University of Colorado - Environmental Health and Safety Guideline

LABORATORY SAFETY

see also: *EH&S Generator's Guide to Hazardous Material / Waste*

Contents:

Work in the University's many laboratories involves a broad spectrum of equipment and materials that may represent chemical, physical and biological hazards to workers and others in the laboratory. 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 Chemical Hygiene Safety Plan which should be prepared by every laboratory. EH&S is responsible for auditing labs for compliance with standards and regulations.

I. RESPONSIBILITY FOR LABORATORY SAFETY

A. Departmental Responsibility

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

Assure that renovations and designs for new laboratory facilities incorporate required safety features.

Allocate the personnel and financial resources to facilitate a safe working environment, safe working practices and safe handling and disposal of hazardous materials and waste.

Areas where hazardous or radioactive materials are used or stored must be thoroughly decontaminated using EH&S approved methods prior to maintenance, renovation, reallocation of space, or closure. It is the responsibility of the supervisor, principal investigator and their department to arrange proper disposal of all hazardous materials prior to personnel relocations or facility closure.

Delegate responsibility for safety to lab supervisors, principal investigators and staff personnel (such as a safety liaison or proctor) in a clear and unambiguous manner, and hold them accountable for those areas to which their responsibility pertains.

B. Duties and Responsibilities of Principal Investigators and Safety Liaisons or Lab Proctors

Monitor operations for safety, advising laboratory supervisors on safety matters, and serve as a focus for safety concerns of the laboratory staff.

Encourage the development and maintenance of a Chemical Hygiene Safety Plan. This plan should include personnel training, standard operating procedures, maintaining Material Safety Data Sheets (MSDS), emergency action plans, medical evaluations and record keeping.

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.

Investigate accidents and report them to the appropriate supervisors, EH&S and Risk Management.

Conduct internal safety audits and recommend improvements.

Monitor storage, labeling and use of hazardous chemicals.

Ensure that the lab is in compliance with hazardous waste regulations and that employees receive formal, annual training.

Maintain safety related files, accident reports, safety equipment, and MSDS.

Maintain a complete written current inventory of all chemicals, gases, biological, radioactive and other hazardous materials in their areas.

II. LABORATORY CHEMICAL SAFETY PLAN (LCSP)

Laboratories are encouraged to complete this fill-in-the-blank template, using it as a self audit to help ensure that personnel are proactively addressing concerns about chemical hazards and potential health exposures. The LCSP covers issues similar to those found in an OSHA Chemical Hygiene Plan. It does not need to be sent to EH&S, rather it is intended to assist labs in identifying weaknesses in their chemical preparedness. Please contact EH&S at 303-492-6025 if you have any questions, concerns, or need guidance relating to the information discussed in this Plan.

DEPT / BUILDING_____ ROOM #s_____

PRINCIPAL INVESTIGATOR (PI)_____ PI PHONE #_____

PERSON COMPLETING PLAN_____

DATE OF LAST PLAN REVISION_____

A. EXPERIMENT PLANNING, SOPs

No one in our lab conducts experiments without first obtaining approval from _____.

Chemical experiments are thoroughly researched before they are applied.

The resources we use for planning experiments and bench-top operations include_____ _____

and can be found at_____.

_____ is/are responsible for preparing standard operating procedures (SOPs) for experiments and other laboratory activities performed in our area.

B. TRAINING

_____ is responsible for making sure that our personnel have received specific lab safety instruction for the activities they are involved with.

_____ is responsible for assuring that all lab staff have obtained formal hazardous waste/material training and that the training is documented by EH&S.

Training records are kept _____.

C. CHEMICAL INVENTORY, STORAGE, LABELING

_____ is/are responsible for keeping our chemical inventory completed, up to date, and available to EH&S.

_____ make(s) sure that our chemical reagents are segregated by compatibility/reactivity, that hazardous liquids are stored in secondary containment, and that all chemicals and solutions are properly labeled.

D. HAZARDOUS WASTE

_____ is responsible for making sure that hazardous waste is properly collected and managed, that the SAA inspection log is checked weekly, and that old, unwanted or expired chemicals are promptly submitted for EH&S pick-up.

E. CHEMICAL HAZARD INFORMATION

Hard copies of Material Safety Data Sheets (MSDS) and other chemical hazard information are located _____.

Additional chemical hazard resources and MSDS can be internet accessed using the computer/printer located in_____.

Useful web links include:
_____
_____.

F. VENTILATION

We have _____ chemical fume hood(s), located _____
_____.

All hazardous chemicals are used inside the hood(s).

If not sure whether or not a particular chemical must be used in a hood rather than on the bench-top, we ask _____ or look up toxicity and other information in _____.

We know our hoods are working properly because _____
_____.

If we have any hood maintenance or operational questions we contact _____ at _____.

G. PERSONAL PROTECTIVE EQUIPMENT (PPE)

Gloves, goggles, aprons, lab coats, face shields and other PPE are obtained from _____.

We can find out which PPE is suitable for different chemicals by asking _____ _____ or by looking up information in _____.

If we have work related health questions or concerns we contact _____ at _____.

H. EMERGENCY PREPAREDNESS

We have ____ emergency eyewashes and ____ emergency showers located _____ _____.

_____ is responsible for flushing the eyewashes each week.

Emergency contingency plans are posted at _____.

We have ____ telephones, located _____.

Emergency spill equipment (including _____

_____) is kept _____

_____.

The nearest fire alarm pull station is located_____.

We have ____ fire extinguishers (type _____), located _____

_____.

If someone has an accidental exposure to a hazardous chemical, they flush with water for _____ minutes while somebody either calls 911 or prepares (gets MSDS and calls ahead) to

bring them to_____, located at

_____.

III. GENERAL LABORATORY DESIGN AND OPERATION

University laboratories should minimize both the health consequences of inappropriate work practices and the effects of accidents in the laboratory. Labs should also be designed as self-contained units to prevent materials and activities within them from affecting other areas of a building under normal or emergency conditions.

Activities that should be prevented in labs include non-related writing, reading, and studying, social activities and relaxation, meals and coffee breaks. The separation of these non-lab activities from lab work has not always been the practice at the University, nor at most research institutions. However, it should become the rule at this University.

Laboratories can be relatively high-risk environments for occupants even during times when there is no active experimentation underway. This risk is significantly greater than in an office. The level of risk is based on the type and quantities of materials stored in the labs, the degree of danger inherent in the lab's facilities and equipment, and the consequences of likely accidents caused by the inattentions of the occupants with materials and equipment.

A. Managing Safety in the Laboratory

Controlling the behavior of students in the laboratory can present special problems. Although many students behave responsibly, some may engage in horseplay or become careless, impatient, or forgetful. Such tendencies may lead to safety problems. It is important that individual instructors, who bear the major responsibility for daily operations in their laboratories, vigorously enforce safety rules. In addition to specific rules for a given laboratory or experiment, a set of general rules for student behavior should be enforced.

B. Precautions for all Laboratory Work

Proper engineering controls including fume hoods, chemical storage cabinets and ventilation systems are critical for ensuring a safe work environment.

Appropriate clothing should be worn by all persons entering the lab, including guests. Cotton is preferable to synthetics. The use of lab coats or aprons should be required. Shorts or other clothing that leaves significant areas of skin exposed should not be allowed. Substantial footwear should also be required (no bare feet, open-toed shoes or sandals). Coats, jackets, etc. should be hung in designated areas. Backpacks and briefcases should be kept out of lab work areas.

Loose hair should be restrained. Jewelry that fits tight to the skin (rings, bracelets) should be removed. Dangling jewelry is also a hazard and should be removed.

Horseplay is not allowed in the lab. This includes the loud playing of radios and tape recorders, and the use of earphones, which may interfere with communication.

No smoking or preparation, storage or consumption of food and drink is permitted in the lab.

Individuals should not work alone, especially after normal hours. Children and pets should not be allowed in the laboratory.

Unauthorized experiments will not be allowed. All laboratory work must be approved by the principal investigator, supervisor, or instructor. Follow predetermined procedures; deviations have caused serious accidents.

As a minimum, splash goggles must be worn when working with chemicals. This should apply to all researchers, students, instructors, and visitors.

Laboratory glassware should never be used as containers for food or drink. Chipped or broken glassware should never be used without fire polishing.

Know what other work is being performed in your laboratory and become aware of the potential hazards. Be inquisitive about hazards. Understanding the hazards of each substance and knowing the severity of the hazard. Supervisors and Material Safety Data Sheets (MSDS) are good starting points for this information.

All pressurized vessels and gas tanks should be adequate for the working pressure to be used. Secure all pressurized gas cylinders properly with a strap or chain.

Keep aisles and exits clear. Eliminate trip hazards. Bicycles should not be allowed in campus laboratories or buildings. Keep the work area cleared of unnecessary equipment, supplies, etc. Keep apparatus away from the front edge of the workbench. Apparatus should be set up so that control valves and switches for water, gas, and electricity are accessible and that it is not necessary to reach through the apparatus to access them.

Evacuation of a vacuum desiccator should only be done when it is protected by a Desi-guard. Dewar flasks should be properly wrapped with either vinyl electrician tape or friction tape to prevent injury from implosion.

Know routes of escape in case of fire or other emergencies. Know the locations and types of available fire extinguishers. Know the location of the nearest available telephone and emergency number. This information should be posted as part of your emergency action plan.

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Never pipette by mouth.

Properly label all chemical containers. Never use chemicals from an unlabeled container. Provide secondary spill containment for all hazardous liquid chemicals.

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Follow predetermined procedures - deviations have caused serious accidents.

Use safety cans and approved chemical cabinets for storage of flammable and volatile liquids.

Establish Hazardous Waste Satellite Accumulation areas (SAAs) and label receptacles for waste collection before beginning work. Properly dispose of waste. NO HAZARDOUS CHEMICALS DOWN THE DRAIN.

Supervisors must be continually on the alert for infractions of the rules. Individuals may be careless or willfully disregard safety rules in the interest of speed or convenience, and such violations should be dealt with immediately. Supervisors and administrators should bear in mind that they may be legally responsible for accidents or injuries in laboratories under their control

C. Eye Protection for Lab Areas

State law requires that every student, instructor, and visitor in a chemistry lab where experiments or demonstrations are being performed wear industrial quality eye protection devices. Approved eye protection for people handling chemicals must prevent both chemical splashes and flying particles (e.g., from broken glass) from entering the eye. The minimum eye protection device that meets these requirements is goggles with hooded or indirectly ventilated ports. A face shield may be worn over goggles to further protect the face and neck areas.

If a chemical is splashed in the eyes, they must be washed for a minimum for fifteen (15) minutes with running water. Safety showers and eyewashes should be located within 75 feet of chemical hazards (20 feet if strong acids or bases are used). Eyewashes should be activated at least weekly by laboratory personnel to flush contaminants and verify proper operation. Any chemicals splashed on the skin should be rinsed off with plenty of fresh water. Escort the victim to the Wardenburg Student Health Center after flushing the victim's eyes or skin, or call 911 for medical assistance. Bring an MSDS with you.

D. Chemical Releases

Hazardous material releases can be minimized by implementing proper controls such as: appropriate storage, secondary containment, safety cans, ventilated cabinets, carrying devices, etc.

If an accident involving hazardous materials occurs which you know poses no immediate health concerns or danger of personal injury, try to keep the contaminant from spreading

into the environment or entering drains by containing it with absorbent material. If the potential for personal danger does exist, secure and leave the area immediately, evacuate others from the dangerous area and notify the CU Police Department by calling 911. Under no circumstances should a person reenter the area where a hazardous spill has occurred, where the possibility of personal danger exists.

E. Glassware Handling

Laboratory glassware is fragile and should be handled properly to avoid injury. Always wear eye protection. When breaking tubing or inserting or removing tubing from stoppers, hands should be protected with towels or gloves. When inserting tubing into a stopper, be sure to choose a stopper with the appropriate hole size. The tubing and holes should be lubricated with water or glycerin to ease insertion. While holding the stopper between the thumb and forefinger grasp the tubing close to point of insertion, apply force and slowly twist the tubing into the stopper. To remove tubing from a stopper, especially if the two have been in contact for some time, insert the small end of a spatula into the hole parallel with the tubing. As an opening is generated, add water for lubrication. Avoid exerting pressure on the glass. If you are experiencing difficulty, seek the help of the instructor or supervisor.

Any apparatus that can roll, such as thermometers, should be placed in appropriate holders. Do not use thermometers as a stirring tool. If a thermometer breaks, report it to your instructor immediately. A mercury spill requires special clean-up procedures. Mercury thermometers and manometers should be used over a water filled containment device to catch mercury in the event of a release. Substitute alcohol, mechanical, digital or other non-mercury temperature measuring devices wherever possible. Mercury spill waste materials, including contaminated glass, must be disposed of as hazardous waste. Keep mercury separate from other collected hazardous wastes.

Filter flasks and other glassware, and all other components used on vacuum filtration or pressure systems should be pressure rated for that application, heavy walled, and inspected for cracks or other imperfections before each use. Vacuum should be released from all parts of apparatus before disassembling. Dewar flasks should be properly wrapped with either vinyl electrician tape or friction tape to prevent injury from implosion. Protective shields should be in place for all pressure systems.

F. Chemical Labeling & MSDS

Before using any chemical, you should familiarize yourself with the properties of that chemical and its hazards. Material Safety Data Sheets (MSDS) must be supplied by manufacturers and vendors and be immediately available to all chemical users. Researchers should prepare MSDS for all compounds synthesized on campus. Also, the same compound, from different manufacturers requires an MSDS from each

manufacturer. Contact EH&S for additional hazardous material information. Material Safety Data Sheets can also be accessed through several links to the EH&S home page.

All chemical containers should be labeled with complete chemical names. Do not use only abbreviations, codes or formulas. Unlabeled/unknown chemicals are not permitted. These must be analyzed, identified and then submitted for hazardous waste disposal if they cannot be used. All chemicals should be dated upon receipt and again upon opening. It is especially important that this procedure be done for all reactive and peroxide formers such as ethyl ether, tetrahydrofuran, etc. Keeping materials beyond their expiration dates is a hazardous waste regulatory violation.

G. NFPA Labeling & Placarding

The National Fire Protection Association (NFPA) developed a standard labeling system to be able to readily recognize and easily understand markings which, at a glance, will give a general idea of the inherent hazards of any material and the order of severity of these hazards as they relate to fire prevention, exposure, and control. The system identifies the hazards of a material in terms of three categories: Health (blue), Flammability (red), and Reactivity (yellow). The order of severity in each of these categories ranges from "4", indicating a severe hazard, to "0" indicating no significant hazard.

Every lab should complete a chemical/gas inventory - contact EH&S for guidance and electronic templates. The inventory should be updated periodically to reflect changes. EH&S will post the appropriate NFPA door placards.

H. Chemical Handling

All chemicals are, to some degree, poisonous to the human body. Routes of entry include inhalation, skin and eye absorption, ingestion and injection. Eating, drinking, smoking and the application of cosmetics are prohibited in the laboratory. All personnel should be properly trained in use and application of MSDS - knowledge of properties, reactivities and compatibilities of chemical constituents, proper design and use of apparatus, engineering controls and correct PPE.

All chemicals should be dated upon receipt and again upon opening. It is especially important that this procedure be done for all reactive and peroxide formers such as ethyl ether, tetrahydrofuran, etc. A first-in, first out (FIFO) inventory system should be adopted to control excess accumulation of chemicals and to prevent expired chemicals from automatically becoming regulated hazard wastes.

All users of hazardous materials are required by EPA law to recycle chemicals, purchase less toxic materials, or use smaller quantities and design procedures that reduce the volume and concentration of hazardous materials used and waste generated.

All chemicals should be stored in closed containers compatible with the chemical inside. Chemicals should be returned to their proper storage place immediately after use. Chemicals should only be used with proper controls in place, (e.g., spill containment, protective shielding, ventilation, personal protective equipment, etc.). Chemical access and transportation should be limited to authorized personnel.

Bottles, when carried, should always be supported on the bottom and never carried by the neck. Use a carrying device such as a rubber bucket which provides secondary spill containment and breakage protection. Whenever possible, protective coated chemical bottles and glassware should be used. A sturdy step stool or ladder should be used when obtaining chemicals from upper shelves that are out of reach.

Proper grounding procedures should be used when transferring flammable liquids from one container to another, including distillation apparatus. Drums from which flammables are dispensed should be grounded.

Hydrofluoric acid, perchlorates, perchloric acid, radioactive materials, pyrophorics, gases and other extremely toxic, reactive, or potentially explosive materials should be handled under the direct supervision of the instructor or research staff and only after consultation with EH&S. Also, the use of perchloric acid may require a specially designed and designated fume hood. A special license must be obtained and a training course completed before any radioactive materials may be used.

Areas where hazardous or radioactive materials are used or stored must be thoroughly decontaminated using EH&S approved methods prior to maintenance, renovation, reallocation of space, or closure. It is the responsibility of the supervisor, principal investigator and their department to arrange proper disposal of all hazardous materials prior to personnel relocations or facility closure.

Transporting hazardous materials in vehicles involves extensive training for compliance with Federal, State, and local regulations. Contact EH&S for details before attempting transportation and to assure compliance with the law

I. Chemical Storage

Chemicals must be stored in secured areas, i.e., not accessible to the general public. Highly toxic and reactive materials need additional means of security such as lockable cabinets.

Chemicals should be stored in approved closed containers and cabinets with secondary containment to prevent releases, separated by compatible hazard class (flammable/oxidizers/acids/bases/reactives) to avoid unwanted reactions and unnecessary exposure to occupants. Whenever possible, protective coated chemical bottles and glassware should be purchased and used to reduce hazardous spills due to breakage. It is important to note that certain hazardous materials are not permitted in

many of our campus buildings, since the facilities are not constructed for high hazard use. Such materials include highly toxic gases, pyrophorics and highly reactive or unstable compounds. EH&S should be consulted before any of these substances are brought onto Campus.

EH&S approved flammable liquid storage cabinets should have proper exhaust ventilation. Shelves and cabinets should be anchored solidly to the wall and safety lips should be installed along the front edges of exposed shelves to keep materials from falling. Heavier items should always be stored closer to the ground. Bottles of chemicals should never be stored on the floor. Hazardous liquid chemical storage must have adequate secondary spill containment devices in place. Priority should be given to acids, reactives, flammables, toxic compounds, radioactive and any other materials that could present a hazard, or affect your ability to work in case of a spill.

Secondary containment can be provided by the use of plastic tubs or storage cabinets with containment features to prevent the spread of spilled or leaking chemicals. Containment materials used should not be reactive with the chemicals stored in them.

Flammable, volatile chemicals should be kept in a cool place, away from sources of heat and ignition. If flammables are stored in refrigerators/freezers, the units should be designed, manufactured and UL-approved to have spark-free interiors. Any refrigerator or freezer not designed for the storage of flammables needs to have "EXPLOSION HAZARD: Do Not Store Flammables in This Refrigerator" marked on the outside of the door. Also, no food is to be stored in the same refrigerator as chemicals, film or batteries. Hazardous substances can be absorbed by the food and subsequently ingested by individuals.

The total volume of flammable solvents in the laboratory should be limited to the amount needed for approximately one week of operations or the limit prescribed by NFPA (National Fire Protection Association), UBC (Uniform Building Code), and UFC (Uniform Fire Code), whichever is more restrictive.

All chemicals, including those for disposal, must be clearly and completely labeled with full chemical names in English. This will aid emergency personnel, lab users (especially where changes of personnel and lab renovations have occurred), waste program personnel, and other building occupants to identify hazards and handle or dispose of chemicals properly.

J. Compressed Gases

Gases present more severe hazards than many materials in the solid and liquid states. Gases have generally higher reactivities, and more rapid diffusion capabilities. Even non-toxic gases can kill by asphyxiation. In addition, compressed gas cylinders are physical hazards due to their high pressure.

1. GAS STORAGE

Keep only those gas cylinders in the lab or work area that are being used. Any additional cylinders should be stored in EH&S approved storage facilities. Building and Fire Codes limit the volume and types of gases permitted in buildings.

Store full and empty cylinders only in isolated areas that are ventilated and protected from direct sunlight, rain, snow, damp ground, heat, fire and electrical contact. Temperatures in storage should be maintained between -20^{o}F and 125 ^{o}F. Never store or use cylinders in corridors or stairwells, or near exits or doorways. This includes cryogenic dewars such as liquid nitrogen.

Chain or strap all cylinders to a sturdy object, like a wall or lab bench, or stand them in a specially designed cylinder pen. Cylinders can become missiles if damaged. Do not secure cylinders to water lines, gas piping or other utilities.

Store and use cylinders in an upright position or as manufacturers recommend. Separate gases by hazard class: flammable, oxidizer, reactive, corrosive. Separate oxidizer gases from flammables and combustibles by at least 20 feet, or a one hour fire-rated wall.

Highly toxic, flammable, and reactive gases can require extensive engineering controls such as special ventilation and building construction, approved enclosures, alarms, fire protection, detectors, restricted flow orifices and other safety features. Fire codes do not permit certain high hazard gases in many of our campus facilities. High hazard gases include, but are not limited to: carbon monoxide, ammonia, ethylene oxide, arsine, phosphine, chlorine, silanes, hydrogen sulfide, hydrogen cyanide, fluorine and nitrogen dioxide. Contact EH&S before purchasing or using dangerous gases.

Store empty and full cylinders separately (by hazard class) and clearly indicate whether they are full, empty or in use with status tags attached to the cylinders. Return empty cylinders to suppliers as soon as possible. Keep caps on all cylinders except when connected for use.

2. MOVING CYLINDERS

Inspect cylinders for damage, leaks, and proper labeling upon receipt. Do not accept delivery if tanks are defective or if gas is the incorrect type. Always consider cylinders to be full when handling.

Do not move a cylinder unless the cap is in place. Use only a hand truck specifically designed for use with cylinders. Do not allow cylinders to strike each other, or be dropped, rolled, cut, scraped or otherwise damaged.

Use an elevator if possible, to move cylinders to floors above or below grade level. Take the stairs; do not accompany gases inside the elevator. Move cylinders on a hand truck which is equipped for stairs, if stairs must be used.

With few exceptions, the transportation of compressed gases is regulated by the U.S. Department of Transportation as well as State and Local laws. Contact EH&S for specific regulations.

3. GAS CONNECTIONS

Follow all manufacturer recommendations. Do not use damaged equipment. Inspect fittings, regulators and apparatus for damage and replace all defective parts before use. Use only regulators, gauges and connections with matching threads which are designed to be used with the gas and cylinder involved. Never interchange regulator valves and tubing between cylinders containing different gases. Use only system components which are compatible and are pressure rated for the application.

Do not use any lubricant on fittings. Use only tools approved by the cylinder vendor on cylinder connections.

Do not exceed the design pressure of the apparatus. Do not change or remove marks or numbers stamped on cylinders.

Check connections for leaks. Systems should be pressure checked using an inert gas prior to use with dangerous gases.

Do not attempt to repair or alter cylinders, valves, or attachments. This work should be done by experts.

4. USE OF CYLINDERS

To avoid explosions, never put oil, grease or other oil-based lubricant in a valve used on an oxygen cylinder or on a system containing oxygen.

Consult with EH&S to determine if ventilation is adequate.

Use flammable gases only after proper bonding and grounding. Use corrosive gases only in locations with access to safety showers and eyewash stations.

Open valves slowly. Close cylinder valves when the cylinder is not in use; the pressure regulator is not sufficiently strong to assure safe closure. Bleed gas from the regulator before removing it. Do not empty cylinders below 25 psig.

Do not fill cylinders.

Do not use cylinders for rollers, supports or any purpose other than to contain gas.

5. UNWANTED AND SPENT CYLINDERS

Handle used cylinders as you would full cylinders.

Store used cylinders separate from full cylinders and separate by hazard class. Clearly label used cylinders "EMPTY" (or "MT") on the cylinder status tags.

All unwanted/unneeded gas cylinders should be returned as soon as possible to the manufacturer for reprocessing or disposal. The EH&S Hazardous Materials Management Program cannot accept compressed gases.

K. Cryogenics

Cryogenics deals with the behavior of materials at low temperatures. The principal hazards involved with the use of cryogenic liquids and systems are: direct physical contact, pressure build up in unvented spaces, fires, explosions, implosions and asphyxiation. Cryogenic fluids exist at temperatures -100^{o}F (- 60^{o}C) to - 460^{o}F (-266^{o}C), low enough to damage body tissue. The hazard level is comparable to that of handling boiling water.

Eye protection (minimum of goggles and face shields) should be worn at all times because the boiling fluids can splash into the eyes. Hand protection (pads, tongs, loose fitting quickly removable insulated gloves) is required when handling containers or cold metal parts. Clothing, jewelry or other items that are capable of trapping or holding a cryogenic fluid close to the body should be avoided. Aprons and lab coats should be used. In all cases of contact or splashing, immediately flood the areas and clothing with water (use warm water at 100 - 105^{o}F, same remedy as frostbite).

Cryogenic gases have limited warning properties and even if they are not toxic, are capable of causing asphyxiation by displacing oxygen. This is particularly true where cryogenic fluids are used in confined areas. Consult EH&S to determine if ventilation is adequate. Since cryofluids exist at temperatures far below ambient, they vaporize with a volume increase of 700 - 800 times and can cause rapid and violent pressure changes if confined. Therefore, containers and equipment must be vented.

Avoid contact of moisture with storage containers and equipment because it can freeze and plug up pressure relief devices.

Never use an ordinary household Thermos bottle for cryogenic service. Explosions have occurred when liquid or cold gas finds its way into the outer vessel at the mouth, which is not adequately sealed from the inner vessel. Use special dewars designed for this purpose.

Combustible cryogens such as liquid hydrogen (H2) and liquid natural gas (LNG) must be handled with the same precautions as flammable gases. These precautions may include: proper grounding, local exhaust ventilation, keeping away from open flames and electrical ignition sources, no smoking, and the discharge of vent gases to a safe location. Liquid hydrogen can condense and solidify air into an air/H2 mixture which is an explosion hazard because of the presence of both oxygen and hydrogen. Closed or flame-arrested hydrogen systems should be used to prevent backflow of air and resulting explosion hazards.

Extreme care should be observed when moving cryogenic storage containers. Avoid rolling them by holding the neck, as it is the main support for the inner portion of the container and is very susceptible to damage. Always use hand trucks for moving cryogenic containers. Extreme cold can drastically alter the basic properties of many materials. Select equipment designed for use with cryogenics.

L. Biological Safety

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, rickettsial, 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 Chemical Hygiene Safety Plan which includes the standard microbiology procedures and practices to be followed; special facilities and equipment needed; and safe handling, transportation, storage, and treatment procedures. An emergency action plan should be developed to cover fire, spills, accidents, injuries, illness, aerosol releases, equipment shut down procedures, etc. Also, bio-research labs may require special placarding on their entrance doors including the universal biohazard symbol.

1. BLOODBORNE PATHOGENS

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

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

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

Physicians, Nurses and Medical Technologists
Dentists and Dental Hygienists
Laboratory workers and researchers
Research laboratory scientists
Some Maintenance and Housekeeping staff

Bloodborne Pathogen Training is available for campus personnel from EH&S; for questions concerning the Campus Bloodborne Pathogen program, contact EH&S at 303-492-6025.

2. INFECTIOUS MATERIAL AND WASTE DISPOSAL

The terms infectious, pathological, biomedical, biohazardous, toxic, and medically hazardous have all been used to describe infectious waste. EPA and Colorado Department of Health & the Environment regulations state that for a waste to be "infectious" it must contain pathogens of sufficient virulence and quantity so that exposure to the waste by a susceptible host could result in an infectious disease.

Please refer to the Biological Laboratory Waste Management and Disposal Policy and Procedure in the EH&S *Generator's Guide to Hazardous Materials / Waste.*

M. Carcinogens, Mutagens, and Teratogens

CAUTION: These materials may have adverse effects on the human reproductive system and fetus. Women of child bearing age should exercise extra caution to avoid contact. For additional information contact EH&S.

It is University policy that when any known or suspected carcinogen, mutagen, or teratogen is used, appropriate health and safety procedures, such as those specified by MSDS, the National Institute of Health, OSHA, NIOSH, EH&S Dept., and other agencies, are followed.

1. RESPONSIBILITY AND COMPLIANCE

The principal investigator or the supervisor of the work activity is responsible for assuring that proper written safety principles and practices are followed. The Department of EH&S is available for interpreting this information, providing workers with general testing of ventilation and containment, identifying suspected carcinogens, mutagens, and teratogens, disseminating pertinent information, and providing assistance that will aid in protecting faculty, staff, and students from exposure.

The investigator, supervisor, laboratory researcher and safety liaison should also be alert to new developments that indicate certain substances are carcinogenic.

Risk Management should be consulted to discuss the need for a baseline physical exam before beginning work with carcinogenic materials. Examinations should cover hematologic, urinary, and hepatic parameters. Periodic re-examinations may be performed as recommended by the attending physician after evidence of exposure and before termination of employment. EH&S should be consulted regarding possible methods available for monitoring exposure to specific carcinogens.

2. PROBABILITY OF HUMAN INTAKE OR CONTACT

There are many factors that affect the likelihood that a material will be contacted by or taken into a person's body. Materials with high vapor pressures and low boiling points are likely to become airborne. A highly reactive material may react vigorously or explode and be dispersed into the atmosphere of the work area. Work requiring complex reactions, distillations, or vacuum or pressure systems can also create loss of containment and material dispersion. Proper precautions and restrictions including engineering controls (ventilated enclosures, etc.) should be utilized if, during its use, the material will be dissolved, separated, divided, or acted on chemically in a way which may cause it to become available for skin contact or bodily intake. Whenever possible, substitute non-carcinogenic materials and as with all chemical procedures, minimize the quantities purchased, used and stored.

3. HANDLING CHEMICAL CARCINOGENS

Carcinogens are to be used, handled and stored in areas where entry and exit are controlled and secured. Controlled areas should be maintained at negative pressure with respect to adjacencies. Entrance to these areas should be posted with signs bearing the legend(s): CAUTION: SUSPECT OR KNOWN CANCER AGENT USED / STORED IN THIS AREA; AUTHORIZED PERSONNEL ONLY.

Containers should be labeled identifying the contents and the warning: CAUTION: CANCER CAUSING AGENT.

Any equipment, material, or other items taken into or removed from a carcinogen use area should be done in a manner that does not cause contamination of surrounding areas or the external environment. Decontamination procedures should be established and implemented to remove carcinogens from surfaces of materials, equipment, and the facility. Dry sweeping and dry mopping are discouraged.

Only those persons who have been trained in relevant safety and lab procedures should be permitted in carcinogen use areas. The supervisor or responsible investigator should frequently inspect and survey the facility to ascertain that each worker is following proper laboratory instructions.

Prior to exiting a controlled area, employees should be required to remove and leave their lab coats and other protective clothing and follow proper personal washing procedures.

N. Hydrogen Fluoride and Hydrofluoric Acid

Hydrogen Fluoride is a colorless fuming gas or liquid. In its liquid state it's called Hydrofluoric Acid. Acute and chronic exposure to both gaseous and liquid HF can have very serious and life threatening health effects. HF will penetrate the skin and attack the underlying tissues and bone, possibly with fatal results. The full extent of damage may not exhibit itself until hours after the exposure. Therefore, all laboratory personnel who work with Hydrogen Fluoride gas or Hydrofluoric Acid must implement the procedures and laboratory design requirements shown below.

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

1. HYDROGEN FLUORIDE GAS

Contact EH&S prior to obtaining HF gas. EH&S must review and pre-approve experimental and research protocols (see "Questionnaire for Use of Hydrogen Fluoride Gas and Hydrofluoric Acid").

Laboratory Information Required:

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

a. HF gas quantities, concentration, pressure, temperature, flow rate, etc.

b. Personal Protective Equipment (see HF PPE Chart) - gloves, eye/face protection, etc.

c. Engineering Controls - fume hood, gas cabinet, special exhaust device, alarm monitoring system, etc.

d. Safe Handling Requirements - routine leak detection, emergency evacuation procedure in case of accidental release/exposure, location of emergency shower and eye/face wash unit(s), location of calcium gluconate gel, posted emergency room contact phone numbers, etc.

A complete laboratory Chemical and Gas Inventory is required to determine if incompatibilities exist for ventilation and storage needs.

Storage and Engineering Requirements:

Maximum quantity of HF gas allowed will be determined on a case by case basis for each Experimental Protocol.

HF gas cylinders must be stored in an approved vented gas cylinder cabinet with a HF alarm sensor that will detect an immediate HF release.

a. Alarm monitoring system should be easy to calibrate by Laboratory User(s).

b. Alarm monitoring system should have battery back-up in case of power outage.

EH&S and Facilities Management will conduct a code review to determine additional Engineering Control requirements. Controls may include, but not be limited to, fume hood or other ventilation containment, room pressurization, duct work and exhaust fan(s), exhaust scrubbers, system alarms, placarding, etc.

Personal Protective Equipment (PPE) & Safe Handling Requirements:

Emergency shower and eye/face wash unit(s) may be required. Flush and assure their proper operation at least weekly.

Experimental Protocols and Material Safety Data Sheets must be posted in visible, prominent locations in the lab. All laboratory personnel must be trained on Experimental Protocols.

2.5% calcium gluconate gel must be immediately available in Lab. EH&S can provide this gel at a reasonable cost.

2. HYDROFLUORIC ACID

Contact EH&S prior to purchase of HF acid. EH&S must review and pre-approve experimental and research protocols (see "Questionnaire for Use of Hydrogen Fluoride Gas and Hydrofluoric Acid", attached).

Laboratory Information Required:

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

a. HF quantities, concentration, temperature, etc.

b. Personal Protective Equipment (see HF PPE Chart) - gloves, eye/face protection, etc.

c. Engineering Controls - fume hood, special exhaust device, alarm monitoring system, etc.

d. Safe Handling Requirements - routine check of HF container(s) for leaks, emergency evacuation procedure in case of accidental release/exposure, location of emergency shower and eye/face wash unit(s), location of calcium gluconate gel, posted emergency room contact phone numbers, etc.

A complete laboratory Chemical and Gas inventory is required to determine if incompatibilities exist for ventilation and storage needs.

Storage and Engineering Requirements:

Maximum quantity of HF acid allowed will be determined on a case by case basis for each experimental protocol.

HF acid container(s) are required to be stored in an approved vented corrosive cabinet.

EH&S and Facilities Management will conduct a code review to determine additional Engineering Control requirements. Engineering Controls may include, but not be limited to, fume hood or other ventilation containment, room pressurization, duct work and exhaust fan(s), exhaust scrubbers, system alarms, placarding, etc.

Personal Protective Equipment (PPE) & Safe Handling Requirements:

Emergency shower and eye/face wash unit(s) may be required. Flush and assure their proper operation at least weekly.

Experimental Protocols and Material Safety Data Sheets must be posted in visible, prominent locations in the lab. All laboratory personnel must be trained on Experimental Protocols.

2.5% calcium gluconate gel must be immediately available in Lab. EH&S can provide this gel at a reasonable cost.

UCB Environmental Health and Safety Laboratory Standard

Questionnaire for Use of Hydrogen Fluoride Gas and Hydrofluoric Acid

Also refer to UCB EH&S "Requirements for Use of Hydrogen Fluoride Gas and Hydrofluoric Acid"

Building _____ **Department** _____ **Room** _____

Principle Investigator _____ **Phone #** _____

Lab Contact _____ **Phone #** _____

Do you use:

Hydrofluoric Acid ☐ **Stock Concentration** _____ **Total Vol.** _____

Hydrogen Fluoride ☐ **Cylinder Concentration** _____ **Total Vol.** _____

Does the lab have a fume hood? ☐ **Yes** ☐ **No**

Has a current laboratory Chemical/Gas Inventory been submitted to EH&S? Yes ☐ **No** ☐

Hydrofluoric Acid:

What is the HF working solution concentration? _____

Where will the HF be used in the Lab? _____

Where will the HF be stored in the Lab? _____

Has an Experimental Protocol been written for HF use? **Yes** ☐ **No** ☐

(If "No" Please prepare and submit Experimental Protocol to EH&S; see "Requirements for Use of Hydrogen Fluoride Gas and Hydrofluoric Acid" for guidance)

Hydrogen Fluoride Gas:

What is the HF Gas working concentration? _____

Where will the HF Gas be used in the Lab? _____

Where will the HF Gas be stored in the Lab? _____

Has an Experimental Protocol been written for HF Gas use? Yes ☐ No ☐

(If "No" Please prepare and submit Experimental Protocol to EH&S; see "Requirements for Use of Hydrogen Fluoride Gas and Hydrofluoric Acid" for guidance)

Please complete this questionnaire and return it to EH&S, 413 UCB