detailed descriptions of all of these program elements can be found on the EHS website https://ehs.uccs.edu/.

1.1 Scope

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, biologicals or other physical hazards are utilized as a normal part of operations." There is no requirement for significant chemicals to be present 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 a list of areas subject to the LSM:

- Chemistry academic and research labs
- Biology academic and research labs
- Physics academic and research labs where chemical/biological/physical hazards are present

- Engineering academic and research labs where chemical/biological/physical hazards are present
- Nursing/Health Sciences academic and research labs where chemical/biological/physical hazards are present
- Biofrontiers Labs
- Photography Lab
- Art studios where chemical/physical hazards are present
- Social science labs where chemical/biological hazards may be present

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

There are areas that may contain significant chemicals, biologicals or other physical hazards which are not subject to this requirement. These other areas are subject to the Hazardous Materials Management Plan, Waste Management Plan and Personal Protective Equipment guidelines. These areas are:

- Facility support areas (mechanical rooms, custodial, etc.)
- Pool Operations
- Athletic Training Facilities
- Dining and Hospitality
- Healthcare Clinical Operations
- Visual and Performing Arts, not specifically listed, and
- Farm House Operations

This plan discusses safe practices and procedures for research and educational laboratories. 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 or work center 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 EHS office.

2 Duties and Responsibilities

An essential component of any ***Laboratory Safety Program*** (LSP) is to clearly articulate and clarify the different roles and responsibilities of all the stakeholders. Clarifying roles and responsibilities for implementing the LSP will establish accountability, streamline processes, enhance safety and avoid confusion and questions in meeting the LSP'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 of hazardous materials. 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, retirements 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 LSP.
- Participate in the campus Safety 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 Lab 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.
- 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.
- 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 C* PI Responsibilities.
- Familiarize yourself with the document *Appendix D* Setting Up a Lab

2.4 Employees and Students

- Follow all safety and health procedures specified in the UCCS LSM and the Lab 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.

2.5 Environmental Health & Safety (EHS)

- Review evaluate and revise (if necessary) initially, and annually thereafter the UCCS LSM;
- Submit the LSM to the Safety Management Team for review and adoption.
- Review and approve those procedures and/or hazardous chemicals specified in the LSM 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 provide 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 LSP and training;
- Provide advice and clarification in regard to the LSP;
- Conduct periodic unscheduled and planned inspections of University facilities to ensure compliance with the LSP.
- 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 materials.

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, biologicals 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 LSP. 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 Material - 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 contact information, develop and maintain laboratory hazardous materials inventories, and establish laboratory safety inspections for ensuring compliance with the UCCS LSP 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 Hazardous Material 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 Lab Specific Safety Plan

In addition to being subject to the guidelines found in this LSP, all non-academic laboratories may be required to develop a Lab 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 https://ehs.uccs.edu/). 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 https://ehs.uccs.edu/).

5.1 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. 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 (*Appendix E*).

6 Identify and Assess Hazards

Supervisors (i.e. lab coordinators, principal investigators, etc.) should 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. A hazard assessment guide can be found in *Appendix F.* 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 the hazards. 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 Hazardous Materials Awareness

UCCS has developed a Hazardous Materials Management Plan (HMMP). Compliance with the HMMP is expected for all laboratory operations. The HMMP addresses the following:

- Glossary of Hazardous Materials Terms

- Classification of Hazardous Materials Hazards
- Toxicity and Hazard Exposure
- Handling and Storage of Hazardous Materials
- Biosafety Management Plan
- Hazardous Materials Requiring Prior Approval

The HMMP also addresses topics such as:
- Labeling requirements
- Safety Data Sheets
- Hazardous Materials Inventory
- Storage requirements including limits
- Handling requirements
- Hazardous material procurement
- Shipping and receiving hazardous materials

8 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.

A separate Biosafety Management Manual (see Attachment E to the HMMP) has been developed to address bloodborne, biological and animal safety requirements.

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.

9 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 available on the CU-Boulder website provides details on the program as implemented.

If you are utilizing radioactive material and/or radiation generating equipment, this needs to be coordinated with both UCCS EHS and CU-Boulder Radiation Safety group.

10 Physical and Equipment Hazards

UCCS laboratories may contain several physical or equipment related hazards. Each Principal Investigator should identify the types of physical or equipment related 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.

10.1 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.

10.1.1 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).

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 EHS 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.

10.2 **Aerosol Production**

Another potential hazard from operating equipment is 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.

10.3 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.

10.4 **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.

10.5 **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.

Reduced Pressure Operations

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 vapors 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 vapor being removed is highly odorous or toxic unless a suitable cold trap is available to capture them. Alternative enclosed systems are recommended.

10.6 **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 generating aerosols, 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.

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. Visually inspect the rotor for mechanical or chemical damage prior to each use. Inspect the underside of the rotor, the web area of the rotor and the outer rim. Insure the top and bottom pieces of the rotor are tightly connected.
e. Certain chemicals (e.g., phenol) attack plastic rotors and some nucleic acid extraction kits can damage the rotor. Chemical damage often appears as discoloration, crazing, granulation, peeling or similar deterioration of the rotor finish.
f. Mechanical damage such as cracks, scratches, or gouges can often be seen or detected as an increase in noise or vibration during a spin. Do not ignore excessive vibration that does not resolve after rebalancing and checking the fit of the rotor cover. Do not use the rotor if any damage or change is evident.
g. Always use the rotor cover. Use an aerosol seal for containment of pathogenic materials. If you see scoring around the circumference of the top of the plastic rotor cover, replace the rotor, since this may indicate rotor deformation
h. Check the expiration date of both the rotor and centrifuge. Always follow the manufacturer's retirement date for rotors and other centrifuge parts.
i. Do not exceed manufacturer recommendations for safe operating speeds.
j. Keep a record of rotor usage and follow the manufacturer's recommendations on when to replace the rotor.
k. For centrifuges that have been refrigerated, wipe away any excess moisture and allow the open unit to dry.
l. Filter the air exhausted from the vacuum lines.

10.7 **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.

10.8 **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. Except for 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 enough 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 near 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 manufacturer’s 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. 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.
b. 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.
c. Consider using Bunsen burner equipment with a pilot light and a button that activates gas flow.
d. A Bunsen flame may be difficult to see in bright sunlight. Blinds should be drawn to shade the flame.
e. 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.

f. Proper protective equipment must be worn i.e. laboratory coat, safety glasses and gloves. Use tongs to handle hot materials.
g. Assure that reaction flasks and beakers are firmly held in place with a ring stand or other means.
h. Assure that the fire extinguisher is in close proximity and ready for use. Attend Fire Extinguisher Training provided by EHS or review Fire Extinguisher Operations on the EHS website.

Bunsen burner safety guidelines:

a. Place the Bunsen burner away from any overhead shelving, equipment or light fixtures.
b. Remove all papers, notebooks, combustible materials and excess chemicals from the area.
c. Tie-back any long hair, dangling jewelry, or loose clothing.
d. 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.
e. Replace all hoses found to have a defect before using.
f. Notify others in the laboratory that the burner will be in use.
g. Utilize a sparker / lighter with extended nozzle to ignite the Bunsen burner. Never use a match to ignite burner.
h. Have the sparker / lighter available before turning on gas.
i. Adjust the flame by turning the collar to regulate air flow and produce an appropriate flame for the experiment (typically a medium blue flame).
j. Do not leave open flames unattended and never leave laboratory while burner is on.
k. Shut-off gas when its use is complete.
l. 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.

10.9 **Refrigerators/Freezers**

Using a household refrigerator to store laboratory chemicals is extremely hazardous for several reasons. Many flammables 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.

10.10 **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 and an operator must be present). 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.

10.11 **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:

a. 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.
b. 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.
c. Know how to properly operate equipment. This may require documented, specific training. Also, the user must be familiar with applicable safeguards and maintenance requirements.
d. Inspect equipment for damage and for required safety features prior to use.
e. Ensure that equipment meets the following requirements:
    i. Controls and safeguards are adequate and functional (e.g., interlocks that shut-off equipment automatically and guards that protect moving parts and belts).
    ii. The location is safe (and well-ventilated, if necessary).
    iii. 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.*

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

10.12 **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.

Refer to UCCS Lock-Out/Tag-Out Program for specifics

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10.13 **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 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).

10.14 **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.

10.15 **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.

a. 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.
b. 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.
c. 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.
d. Permits will be picked up from the EHS Office in the Academic Office Building Suite 106 or may be dropped at your location

e. The permit should be displayed on site during the work, completed and returned to EHS when the hot work is complete.
f. Permits contain a checklist to be completed prior to commencing hot work activities and at the conclusion of the hot work.
g. 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.
h. Unless we are under a fire restriction or ban, hot work permits are not required for work performed outside of buildings.
i. 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
j. Please return the completed hot work permit to Public Safety for their recordkeeping

10.16 **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.

10.17 **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 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. 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.
    i. Side guards should cover the spindle, nut, flange, and seventy-five percent of the wheel diameter.
    ii. Adjust the tongue guard on the top side of the grinder to within 1/4-inch (0.6350cm) of the wheel.
    iii. 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.
    I. The clearance between the wheel side and the guard shall not exceed one-sixteenth inch.
    II. 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.
    III. 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 always be enclosed
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.

10.18 **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. Act 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 enough 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.

11 Mitigating Hazards in the Laboratory

11.1 General Laboratory Safety Practices

For the general safety of laboratory personnel, all chemical usage must be conducted in adherence with the general safe laboratory practices below. The methods used to specifically control chemical exposures are categorized as follows: Engineering Controls, Administrative Controls, and Personal Protective Equipment.

11.2 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)

Performance Verification of Engineering Controls and Safety Equipment To assure that primary engineering controls and safety equipment provide proper and adequate performance, the University provides performance verification checks on a routine basis as identified in various standards:

- Fume hoods – ANSI/AIHAZ 9.,5 – 1992
- Eyewash – ANSI Z358.1-1990
- Safety Shower – ANSI Z358.1–1990

11.3 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 section discusses different types of laboratory ventilation. In general, laboratory fume hoods are recommended whenever using hazardous chemicals that:

- Have a high degree of acute toxicity, are carcinogens, or are reproductive toxins, except where there is very low risk of exposure (e.g., use of minimal quantities in a closed system).
- Have a permissible exposure limit of less than 50 ppm (or 0.25 mg/m^3 for particulate matter).
- Are appreciably volatile (e.g., solvents) or are easily dispersible in air (e.g., dust).

11.3.1 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 except under special conditions.

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-born 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 6 inches 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:

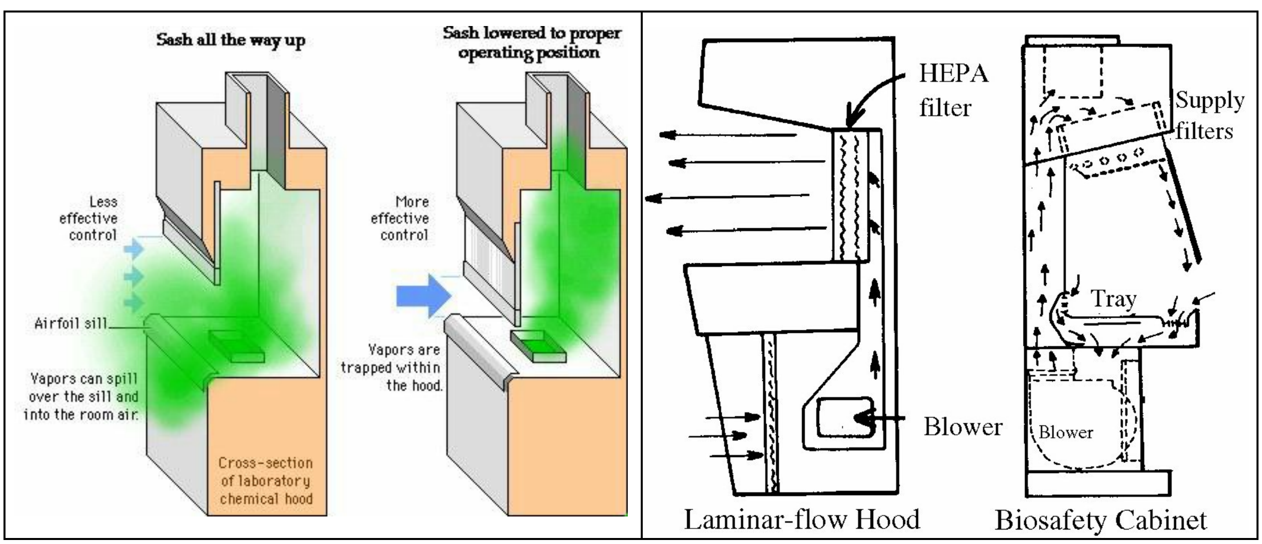
a. Note pressure gauge reading, if one is provided.
b. Shut off experiments, turn off heat, relieve system pressure.
c. Seal containers; remove compressed gas cylinders from the hood.
d. Ensure no other lab equipment is vented into the hood.
e. Place ―Do Not Use; Hood Out of Order‖ sign on the fume hood.
f. Where radioisotopes are used, contact the Radiation Officer.
g. Call Trouble Calls 719-255-3313
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 EHS. Appendix G is a form which can be used to document fume hood function,



11.3.2 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 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 can 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.

11.4 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
t. Isolating or enclosing an experiment within a closed system (e.g., glove box, sealed chamber).
u. Micro-scaling the size of the experiment to reduce the amount of chemical usage.
v. Scale up reactions in small steps and evaluate safety issues after each step to fully understand the reactive properties of the reactants and solvents, which may not have been evident at a smaller scale.

11.4.1 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.

11.4.2 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

11.4.3 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
    - always has adult supervision; 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
    - always has adult supervision; 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

11.4.4 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:

a. Faculty Members or Principal Investigators must notify and receive documented approval from the Chair of the Department or Director of the Program.

b. The volunteer worker must attend all applicable safety training sessions prior to commencing to working in the laboratory
c. The volunteer worker is under the supervision of a faculty member in the laboratory or area where the work will occur.
d. 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.
e. 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.
f. The volunteer must follow all Departmental and University safety procedures and policies.
g. 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
h. Refer to Use of Volunteers Guidelines for any additional guidance https://www.cu.edu/risk/services/volunteer-trainee-and-minor-participants

11.5 Personal Protective Equipment

In addition to both engineering and administrative controls, personal protective equipment (PPE) may be necessary to ensure an adequate margin of safety in case of incidental/accidental chemical release or contact.

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 encountering other individuals or before going in or near elevators, break rooms, classrooms, bathrooms, etc.

UCCS has developed a tiered matrix for the identification of required PPE. To determine the required PPE, you should:

- Identify the task(s) you will be performing
- Determine the space you will be performing these tasks in
- Review the task specific PPE matrix to see if your task is listed – if so then this is the required PPE for this task
- If your task is not listed, then review the minimum required PPE based upon the space in which you are performing the work

Specific requirements related to PPE are detailed on the UCCS PPE web page.

11.6 Additional Provisions for Work Involving Particularly Hazardous Substances

Additional provisions for laboratory work with Particularly Hazardous Substances include:

1. Establishment of a designated area.
2. Use of containment devices such as fume hoods or glove boxes.
3. Procedures for safe removal of contaminated waste.
4. Decontamination procedures.

These provisions are further described in the Hazardous Materials Management Plan under Carcinogens, Highly Toxic Chemicals, and Reproductive Hazards.

12 Inspections

It is the aim of the Safety 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.

12.1 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 H*.

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.

12.2 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.

12.3 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

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. Refer to the UCCS EHS Training web page to identify the types of training that may apply to a particular employee/ volunteer/ student.

13.1 Work Area Specific Training

In addition to the generic training provided through EHS, 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. EHS maintains records on the training it provides. Each supervisor (PI-lab manager, etc.) is responsible for documentation of work area specific training. This documentation should include the date of training, specific topics covered, the name of the person providing the training, and the signature of the trainee. *Appendices I-M* provide examples of various tools which can be utilized to both determine the required training for an individual as well as the ways to document them.

13.2 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.

14 Emergency Response

UCCS has developed a Hazardous Materials Management Plan (HMMP). Compliance with the HMMP is expected for all laboratory operations. Emergency Response is addressed in the HMMP:

- Fire Safety Procedures
- Ventilation Failure/Power Failure
- Gas Leaks and Unknow Odors
- Spill Clean-up Procedures
- Safety Showers and Eye Wash Stations
- Injury, Illness, personal contamination, minor first aid
- Work area floods
- Accident and Near Miss Reporting

15 SAFE EXPERIMENT DESIGN

A comprehensive experimental design process is an essential step in running safe laboratory operations. 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!

In many instances, a Standard Operating Procedure (SOP) may suffice to cover the Safe experiment design. Development of SOPs will be presented later in this section.

15.1 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.

15.2 **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.

15.3 Standard Operating Procedures

A standard operating procedure (SOP) is a set of written instructions that describes in detail how to perform a process or experiment safely and effectively. SOPs may be utilized in laboratory and non-laboratory operations.

Examples of SOP topics:
Lab Areas:
- The specific use of a chemical or class of chemicals (such as a specific laboratory procedure).

- The generic use specific chemical or class of chemicals with similar hazards (for example, mineral acids).
- A generic procedure (such as distillation) that covers several chemicals.
- Radionuclide use in DNA and RNA labeling.
- Laser operations.
- X-ray diffraction machine operation.
- Use and maintenance of laboratory equipment or instruments.
- Non-lab Areas:
- Specific work practices (such as lifting techniques) to mitigate physical/health hazards.
- Specific tasks that are unique to work performed at Stanford University.

Responsibility in Laboratories
The PI/Lab Supervisor is responsible for providing written Standard Operating Procedures (SOPs) relevant to health and safety for laboratory activities he/she directs involving hazardous materials or processes. Laboratory personnel working autonomously or performing independent research are responsible for developing SOPs appropriate for their own work using the guidance below.

Prioritizing SOP Development for Laboratories
Priority for SOP development should be given to any operation involving certain higher risk chemicals, such as Particularly Hazardous Substances and highly reactive chemicals, and specified higher risk research procedures described in the LSM.
It may be appropriate to develop a General Use SOP for certain hazardous materials or processes within a lab. *Appendix N* provides a template and guidance on development of SOPs. EHS has developed some SOPs for select groups of hazardous materials which can be found on the EHS website.

15.4 **Activities Requiring Prior Approval**

The Hazardous Materials Management Plan goes into detail about hazardous materials or operations which require prior approval before use or implementation.

15.5 **Restricted Use/Designated Areas**

15.5.1 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

15.5.2 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.

15.5.3 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

the 100-011 signature matrix: 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 can 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.

16 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 O) 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 ensure 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 (*Appendix P*) 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 P*) 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.

16.1 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

17 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) – https://ntp.niehs.nih.gov/whatwestudy/assessments/cancer/roc/index.html
- 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/