Ozarks Technical Community College

Chemical Hygiene Plan

In compliance with OSHA 29 CFR 1910.1450

5/1/2023

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The Chemical Hygiene Program has been updated by the facilities and grounds department's environmental safety and compliance coordinator with the intent of demonstrating safe practices in laboratories where hazardous chemicals are used. The Chemical Hygiene Program is reviewed and updated as needed following major incidents, drills, exercises, or when new or special safety information becomes available. The recommended revisions are peer-reviewed by the college director of facilities and grounds as well as the department chair of the department in which the incident occurred prior to approval and posting.

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List of Acronyms / Abbreviations used in the Chemical Hygiene Plan

ACGIH	American Conference of Governmental Industrial Hygienists
AL	Allowable Limit
CFR	Code of Federal Regulations
CHP	Chemical Hygiene Program
DOT	Department of Transportation
ESCC	Environmental Safety and Compliance Coordinator
GHS	Globally Harmonized System
HCS	Hazard Communication Standard
HEPA	High-Efficiency Particulate Air Filters
HVAC	Heating Ventilation Air Conditioning
IARC	International Agency for Research on Cancer
LC50	Lethal Concentration 50
LD50	Lethal Dose 50
LSO	Laboratory Safety Officer
NFPA	National Fire Protection Association
NIOSH	National Institute for Occupational Safety and Health
NTP	National Toxicology Program
OSHA	Occupational Safety and Health Administration
PASS	Pull Aim Squeeze Sweep
PEL	Permissible Exposure Limit
PI	Principal Investigator
PPE	Personal Protective Equipment
PPM	Parts Per Million
SDS	Safety Data Sheets (formerly Material Safety Data Sheets)
STEL	Short Term Exposure Limit
TLV	Threshold Limit Value
TWA	Time Weighted Average
USEPA	United States Environmental Protection Agency

1. General Principles

The Chemical Hygiene Program (CHP) is written to comply with the Occupational Safety and Health Administration (OSHA) regulation set forth in 29 CFR 1910.1450, the Occupational Exposure to Hazardous Chemicals in Laboratories (the "Laboratory Standard"). This regulation mandates a program of practices, procedures, and policies designed to protect employees who use hazardous chemicals in a laboratory setting. The laboratory chemicals include not only those regulated in 29 CFR 1910, Subpart Z but also any chemical meeting the definition of a hazardous chemical with respect to physical and health hazards as defined in OSHA's Hazard Communication Standard, 29 CFR 1910.1200.

The CHP applies to all OTC laboratories on all campuses / centers. This "Program" includes research laboratories, clinical labs, student labs, instrumental labs, lab support locations, environmental chambers/rooms, quality control labs, storerooms for lab equipment, linear equipment rooms, and corridors adjoining labs. Locations not covered by this "Program" include sound labs, computer labs, and many electrical engineering labs.

The purpose of the CHP is to provide laboratory personnel with basic safety information regarding the use of chemicals in laboratories. Although a number of chemicals are mentioned in this “Program”, they are not the only chemicals that may be present. They serve to illustrate hazards that may be present. This “Program” also presents information on the safe storage, use, and disposal of chemicals/wastes in laboratories.

It is the policy of Ozarks Technical Community College to provide an environment free from recognized hazards that could cause injury or illness. To this end, employees or students may not be exposed at or above a chemical’s Permissible Exposure Limits (PEL) or Short-Term Exposure Limit (STEL) set by OSHA. Working with any chemical involves a degree of risk. Even though a chemical may not be considered hazardous by today's standards, everyone is advised to minimize their exposure to chemicals by using established safe practices. Three main categories exist to control exposure: (1) engineering controls, (2) work practices and administrative controls, and (3) personal protective equipment (PPE).

Engineering controls, the preferred method of reducing exposure, should be used whenever the chemical hazard information on the chemical label or the Safety Data Sheet (SDS) indicates "use local exhaust." Examples of engineering controls include fume hoods, canopy hoods, slot hoods, glove boxes, and biological safety cabinets. The Principal Investigator or lab supervisor should make all efforts to ensure the least hazardous substances are used and that all chemicals are used in the most efficient manner to minimize both exposure and waste.

Work practices and administrative controls are also methods in reducing human exposure after the use of engineering controls. SDS and chemical labels must be reviewed for specific work practice instructions. Additional work practices and administrative controls include items such as not working alone and compiling specific experimental protocols that include safe work practices, as listed in this document, and Standard Operating Procedures, both written/approved by the PI/supervisor and those listed in the appendices of this document. Some chemical manufacturers may have detailed work practices to follow for the safe use of extremely hazardous agents. For example, the chemical production company Sigma-Aldrich provides detailed work practices that can be downloaded for tertiary butyl lithium.

Personal Protection Equipment (PPE) must be used in addition to, but not as a substitute for, engineering controls and work practices to reduce exposure. PPE may consist of respiratory protection, eye protection, face protection, gloves, hearing protection, dermal coverings, or protective clothing. SDS and chemical labels contain specific information on the PPE needed. When PPE is selected, its use shall be in accordance with OSHA standard 29 CRF 1910, sections 132-134.

It is not enough, however, to provide safe equipment, Standard Operating Procedures, and training if the "culture" does not encourage and support working safely in the laboratory. Ozarks Technical Community College strongly encourages all laboratory staff including Deans, Department Chairs and lead instructors to place the highest priorities on best practices and to raise concerns to colleagues and supervisors when they identify or are concerned about potential safety problems.

Many Ozarks Technical Community College laboratories utilize not only hazardous chemicals but also have/use biological agents, research animals, special instruments (lasers, mass spectrophotometers), and/or have physical hazards (car lifts, oil canister crusher, saws).

2. Responsibility

Responsibility for implementing the CHP resides with each department that has a laboratory. Each individual department chair has the responsibility for implementing any specific policy needed for that specific laboratory.

Principal Investigators /Department Head

Principal Investigators (PIs) have primary responsibility for the safety of the labs under their jurisdiction. They are responsible for providing leadership and promoting and advancing the laboratory safety culture. The PI may delegate safety duties for which they are responsible for but can't relinquish that responsibility/obligation. The PI must ensure that the delegated safety duties are carried out.

Department Head

The Department Head is responsible for chemical hygiene in the laboratory. This person shall ensure:

1. Laboratory employees know and follow the chemical hygiene rules.

2. Appropriate training is provided and protective equipment is available and in working order.

3. Facilities and training for use of any material being ordered are adequate.

4. Routine and periodic checks are conducted of emergency equipment, chemical hygiene, and departmental housekeeping.

5. Select personal protective equipment based on the risk assessment or as written in the pertinent site-specific SOPs.

6. Completing an annual chemical inventory for the laboratory locations under his/her direction and reporting it to Environmental Safety and Compliance Coordinator.

Laboratory Employees

1. Completing laboratory-specific safety training.

2. Planning and conducting laboratory procedures in accordance with the laboratory's SOPs and the colleges CHP.

3. Developing and practicing good laboratory practices and personal hygiene habits such as frequent hand washing, no eating/drinking in labs, maintaining good housekeeping, not wearing gloves outside of the laboratory, etc.

4. Wearing clothing and attire appropriate for lab activities. This includes, but is not limited to, wearing pants that cover the entire leg, confining long hair, not wearing dangling jewelry, and wearing only completely enclosed shoes (no sandals).

5. Wearing PPE when and where required, such as wearing lab coats over street clothes, and eye/face protection, gloves and hearing protection for high noise areas.

6. Reporting unsafe conditions to Department Head, the Principal Investigator, or the Environmental Coordinator.

7. Reporting incidents of hazardous chemical exposures and near misses to Department Head and the Environmental Coordinator.

8. Ensuring hazardous waste is collected at the point of generation and handled in accordance with RCRA regulations (40 CFR 260).

9. Using compressed gases and cryogenic liquids properly by securing the cylinders in the upright position with a stand or cylinder strap, ensuring caps are placed on cylinders when not in use, and verifying the regulator is approved for the gas to be used for the pressure in the cylinder.

10. Ensuring at least one other individual is present (never work alone) when using chemicals of moderate, chronic, or high acute toxicity.

11. Enforcing all these procedures and leading by example for their students.

Facilities

Facilities have direct control over the laboratory's general and local ventilation systems and utility systems. Facilities responsibilities include:

1. Informing laboratory personnel in advance of scheduled utility or maintenance shutdowns (gas, water, fume hoods, etc.) through the posting of notices.

2. Maintaining local exhaust (fume hoods) systems to provide the engineering controls necessary to maintain safe laboratory conditions.

Safety and Security Department

The Safety and Security Department maintains direct access to all safety showers, and eyewash stations and are inspected and flushed on a routine basis while maintaining documentation of these activities.

3. Employee Information and Training

It is the responsibility of the PI/supervisor/department chair to have new employees and students complete any required training session(s) before they begin bench work. All new laboratory employees should be informed of:

1. The existence of the CHP and the requirements of OSHA's Laboratory Standard.

2. Control methods (engineering controls, workplace practices, administrative controls, and personal protective equipment) to minimize employee exposure to hazardous chemicals in the laboratory.

3. Modes of potential exposure to chemicals and signs and symptoms associated with exposure to common hazardous chemicals used in the laboratories.

4. The location and availability of known reference materials within the College - including SDSs, information on the hazards, safe handling, and storage of chemicals.

5. How to read and understand the information found on an SDS.

6. The proper use of emergency equipment and the proper use, maintenance, and limitations of PPE, including respirators and hearing protection, and other safety equipment.

7. Emergency procedures to follow in the event of a fire, exposure, or spill.

8. Requirements for the storage and emergency response for chemicals as well as the disposal of hazardous waste in laboratories.

9. Review and follow the information listed in the laboratory's Standard Operating Procedures for particularly hazardous chemicals and for the general procedures for hazard classes of chemicals.

The PI/supervisor must provide and document the training/orientation for the laboratory staff under his/her direction. The training is to include topics such as departmental safety policies, Standard Operating Procedures, and any other procedures/activities performed in the employee's work location(s). When a new hazard is introduced in the workplace, the PI/supervisor must train and document the training the employees received for said hazards.

Frequency of Training

Site-specific training addressing the hazards posed by the lab's activities must be provided by the PI/supervisor upon initial assignment. The PI/supervisor is to provide site-specific training when new processes/procedures are implemented and maintain the associated documentation. Should laboratory personnel be found to not follow safe working procedures, the PI/supervisor is to provide retraining and maintain the associated documentation.

4. Hazardous Chemicals

The term "hazardous chemical" refers to a chemical for which there is statistical evidence that acute or chronic health effects may occur in exposed employees, or if it is listed in any of the following:

- OSHA, 29 CFR 1910 Subpart Z, Toxic and Hazardous Substances;
- "Threshold Limit Values for Chemical Substances and Physical Agents in the Work Environment", ACGIH (latest edition);
- "The Registry of Toxic Effects of Chemical Substances", RTECS (latest edition); or,
- Select Agents Regulations: 42 CFR 73 or 9 CFR 121.

In 2012, OSHA revised the Hazard Communication Standard (HCS) 29 CFR 1910.1200 and aligned the program with the United Nation's Globally Harmonized System (GHS) of Classification and Labeling of Chemicals. One key component of the updated program utilizes pictograms to help identify hazards. The pictogram and the common descriptions of the hazards identified are listed below. Some chemicals and most mixtures could have more than one pictogram to identify the hazard(s).

Types of Health Hazards

1. **Irritants**: Irritants are agents that can cause inflammation of the body surface with which they come in contact. Irritants can also cause changes in the mechanics of respiration and lung function.

   Common irritants include:

   Common Skin Irritants
   - Ammonia
   - Alkaline dust and mists
   - Acids
   - Halogens
   - Nitrogen dioxide
   - Ozone
   - Phosgene
   - Phosphorous chloride

   Common Respiratory Irritants
   - Acetic acid
   - Acrolein
   - Formaldehyde
   - Formic acid
   - Halogens
   - Hydrochloric acid (hydrogen chloride)
   - Sulfur dioxide
   - Sulfuric acid

The pictogram for chemicals in this hazard group is:

2. **Asphyxiants**: Asphyxiants are broken into two groups. Simple asphyxiants which deprive the tissue of oxygen. Chemical asphyxiants which render the body incapable of maintaining an adequate oxygen supply.

Examples include:

Simple Asphyxiants

- Carbon dioxide
- Helium
- Nitrogen
- Nitrous oxide

Chemical Asphyxiants

- Carbon monoxide
- Cyanides
- Hydrogen sulfide

The pictograms for chemicals for this hazard group can include one or both of the following:


3. **Hepatotoxic agents**: Hepatotoxic agents cause damage to the liver.

   Examples include:
   - Carbon tetrachloride
   - Dichloropropane
   - Dimethylformamide
   - Diphenyl
   - Ethylene dibromide
   - Nitrosamines
   - Tetrachloroethane

The pictogram for chemicals for this hazard group is:

4. **Nephrotoxic agents**: Nephrotoxic agents damage the kidneys.

   Examples include:

- Cyclosporin
- Ethylene glycol
- Halogenated hydrocarbons
- NSAIDs
- Radiological contrast media
- Uranium compounds

The pictogram for chemicals for this hazard group is:

5. **Neurotoxic agents**: Neurotoxic agents damage the nervous system. Generally, the nervous system is sensitive to organometallic compounds and sulfide compounds.

   Examples include:
   - Carbon disulfide
   - Chlorinated solvents
   - Formaldehyde
   - Manganese
   - Lithium
   - Methylene chloride
   - Methyl isocyanide
   - Methylmercury
   - Naphthalene
   - N-hexane
   - Organic phosphorous insecticides
   - Tetraethyl lead
   - Thallium
   - Trialkyltin compounds

The pictogram for chemicals for this hazard group is:

6. **Hematopoietic System Effects**: These agents act on the blood. The blood cells can be directly affected or the bone marrow can be damaged.

Examples include:

- Analine
- Benzene
- Nitrites
- Nitrobenzene
- Toluidine

The pictogram for chemicals for this hazard group is:

7. **Carcinogens**: A carcinogen is an agent that can initiate or speed the development of malignant or potentially malignant tumors or malignant neoplastic proliferation of cells. Select carcinogens are those substances that meet one of the following criteria:
   - It is regulated by OSHA as a carcinogen;
   - It is listed under the category "known to be carcinogens", as listed in the latest edition of the National Toxicology Program's (NTP) "Annual Report of Carcinogens"; or,
   - It is listed under Group 1, "carcinogenic to humans" by the International Agency for Research on Cancer Monographs (IARC).

The pictogram for chemicals for this hazard group is:

8. **Reproductive hazards**: Reproductive hazards are those chemicals that affect the reproductive health of women and men or the ability to have healthy children. This can be from chromosomal damage (mutagens) and effects on the fetus (teratogens). Mutagens change the genetic material, usually DNA, and increase the frequency of

mutations. A teratogen is an agent that interferes with normal embryonic development without damage to the mother or lethal effects on the fetus.

Examples include:
- Dioxin
- Endocrine disrupters
- Lead
- Many pesticides
- Carbon disulfide
- Ethylene oxide

The pictogram for chemicals for this hazard group is:

9. **Sensitizer**: A sensitizer is an agent that causes a majority of the exposed population to develop an allergic reaction in normal tissue after repeated exposures to the chemicals. Reactions can range from mild, such as a rash, to severe, such as anaphylactic shock.

   Examples include:
   - Chlorinated hydrocarbons
   - Chromium compounds
   - Epoxies
   - Nickel compounds
   - Toluene diisocyanates

The pictograms for chemicals for this hazard group can include:


10. **Acutely Toxic Chemicals**: These chemicals are substances falling into the following categories:
   - A chemical that has a median lethal dose (LD50) of 50 mg/kg or less of body

weight, when administered to rats weighing 200 to 300 g each;
- A chemical that has a median lethal dose (LD50) of 2000 mg/kg or less of body weight, when administered by continuous contact for 24 hours to the bare skin of rabbits weighing 200 to 300 g each; or,
- A chemical that has a median lethal concentration (LC50) in the air of 200 ppm by volume or less when administered by continuous inhalation for one hour to rats weighing 200 to 300 g each.

The pictograms for many of the chemicals for this hazard group can include:

11. **Nanomaterials**: The health effects for exposures to nanomaterials are not fully understood at this time. Until the potential risks and more definitive findings are available, researchers working with nanomaterials must implement a combination of engineering controls, workplace practices and use personal protective equipment to minimize potential exposures.

    There is no pictogram for this group of the chemical. The appropriate pictogram is based on the hazard of the individual chemical(s) present(s).

Physical Hazards

1. **Flammable agents**: Flammable agents are any solid, liquid, or gas that will ignite easily and burn rapidly.

    a. Flammable solids can include dusts or fine powders (metallic or organic substances such as cellulose, flour, etc.), those that ignite spontaneously at low temperatures (white phosphorous), those in which internal heat is built up by microbial or other degradation activities, or films, fibers, and fabrics of low-ignition point materials.

    b. Flammable liquids are classified by the NFPA and the DOT as those having a flash point less than 100F and a vapor pressure of not over 40 psi at 100F.
    c. Flammable gases are ignited very easily and the flame and heat propagation is so great as to resemble an explosion, especially if the gas is confined. Common examples of flammable gases include hydrogen, carbon monoxide, and acetylene.

The pictogram for chemicals for this hazard group is:

2. **Combustible agents**: Combustible solids are those solids that are relatively difficult to ignite and that burn relatively slowly. Combustible liquids were previously defined as those liquids that have a flash point greater than 100F. Under the GHS, chemicals in this grouping are now listed under flammable agents.

   Examples include:
   - Greases
   - Kerosene
   - Lubricants
   - Mineral oil
   - Paraffin oil
   - Vegetable oil

The pictogram for chemicals for this hazard group is:

3. **Oxidizers:** Oxidizers are agents that, by yielding oxygen, may cause or contribute to the combustion of other materials.

   Examples include:
   - Hydrogen peroxide
   - Nitric oxide
   - Oxygen
   - Perchlorates
   - Permanganates

The pictogram for chemicals for this hazard group is:

4. **Compressed Gases / Cryogenic Liquids**: A **compressed gas** is a substance that is a gas at normal room temperature and pressure, and is contained under pressure, usually in a cylinder. Some compressed gases (e.g. acetylene) are stabilized in the cylinder by dissolving the gas in a liquid or solid matrix. These materials can pose both a health hazard and a physical hazard to personnel. Compressed gases can create pressure hazards and dilute the oxygen content or create flammable atmospheres should a sudden release occur.

The pictogram for chemicals for this hazard group is:

5. **Explosive, Highly Reactive / Unstable Materials**: These substances have the potential to decompose, condense, vigorously polymerize, react with water, react with moisture in the air, or otherwise form peroxides upon exposure to light or oxygen in the air. A list of these chemicals is too numerous to include here and can be found in the appendices of this document.

The pictograms for chemicals for this hazard group can include:

High Hazard Chemicals

Some laboratory locations may use some high hazard chemicals that may present severe health and/or physical hazards. These agents include:

- APHIS and CDC Select Agent Toxins as listed in 9 CFR Part 121. Refer to the UR Select Agent Program for additional information.
- OSHA Carcinogens, as listed in 29 CFR 1910.1003.
- OSHA high energy chemicals, categorized as Division 1.1 and 1.2 chemicals, as listed in 29 CFR 1910.1200, Appendix B.

It is the responsibility of the PI/supervisor to develop Site Specific Procedures (SOPs) for the use of these agents and to provide the environmental safety and compliance coordinator copies of the SOPs prior to the purchase and use of these agents. The ESCC will audit the SOPs and complete a workplace evaluation for the planned storage/use location and upon successful findings, authorize the purchase/use of the planned agents. Periodic workplace evaluations as required by the pertinent regulation will be completed. Records of these evaluations will be retained by the ESCC.

5. Medical Emergency Policies

Immediate Action Plan

1. If the situation is life-threatening, first notify Emergency Response Personnel via campus phone at x9-911 or via cell phone at 911.

2. Notify the OTC Safety & Security Department via campus phone at x6911 on any campus phone or via mobile phone at (417) 447-6911.

3. Do not move the victim unless necessary to sustain life.

4. If appropriate, administer first aid.

Detailed Information

When reporting a medical emergency, remember the following:

1. Be sure to provide the following information:
   a. Type of emergency
   b. Location of the victim to include building and room number or parking lot letter if applicable
   c. Condition of victim
   d. Any dangerous conditions
   e. Your name and call back number

2. Stay on the telephone until 911 correspondents or Safety & Security Department dispatcher tells you to hang up.

Students should immediately report all incidents and injuries to their instructor. Call

911 if the incident/injury is an emergency or if requested by the student (victim), then call the Safety & Security Department at (417) 447-6911.

Employees injured at work should contact the Workman's Compensation Representative and the Safety & Security Department at 417-447-6911. Injured employees will be referred to the Work. Comp. Occupational Medicine facility for their location:

Spfld & RVC	**Table Rock**	**Lebanon**	**Waynesville**
Cox Health Occupational Medicine	Cox Health Occupational Medicine	Occupational Medicine	Mercy Occupational Medicine
1423 N. Jefferson Ave	121 Cahill Rd, #201	1216 Diedra Dr.	608 Old Route 66
Springfield, MO	Branson, MO	Lebanon, MO	St. Robert, MO
(417) 269-3813	(417) 335-7555	(417) 533-0848	(573) 336-8991

6. Personal Protective Equipment (PPE) and Emergency Equipment

Personal Protective Equipment (PPE)

Laboratory personnel must wear PPE as necessary, in accordance with OSHA standard 29 CFR 1910.132. All Laboratory personnel must be made aware of the limitations of the PPE before use.

Any necessary PPE is provided by the college at no cost to the employee or student. The PI/supervisor should determine the PPE by completing the appropriate SOPs that include the PPE to be used.

PPE may include, but is not limited to:

1. Appropriate eye protection: to be worn by all persons, including visitors, where chemicals are stored or handled. The eye and face protection needed must comply with the most recent edition of American National Safety Standards "Practice for Occupational and Educational Eye and Face Protection".

2. Appropriate gloves: to be worn when the potential for contact with toxic or corrosive materials exists. The gloves are to be inspected before each use and replaced periodically. Disposable gloves must never be reused. The selection of gloves is to be based on chemical permeability. Because of the wide number of gloves and manufacturers available, information from the manufacturer should be obtained to ensure the appropriate glove selection has been made. A glove compatibility chart can be used to assist in the selection of gloves.

  a. Gloves are to be removed and hands washed before leaving the lab to prevent contaminating surfaces (door knobs, elevator buttons, etc.) outside of the lab.
  b. Powdered latex gloves are not recommended to be used when handling chemicals. These gloves can present a risk to some individuals who have been sensitized to latex.

3. Appropriate lab coats must be worn in the lab when working with chemicals to protect your skin and clothing from splatters and spills. In the event of an accident, a lab coat is easier to remove than street clothes. A variety of lab coats are available and the proper selection is important.

   a. Lab coats made with a blend of Polyester and/or Rayon provide splash protection when working with aqueous solutions. However, when used with flammable liquids; they can ignite.
   b. For those frequently using large quantities of flammable liquids, a Nomex HRC1 or 2 rated lab coat is recommended. Cotton lab coats are recommended when working with lower quantities of flammable liquids and when working with an open flame.
   c. Lab coats are to fit properly to allow them to be fully buttoned and the sleeves extended (not rolled up).
   d. Do not wear lab coats outside of laboratory locations.
   e. Do not take lab coats home for laundering because they may contaminate others in your household.

4. Other PPE may be used provided the limitations of its use are made known to the laboratory personnel.

Fire and Extinguisher Use

Reporting a fire

1. Yell, “FIRE – FIRE – FIRE” while going to and activating a nearby fire alarm pull station.
2. Evacuate the building immediately, closing doors and windows and performing laboratory emergency shut-down procedures (only if procedures can be safely completed).
3. When you are safe, call 911 and report the exact location(s) of the fire to the operator. Call OTC Safety and Security Department.
4. Go to your designated assembly area or gathering point.
5. Do not re-enter the building until fire and college officials indicate it is safe.

Fire Safety Rules:

Plan fire escape routes

1. Know where all exits are located in the building and plan two escape routes
2. Practice your escape plan

Do not use the elevators

Feel the door handle

1. If the door handle is hot, do not open it – go to a window and call for help.
2. If the handle is not hot, open cautiously checking for smoke or fire before going out.

Don't look for other people or gather up your things

1. Beat on any doors and yell "FIRE" as you leave.
2. Do not stray from your path as you leave

Crawl low to the floor

1. Thick smoke can make it impossible to see – Breathe through your nose or through a shirt
2. Do not breathe the smoke – Toxic chemicals from smoke can be deadly in minutes

Close doors behind you

1. It may help keep the fire from spreading.
2. It may protect your possessions from fire and smoke damage.

If you can't get out, get someone's attention

1. Yell and scream.
2. Hang a sheet out of a window and then close the window tightly to hold it in place.
3. Stay low, there is less smoke and poisonous gasses close to the floor. Use wet towels to block smoke from entering the room.

Using a Fire Extinguisher

1. Only use a fire extinguisher if you are comfortable with your ability to effectively fight the fire.
2. If you decide to use the fire extinguisher, remember to position yourself between the fire and exit.

Remember PASS

Pull the pin – **Aim** – for the base of the fire – **Squeeze** the handle – **Sweep** – from side to side

Other Emergency equipment

Emergency equipment may be required based on the quantity and the hazard classes of the chemicals used. This equipment may include:

1. An eyewash station is required where chemicals that could cause harm to eyes are used or stored. Access must be free of obstructions that would inhibit the immediate use and the eyewash must be reachable within 10 seconds of the hazard (roughly 50-75 feet).

2. An easily accessible drench-type safety shower is required within 10 seconds (75 feet) of locations where hazardous chemicals are used or stored.

3. A fire blanket is recommended in those locations where large quantities of flammable materials are used or stored.

4. Spill control kits are to be readily available for minor chemical spills that may occur within a laboratory. Individual spill kits for different chemical classes are available through scientific supply companies and their purchase is highly recommended.

7. Chemical Procurement, Distribution, and Storage

Procurement

1. Whenever possible, researchers should consider using safer alternative chemicals in place of hazardous chemicals.

2. To reduce future wastes, purchase only those quantities needed for immediate/near future needs.

3. Before a chemical/mixture is used, information on the chemical properties, proper handling, storage, and disposal must be made available for those who will be using the substance. This information is found in the SDS. No chemical container is to be accepted without an adequate identifying label.

4. Because Safety Data Sheets are frequently updated, please check with our SDS database found on all campus computers called MSDS Source for more information about hazards, PPE, storage, and disposal.

Chemical Inventories

Inventories must be maintained and regularly updated. Please contact the college's environmental safety and compliance coordinator to submit your chemical inventory.

Distribution of chemicals

When a chemical is transported by hand or cart, the container is to be sealed and placed within a secondary containment vessel to prevent spillage.

Storage and Use

1. Store chemicals in cabinets or shelving according to chemical classes. Routine storage of chemicals on bench tops and in chemical fume hoods is not recommended.

2. Chemicals must be stored in a manner to prevent their exposure to heat or direct sunlight.

3. Laboratory refrigerators must never be used for storage of food or beverages for human consumption.

4. Stored chemicals must be examined at least annually for expiration dates and visually examined for container and label integrity. Expired chemicals or chemical containers showing possible deterioration need to be disposed of through the environmental safety and compliance coordinator.

5. Unwanted chemicals should be submitted to the ESCC for proper disposal.

6. Incompatible chemicals must be adequately separated by distance, secondary containment, or separate storage areas. See "incompatible chemicals" at the end of this document. Most chemicals should be stored by general hazard groups.

7. The preferred locations for the storage of flammable liquids are stored in flammable material storage cabinets with specifications listed in 29 CFR 1910.106 (3).

8. Chemicals must NOT be stored on the floor, even as a temporary measure.

9. All compressed gas cylinders are:
    a. To be secured with approved cylinder chain or strap to the wall or bench or supported with a cylinder stand.
    b. To be used in an upright position
    c. To be used with proper regulator
    d. To be capped when not in use
    e. Never to be stored or used in or near corridors or egress paths such as a lab exit door.

10. Lecture bottles, small compressed gas cylinders containing flammable or toxic compressed gases, must be:
    a. Stored in a well-ventilated area (in a cabinet under a chemical fume hood, a fume hood, ventilated storage cabinet, or a ventilated gas cabinet
    b. Used in a chemical fume hood or ventilated gas cabinet unless the cylinder's use is for a special instrument used in the lab

8. Waste Disposal Program

Purpose

The environmental safety and compliance coordinator is charged with running a chemical waste disposal program for the entire college. Its purpose is to minimize any harm to people, the facility, and the environment that results from the disposal of laboratory wastes.

Examples of wastes generated from labs include chemical wastes that normally have characteristics of being flammable, corrosive, oxidizers, and/or toxic. This does not preclude other waste types from being generated as labs change over time.

For labs that generate biohazardous wastes which include infectious wastes and sharps, these materials may be properly disinfected through the use of an autoclave. An autoclave can only be used by faculty that are properly trained in using one.

Minimize the generation of hazardous wastes. Before purchasing chemicals, limit the quantities ordered to what is needed for a 1-year duration. Rotate chemicals by using older chemicals first and putting them on the front of the shelf, with newer containers placed in the back.

Discarding Chemical Stocks

Any laboratory having unlabeled chemicals or solutions is responsible for the identification, concentration, and volume of the contents before disposal by the ESCC.

Frequency of Disposal

Hazardous waste is routinely removed from labs throughout the college when the ESCC deems so, or when called to remove the waste.

Laboratory personnel must comply with the U.S. Environmental Protection Agency (USEPA) and the Missouri Departmental of Natural Resources (MODNR).

1. Hazardous waste is defined by the USEPA as those chemicals that are listed wastes or have the characteristics of ignitability, toxicity, corrosivity, or reactivity.
2. Federal and state regulations prohibit the disposal of hazardous waste into the sewer or in the trash.
3. Waste containers must be marked with the words "Hazardous Waste" and must have a start date from the moment the first drop of hazardous waste went into the container. The waste must have a list of the composition of the waste including:
    a. What the waste is by name.
    b. The concentration of the waste
    c. The volume of waste.

4. The waste must have the proper container for that waste type.

5. Waste containers must be closed when waste is not actively being added.

6. Waste collection containers should be placed in a secondary containment container/tray.

9. Signs and Labels

Signs

Signs of the following types shall be displayed in laboratory and laboratory support locations:

1. Location signs identifying safety showers, eyewash stations, other safety equipment, first aid equipment, and emergency exits.

2. Warnings in areas or on equipment where special or unusual hazards exist.

3. Cabinets, where flammable liquids are stored, must be labeled "FLAMMABLE LIQUID STORAGE" or "FLAMMABLE STORAGE".

4. The doors to those laboratories storing/using chemicals will utilize the NFPA diamond to identify to the PI, the principal hazard classes of chemicals, precautions for the fire department and facilities personnel.

5. Section 5 of this document lists important phone numbers and other information.

6. Laboratories having biological hazards or biohazards must have the appropriate biohazard signage.

Chemical Labels

All chemicals and solutions must have identity labels showing the contents of the containers and the associated hazards.

1. Never remove or deface labels on any chemical container. Should labels become difficult to read, the labels must be replaced. The labels must be written in English.

2. All chemical solution bottles should contain the name of the solution, the concentration and the date on the container.

3. For research labs, the synthesis of new compounds presents a challenge because the compound's structure and hazards may be unknown. Labeling of containers of these synthesized chemicals can be achieved by unique identifiers listed in the researcher's notebook.

10. Records

All injuries and chemical exposures shall be documented with the PI, the ESCC and the Safety & Security Department.

Attendance sheets or copies of, for those attending, must be submitted to the ESCC.

Chemical inventories will be conducted yearly and submitted to the ESCC by May 1 for the online SDS program to be updated.

11. Safety Data Sheets

Safety Data Sheets (SDS) are provided by manufacturers/suppliers for hazardous chemicals. SDS must be readily available for all chemicals used in the laboratory and needs to be provided to the employees or students at their request.

To obtain an SDS, locate the mSDS Source icon on any OTC computer. Search the SDS database from that point. The SDS can be printed if needed.

12. Laboratory Inspection

The ESCC routinely inspects laboratories to ensure compliance for OSHA and USEPA code. These inspections are normally a walkthrough process and if any issues are found, they can be either fixed by the investigator or brought to the attention of that laboratory's PI/supervisor about what changes need to be made for future compliance.

13. General Ventilation

OSHA requires the use of engineering controls to prevent exposures to laboratory employees. Although Section 14 provides information on local exhaust ventilation systems that can be used for hazardous chemicals, general ventilation is also required for locations where chemicals are stored and used. The following lists the required general ventilation needed in laboratory locations.

Standard	Comments
OSHA lab standard 29 CFR 1910.1450	OSHA's range is broad and normally adequate if local systems (fume hoods) are used as the primary method of control.

Laboratory-type hood or fume hood means a device located in a laboratory, enclosure on five sides with a moveable sash or fixed partial enclosed on the remaining side; constructed and maintained to draw air from the laboratory and to prevent or minimize the escape of air contaminants into the laboratory; and allows chemical manipulations to be conducted in the enclosure without insertion of any portion of the employee's body other than hands and arms.

14. Local Exhaust Systems

OSHA requires the use of engineering controls to prevent exposures to laboratory employees. Many chemicals should be used only with the appropriate local exhaust system (fume hoods, slot hoods, canopy hoods, glove boxes, etc.) to prevent inhalation exposures. By far, laboratory staff using a chemical fume hood as it is intended is the most important component of engineering control.

Fume Hood Face Velocity Measurements

1. Standard chemical fume hood face velocity shall be 100 ± 20 linear feet per minute (fpm) with the fume hood sash approximately 2/3 open (18-19.5” opening).

2. Low-flow or high-efficiency chemical fume hoods shall be 80 ± 10 linear feet per minute (fpm) with the fume hood sash approximately 2/3 open (18-19.5” opening) to comply with National Institute of Health requirements.

3. Green Technologies ductless chemical fume hoods shall be 60 ± 10 linear feet per minute (fpm) with the fume hood sash approximately 2/3 open (18-19.5" opening). This very low airflow was found acceptable because the filters were found to remove the low hazard chemical vapors from the airstream very effectively. **These hoods are limited to the use of chemicals that are effectively removed from the air.**

4. A sticker will be placed on the chemical fume hood indicating the date of the testing, the initials of the inspector, and an expiration date. If the chemical fume hood is found not to have an acceptable face velocity, the problem will be reported to the maintenance department for corrective action.

5. The face velocities of all chemical fume hoods are to be measured every 6 months.

Chemical Fume Hoods Not Meeting Standards

1. If a chemical fume hood is found NOT to be functioning properly, lab personnel must notify Maintenance immediately by submitting a work order request (otc.gofmx.com). A note must be placed on the fume hood stating “HOOD BROKEN, MAINTENANCE HAS BEEN CALLED” as a reminder to lab staff of the problem.

2. Upon notification that the chemical fume hood has been repaired, Maintenance is to notify the ESCC so the face velocity of the chemical fume hood can be rechecked. If the chemical fume hood still does NOT work or conform to standards, Maintenance will be notified immediately. Those chemical fume hoods that do not pass will have a sign posted on the sash stating, "DO NOT USE FUME HOOD".

Fume Hood Users

1. Do not work in a malfunctioning fume hood. If a hood does not appear to be working properly, faculty/staff can submit a work order request.

2. Check the inspection sticker on the hood to verify it has been inspected within the last 12 months. If it is over 12 months, inform the ESCC.

3. Use the chemical fume hood properly by:
   a. Always working at least 6” inside the chemical fume hood to ensure chemicals and vapors are not released into the lab.
   b. Do not use a fume hood with the sash higher than the approved working height which is 2/3 open.
   c. Keep items stored in a chemical fume hood to a minimum. The greater the number and size of the items, the higher the probability of the creation of a disruptive air flow that could generate chemicals and vapors into the lab.
   d. If large items must be used inside of a chemical fume hood (for example, a drying oven), place 2” blocks under the equipment to allow air to readily flow through the hood.
   e. Never place your head inside a chemical fume hood. Such action could result in chemical exposures.
   f. Chemical fume hoods are for the use of chemicals. Use a biological safety cabinet for the control of biological hazards.
   g. Do not modify your chemical fume hood. The installation of shelves on the side or back walls of the unit can compromise the air flow within the hood resulting in chemical exposures.
   h. All electrical appliances need to be plugged into outlets outside of a chemical fume hood. Never place a power strip within a chemical fume hood to permit plugging in appliances.
   i. Even though some protection may be afforded by the sash, eye protection is still required.

15. General Procedures for Working with Chemicals

The Chemical Hygiene Plan requires laboratory employees to know and follow laboratory rules and procedures. **In addition to the information provided in the preceding sections**, the following should also be followed.

General Rules for All Laboratory Work with Chemicals

The following rules are considered good laboratory practices and should be followed for all laboratory work with chemicals:

1. Equipment and Glassware
   a) Handle and store laboratory glassware with care to avoid damage. Discard clean damaged glassware immediately into the broken glass box.
   b) Do not use equipment with damaged or frayed electrical cords, wires, or plugs.

c) Do not use extension cords as permanent wiring. Never couple extension cords together. Never couple power strips together. Never attach an extension cord with a power strip.
d) Hose clamps are to be placed on all condenser water connections.
e) For procedures where equipment such as vacuum pumps might become chemically contaminated, a prefilter such as a cold trap, a scrubber, or a filtration system should be used. The exhaust should then be vented into a chemical fume hood. Decontaminate vacuum pumps or other contaminated equipment, including glassware, in a hood before removing them from the designated area.

2. Choice of Chemicals**:** Use only those chemicals for which the quality of the available ventilation system is appropriate.

3. Eating, Smoking, Etc.
   a. Eating, drinking, taking medications, smoking, chewing gum, applying cosmetics, or handling contact lenses in areas where laboratory chemicals are present is prohibited. Wash hands and any potentially exposed skin before leaving the lab to conduct these activities.
   b. Food and beverages must not be stored in refrigerators or freezers used for specimens or chemical storage. Laboratory glassware, utensils, and microwaves are not to be used for the storage, cooking, or consumption of food or beverages.
   c. The handling of cell phones while wearing gloves is not allowed.

4. Mouth Suction**:** Mouth suction for pipetting or starting a siphon is strictly prohibited.

5. Personal Apparel: Severe injuries and death have been reported to have occurred to lab personnel because their hair was caught in moving lab equipment or inappropriate clothing was worn. Although the PI/supervisor is responsible for having his/her personnel wear appropriate apparel, the College requires lab personnel, at a minimum:
   a. to confine or tie long hair and loose clothing;
   b. not wear dangling items (strings, neckties, long necklaces);
   c. utilize break-away lanyards for IDs;
   d. wear only shoes/sneakers that enclose the entire foot, preferably NOT made of a material that would readily absorb liquids;
   e. wear shoes that will protect your feet from chemical spills, broken glass, needles, blood, or other potentially infectious materials;
   f. wear lab coats over street clothes to minimize potential chemical contamination when working with chemicals;
   g. wear a flame retardant lab coat when working frequently with flammable and pyrophoric agents;
   h. wear eye and face protection as determined by the Standard Operating Procedure;
   i. wear hearing protection, when required.

6. Personal Housekeeping: Keep the work area clean and uncluttered. Chemicals and equipment should be properly labeled and stored. Clean up the work area on completion of an operation or at the end of each day.

7. Planning: Employees are to seek information and advice about hazards, plan appropriate protective procedures, and plan the positioning of equipment before beginning any new operation/protocol.

8. Unattended Operations: An appropriate sign (including an emergency contact person and phone number) is to be placed on the door for any unattended operation. Provisions for the containment of toxic substances in the event of failure of a utility service (such as cooling water) are to be made for all unattended operations.

9. Working Alone: A minimum of two employees must be present for procedures using chemicals of moderate, chronic, high acute toxicity, or high hazard chemical.

Work with Chemicals of Moderate Chronic or High Acute Toxicity

Examples of these materials include hydrofluoric acid, diisopropylfluorophosphate, hydrogen cyanide. The following supplemental rules, in addition to those listed in "general rules for all laboratory work with chemicals", are to be followed:

1. Location: Use and store these substances only in areas of restricted access with appropriate warning signs. Always use a chemical fume hood or another containment device for procedures that could result in the generation of aerosols or vapors containing the substance. Trap released vapors to prevent their discharge into the workspace by exhausting them into the hood exhaust.

2. Personal Protection**:** Always avoid skin contact by using gloves and other protective apparel, as established by the lab's SOP. Always wash hands and any potentially exposed skin immediately after working with these materials.

3. Prevention of Spills and Accidents: Be prepared for accidents and spills. Assure that at least 2 people are present at all times when using a highly toxic chemical or one of unknown toxicity. Containers of these substances are to be stored in chemically resistant trays, capable of holding 110% of the contents of the stored chemicals. Also, work and mount apparatus on trays, or cover work and storage surfaces with removable, absorbent, plastic backed paper. If a major spill occurs outside the hood, evacuate the area and notify the environmental coordinator of the location of the spill, the chemicals, and the quantities involved.

Work with Chemicals of High Chronic Toxicity

Examples of these materials include acroline, arsine, chlorine, diazomethane, diborane (gas), hydrogen cyanide, hydrogen fluoride, methyl fluorosulfonate, nickel carbonyl, nitrogen dioxide, osmium tetroxide, ozone, phosgene, sodium azide, sodium cyanide, carcinogens, and reproductive agents. Further supplemental rules to be followed, in addition to those listed previously in “general rules for all laboratory work with chemicals” & “work with chemicals of moderate chronic or high acute toxicity” above, include:

1. **Access:** Conduct all transfers and work with these substances in a "controlled area" - a restricted access hood, glove box, or portion of a lab designated for use of highly toxic substances for which all people with access are aware of the substances being used and necessary precautions.

2. **Non-Contamination/Decontamination:** Protect vacuum pumps against accidental contamination by using cold traps, scrubbers, or HEPA filters, and vent the exhaust into a fume hood. Decontaminate vacuum pumps or other contaminated equipment, including glassware, in the hood before removing them from the controlled area. The controlled area must be decontaminated before normal work is resumed there.

3. **Exiting:** Upon leaving a controlled area, reusable protective equipment must be decontaminated and any disposable protective apparel discarded in an appropriately labeled waste container. Hands and any potentially exposed skin surface must be washed thoroughly.

4. **Housekeeping:** For dry powders, use a wet mop or a vacuum cleaner equipped with a HEPA filter.

5. **Medical Surveillance:** If using toxicologically significant quantities of such a substance on a regular basis (e.g., 3 times per week), and where a potential for exposure exists, have regular medical surveillance.

6. **Records:** Users are to keep accurate records of the amounts of these substances stored and used, the dates of use, and the names of users.

7. **Signs and Labels:** Assure that the controlled area is conspicuously marked with warning and restricted access signs and that all containers of these substances are appropriately labeled with identity and warning labels.

8. **Spills:** Assure that contingency plans, equipment, and materials (spill kits) are available to minimize exposure to people and property are available.

9. **Storage:** Store containers of these chemicals only in a ventilated, limited access area inappropriately labeled, unbreakable, chemically resistant, secondary containers.

10. **Glove Boxes:** For a negative pressure glove box, ventilation rate must be at least 2 volume changes/hour and a negative air pressure at least 0.5 inches of water. For a positive pressure glove box, thoroughly check for leaks before each use. In

either case, trap the exit gases or filter them through a HEPA filter and then release them into a fume hood.

11. **Waste and Decontamination:** Prepare a plan for the disposal of these materials prior to use. Whenever possible; ensure that containers of contaminated waste (including washings from contaminated flasks) are transferred to the hazardous waste container for disposal through the Environmental Safety Coordinator.

16. Common Chemical and Physical Hazards in the Lab

Many chemicals or processes in laboratories present physical hazards that needs to be recognized and controlled. Serious injuries or death have occurred when certain chemical reactions release dangerous by-products (toxic gases) or result in a fire or an explosion. The Laboratory Safety Unit recommends the PI/supervisor train personnel for the safe use of these chemicals. Many of these chemicals should be handled following a written SOP.

Common Chemical Reactive Hazards

1. **Aluminum Chloride ($AlCl_3$):** Dangerous material if moisture is present. Decomposition can produce hydrogen chloride gas (HCl) and build up a pressure in a container. When opening a bottle of aluminum chloride, always cover the top with a heavy towel.

2. **Ammonia (NH_3):** Reacts with iodine to form nitrogen tri-iodide (a contact explosive). Reacts with the group of chemicals known as hypochlorites to produce chlorine. Do not mix with bleach. Ammonia mixed with organic halides can react violently when heated under pressure. Ammonia gas needs to be stored and used in an operational ventilated gas cabinet with the gas line extending into an operational chemical fume hood. Concentrated ammonium hydroxide solutions need to be used in an operational chemical fume hood.

3. **Aqua Regia (HNO_3 + 3HCl):** This mixture of nitric acid and hydrochloric acid is sometimes used to dissolve nanomaterials, noble metals or as a gas cleaner. This agent should be used only when other agents fail to dissolve the materials of concern or clean the intended glass item(s). Storage of this agent in a closed container can cause the container to rupture/fail. When the nitric acid in Aqua Regia begins to reduce, it evolves toxic nitrogen dioxide gas. Therefore, all uses of Aqua Regia need to be carried out in an operational chemical fume hood.

4. **Benzoyl Peroxide ($(C_6H_5CO_2)_2$):** Easily ignited and sensitive to shock. Spontaneously decomposes at temperatures above 50 degrees Celsius. Hazards can be minimized by the addition of 20% (V/V) water.

5. **Carbon Disulfide (CS_2):** Highly toxic and highly flammable. If open to the atmosphere, its vapors can be ignited by heat exceeding 80$^{\circ C}$ (from a hot plate, a

"hot" light bulb, a steam bath, etc.). Handle this agent in an operating chemical fume hood.

6. **Catalysts (Palladium or Platinum with carbon, Platinum oxide, Raney nickel, etc.):** When catalysts are used to generate certain catalytic hydrogenation reactions, such catalysts exposed to the air will ignite spontaneously. Keep such catalysts covered with water. When recovering a catalyst, place the material into a water bath immediately after completion of any filtration.

7. **Chlorine (Cl_2):** Reacts violently with hydrogen or with hydrocarbons in the presence of sunlight. Chlorine needs to be stored and used in an operational ventilated gas cabinet with the gas line extending into an operational chemical fume hood.

8. **Diazomethane (CH_2N_2) and Many Diazo Compounds:** These agents are very toxic and the pure form of the compounds explode readily. Solutions in ether are "safer". Solutions can be rendered harmless by the drop-wise addition of acetic acid.

9. **Diethyl zinc ($(C_2H_5)_2Zn$):** Because this agent is such a violent pyrophoric (air-reactive), water-reactive, and light-sensitive, it is normally sold in a mixture of toluene, hexane, or other organic solvents. Do not attempt to concentrate (keep the concentration below 1.1 molar) this agent by allowing the solvent to evaporate. Fires of this agent require the use of a Class D (dry powder) fire extinguisher or the use of soda ash or lime.

10. **Dimethyl Sulfoxide ($(CH_3)_2SO$):** Decomposed violently in the presence of halogen compounds. Explosions have been reported when this chemical is mixed with metal halides. Because this chemical readily penetrates the skin, it can carry any other chemical present through the skin as well.

11. **Dinitrophenols ($(NO_2)_2C_6H_3OH$):** These compounds are sensitive to friction, shock, and light and should never be allowed to dry. 2,4-dinitrophenol reacts with alkalis and ammonia to form explosive salts**. Dinitrophenols are explosive, they are subject to *Bureau of Alcohol, Tobacco, Firearms and Explosives* (ATF) regulations.** The ESCC must be contacted for the possession of dinitrophenol materials to ensure proper storage and quantity storage. Decomposition of these compounds can produce nitrogen oxides that can cause pulmonary edema and/or genetic changes.

12. **Dry Ice (CO_2, solid carbon dioxide):** Dry ice can produce severe skin burns. Dry ice will sublimate at room temperature to carbon dioxide gas. Do not store in walk-in cold rooms because sufficient gas can be generated to cause an oxygen-deficient atmosphere. Do not store in ultra-low freezers because the loss of power can result in the release of sufficient carbon dioxide gas to cause a pressure buildup that could result in a mechanical explosion.

13. **Fulminic Acid (HCNO):** Compounds containing the fulminate ion are highly unstable and are friction-sensitive explosive substances. **These compounds are subject to ATF regulations.** The ESCC must be contacted for the possession of mercury fulminate, silver fulminate, and fulminic acid to ensure proper storage and quantity storage.

14. **Grignard Reagents (R-Mg-X):** These alkyls- and aryl-magnesium halides are highly reactive with oxygen and carbonyls compounds. Exposure to moist air can result in spontaneous ignition. Handle Grignard reagents under inert atmospheres (argon or nitrogen) or in solvents such as ethyl ether or tetrahydrofuran.

15. **Halogenated Compounds:** Violent explosions can result when halogenated compounds (chloroform, methylene chloride, carbon tetrahydrofuran) are dried with sodium, potassium or other active metals.

16. **Hydrofluoric Acid (HF):** Hydrofluoric acid exposures can result in severe, deeply penetrating burns to the eyes, lungs, and skin. The concentrated form of these compounds can cause a burning sensation. Exposure to dilute solutions may not result in a burn sensation for several hours. This time delay between exposure recognition and treatment can lead to burns that are difficult to treat or other systemic complications. NEVER store hydrofluoric acid or its solutions in glass containers (always use polyethylene containers). Check containers annually and dispose of the old container of the acid upon the first indication of aging (hairline fractures in the plastic).

17. **Hydrogen Peroxide (H_2O_2):** Solutions of 30% or greater of hydrogen peroxide can cause severe skin burns. 30% hydrogen peroxide can decompose violently if mixed or become contaminated with iron, copper, chromium or their metal salts.

18. **Liquid Nitrogen (N_2):** Approximately one liter of liquid nitrogen will expand to roughly 700 liters of gas. Because of the thermal expansion, good general ventilation is mandatory when handling cryogenic materials to ensure oxygen-deficient atmosphere is not generated. Contact with skin tissue can result in severe burns in a very short period of time. Personnel must wear a face shield and thermal gloves.

19. **Lithium Aluminum Hydride ($LiAlH_4$):** Do not use this chemical to dry methyl ether or tetrahydrofuran (THF) or a fire may occur. An explosion can occur if mixed with carbon dioxide. Therefore, do not use a carbon dioxide fire extinguisher to put out a lithium aluminum hydride fire. Rather, use sand or a Class D fire extinguisher.

20. **Nitric Acid (NHO_3):** Because nitric acid is such a strong oxidizer, do not store nitric acid with organic acids (i.e., acetic acid or formic acid). Nitric acid will react explosively with organic substances (for example, acetic anhydride, acetone, acetonitrile, alcohols, benzene, methylene chloride, etc.). Nitric acid will react

violently with bases, reducing agents alkali metals, copper, phosphorous, and ammonia. Nitric acid can react on wood surfaces causing the wood to char.

21. **Nitrocellulose ($(C_6H_7O_{11}N_3)_4$):** Dry nitrocellulose (Guncotton, Parlodion, Pyroxylin) is explosive when subject to sudden shock or when heated. This agent needs to be maintained in the moistened state.

22. **Nitroglycerin $C_5H_3(NO_3)_3$:** Nitroglycerin in the dry state is a high explosive. Any nitroglycerin that may be present in a lab must be kept moist, usually by the addition of alcohol. **This agent is subject to ATF regulations.** The ESCC must be notified of the possession of this agent.

23. **Oxygen (O_2):** Oil or grease on either fittings or threads of an oxygen tank or a regulator can result in an explosion should the oxygen be turned on. Personnel is to inspect the threads of an oxygen tank and the regulator connection before mounting the regulator onto the tank. To minimize potential grease/oils on these surfaces, personnel are to wear disposable gloves. Do not use a soap solution to check for a gas leak from any connections.

24. **Ozone (O_3):** Ozone may be generated in a lab when certain ultraviolet sources are used. Such sources should be vented into a local exhaust system (fume hood, slot hood, canopy hood).

25. **Perchlorates (ClO_4):** Perchlorates when in contact with metals can result in an explosion hazard. Perchloric acid digestions must be carried out in a special perchlorate hood, equipped with wash down capabilities. Frequent washing of these hoods is needed to minimize the potential build-up of perchlorates in the duct. Heated (boiling) 70% perchloric acid in the presence of organic material will readily oxidize the organic material and could lead to an explosion. Do not use perchlorates as a drying agent or concentrate perchloric acid to concentrations greater than 70%.

26. **Permanganates (MnO_4):** Permanganates in the presence of sulfuric acid become explosive. Always keep permanganates separate from sulfuric acid in storage and in use.

27. **Peroxides ($R\text{-}O_2\text{-}R$):** Explosive mixtures are generated when inorganic peroxides come into contact with or are mixed with combustible materials, barium, sodium, or potassium.

28. **Phosphorus (P):** Explosive mixtures are generated when either red or white phosphorus comes into contact with or are mixed with oxidizing agents. Because white (yellow) phosphorus is pyrophoric, it needs to be stored under water. Phosphine, a highly toxic gas, is generated if phosphorus contacts or mixes with aqueous hydroxides.

29. **Phosphorus trichloride (PCl_3):** Phosphine, a highly toxic gas, can be generated if phosphorus trichloride reacts with water. Eye protection, a face shield, and gloves must be worn when opening containers of phosphorus trichloride.

30. **Picric Acid (dinitrophenol) and related compounds (dipicrylamine) ($C_6H_3N_3O_7$):** These compounds form explosive compounds when they come into contact with or are mixed with combustible materials. These compounds are relatively stable provided they are saturated with water. Should they dry (less than 10% water by weight), they are highly explosive and the containers must not be touched/disturbed except by a bomb squad. If these materials are stored in metal containers, highly explosive metal picric salts are generated.

31. **Piranha Solution (H_2SO_4+H_2O_2):** Piranha solutions are prepared by mixing sulfuric acid and hydrogen peroxide and when made, can generate heat over 100°^{C}. It is used to remove organic material from surfaces. Make only what is needed for immediate use and discard (as hazardous waste) any remaining as well as the used solution. NEVER STORE UNUSED SOLUTION.

32. **Potassium (K):** Potassium ignites quickly on exposure to humid air. Handle under the surface of mineral oil or kerosene (like sodium). Destroy any scraps of potassium by reacting them with n-butanol. Use a sand or Class D fire extinguisher on alkali fires (do NOT use a CO_2 extinguisher).

33. **Sodium (Na):** Sodium reacts violently with water to form hydrogen. The heat that is released can cause ignition. Keep sodium stored under kerosene, toluene, or mineral oil. Destroy any scraps of sodium by reacting them with n-butanol. Use a sand or Class D fire extinguisher on alkali fires (do NOT use a CO_2 extinguisher).

34. **Sodium Azide (NaN_3):** Sodium azide, even trace quantities, reacts with copper and lead to form explosive copper or lead azide. NEVER drain or dispose of solutions containing azide compounds. Rather, dispose of these solutions as hazardous waste. Sodium azide is highly toxic. Sodium azide can decompose explosively due to heat, shock, or friction. Sodium azide should never be mixed with nitric or sulfuric acid.

35. **Tertiary Butyl Lithium ($(CH_3)_3CLi$):** tert-butyl lithium is the most reactive of commercially available organo-lithium reagents. This is a pyrophoric chemical – it will spontaneously catch on fire when exposed to air. A dry chemical fire extinguisher is needed in the event of a t-butyl lithium fire. A written SOP must be followed for handling this agent.

36. **Trichloroethylene (C_2HCl_3):** Trichloroethylene is toxic. NEVER use this agent as a degreasing solvent. A mixture of trichloroethylene hydroxide (sodium or potassium) can spontaneously ignite in the air.

Physical Hazards in the Lab

1. **Autoclaves:** Steam sterilization of materials is a dependable procedure for the destruction of microbial life. The hot, pressurized steam that autoclaves create presents a serious burn hazard to users.

2. **Centrifuges:** Although centrifuges are typically used for the separation of biological materials, a number of chemicals are used with centrifuges. The use of cesium chloride gradients can present a hazard to the user should the load not be balanced or the rotors are used above the recommended speed for the density of the materials.

3. **Cold Rooms:** Because cold rooms do NOT have ventilation, personnel need to limit their use to about 2 hours per day to minimize the buildup of carbon dioxide. Compressed gases and solvents are not to be used in cold rooms.

4. **Electrical Hazards:** Electrically powered lab equipment pose a significant hazard to personnel. Even currents of 6 milliamps can be painful and ventricular fibrillation can occur at 1000 milliamps. Damaged electric cords/appliances must be taken out of service for repair by an electrician. Check outlets within 6 feet of a sink to verify outlets are GFCI protected.

5. **Glassware:** Check all glassware before use for cracks/damage. If damaged, discard immediately into a glass waste container.

6. **Hot Surfaces:** Continuously operating hot plates pose a burn hazard. Post a hazard sign to warn personnel of the hot surface.

7. **Lasers:** In addition to the intense coherent, collimated, and monochromatic light lasers generate, lasers can also present eye/skin damage, release particulates into the air, create potential exposures to carcinogens, make intense noise, and possible electrical shock hazards.

8. **Liquid Nitrogen Cooled Traps:** Should these traps become open to the atmosphere, atmospheric oxygen can condense within the trap resulting in the glass to shatter. If the trap contains organic materials, an explosion could occur.

9. **Magnetic Fields:** Intense magnetic fields can present a hazard to people with implanted medical devices. Signage will indicate locations that have a static magnetic field of 1.5 Tesla or a spatial gradient field of 1000 Gauss/cm.

10. **Parr Bombs:** Handle all bomb calorimeters as high-stress equipment. Such handling includes working with the unit while protected by a bench shield and while wearing eye protection.

11. **Pinch Points:** Belt driven equipment, such as vacuum pumps, must have a guard in place to prevent fingers/clothes from becoming entangled in the moving parts.

12. **Tubing:** Tubing (Tygon® and rubber) provide some flexibility when used. When tubing is used for hazardous gases (gas anesthesia or natural gas) check all connections for possible leakage.

13. **UV Light:** Exposure to UV light can result in adverse health effects that include erythema (sunburn), photokeratitis (a feeling of sand in the eyes), skin cancer, melanoma, cataracts, and retinal burns. UV lights may be found in germicidal lamps, biological safety cabinets, and transilluminators.

14. **Vacuum Distillation Residues:** Explosions can occur when a vacuum distillation still is vented to the air before the material has cooled. Always vent stills with nitrogen, allow the equipment to cool to room temperature, before venting.

Incompatible Chemicals

A wide variety of chemicals react dangerously when mixed with certain other materials. Some of the more widely used incompatible chemicals are given below, but the absence of a chemical from this list should not be taken to indicate that it is safe to mix with any other chemical.

Chemical	Incompatible Chemicals
acetic acid	Chromic acid, ethylene glycol, nitric acid, hydroxyl compounds, perchloric acid, peroxides, permanganates
acetone	concentrated sulfuric acid and nitric acid mixtures
acetylene	chlorine, bromine, copper, fluorine, silver, mercury
alkali and alkaline earth metals	water, chlorinated hydrocarbons, carbon dioxide, halogens, alcohols, aldehydes, ketones, acids
aluminum powder	chlorinated hydrocarbons, halogens, carbon dioxide, organic acids
anhydrous ammonia	mercury, chlorine, calcium hypochlorite, iodine, bromine, hydrofluoric acid
ammonium nitrate	acids, metal powders, flammable liquids, chlorates, nitrites, sulfur, finely divided organic combustible materials
aniline	nitric acid, hydrogen peroxide
arsenic compounds	reducing agents
azide	acids

Chemical	Incompatible Chemicals
bromine	ammonia, acetylene, butadiene, hydrocarbons, hydrogen, sodium, finely divided metals, turpentine, other hydrocarbons
calcium carbide	water, ethanol
calcium oxide	water
carbon activated	calcium hypochlorite, oxidizing agents
chlorates	ammonium salts, acids, metal powders, sulfur, finely divided organic or combustible materials
chromic acid	acetic acid, naphthalene, camphor, glycerin, turpentine, alcohols, flammable liquids
chlorine	ammonia, acetylene, butadiene, hydrocarbons, hydrogen, sodium, finely divided metals, turpentine, other hydrocarbons
chlorine dioxide	ammonia, methane, phosphine, hydrogen sulfide
copper	acetylene, hydrogen peroxide
cumene hydroperoxide	acids, organic or inorganic
cyanides	acids
flammable liquids	ammonium nitrate, chromic acid, hydrogen peroxide, nitric acid, sodium peroxide, halogens
hydrocarbons	fluorine, chlorine, bromine, chromic acid, sodium peroxide
hydrocyanic acid	nitric acid, alkali
hydrofluoric acid	aqueous or anhydrous ammonia
hydrogen peroxide	copper, chromium, iron, most metals or their salts, alcohols, acetone, organic materials, aniline, nitromethane, flammable liquids, oxidizing gases

Chemical	Incompatible Chemicals
hydrogen sulfide	fuming nitric acid, oxidizing gases
hypochlorite	acids, activated carbon
iodine	acetylene, ammonia (aqueous or anhydrous), hydrogen
mercury	acetylene, fulminic acid, ammonia
mercuric oxide	sulfur
nitrates	sulfuric acid
nitric acid concentrated	acetic acid, aniline, chromic acid, hydrocyanic acid, hydrogen sulfide, flammable liquids and gases
oxalic acid	silver, mercury
perchloric acid	acetic anhydride, bismuth and its alloys, ethanol, paper, wood
peroxides (organic)	acids, avoid friction or shock
phosphorous (white)	air, alkalis, reducing agents, oxygen, carbon tetrachloride, carbon dioxide, water, alcohols, acids
potassium	air, alkalis, reducing agents, oxygen, carbon tetrachloride, carbon dioxide, water, alcohols, acids
potassium chlorate	acids
potassium perchlorate	acids
potassium permanganate	glycerin, ethylene glycol, benzaldehyde, sulfuric acid

Chemical	Incompatible Chemicals
selenides	reducing agents
silver	acetylene, oxalic acid, tartaric acid, ammonium compounds, fulminic acid
sodium	carbon tetrachloride, carbon dioxide, water
sodium nitrate	ammonium salts
sodium peroxide	ethanol, methanol, glacial acetic acid, acetic anhydride, benzaldehyde, carbon disulfide, glycerin, ethylene glycol, ethyl acetate, methyl acetate, furfural
sulfides	acids
sulfuric acid	potassium chlorate, potassium perchlorate, potassium permanganate (or compounds with similar light metals, such as sodium, lithium, etc.
tellurides	reducing agents
zinc powder	sulfur

Potentially Explosive Chemical Reagent Combinations

Some chemical and reagent combinations have the potential for producing a violent explosion when subject to shock or friction.

The following tables list some common laboratory reagents that can produce explosions when they are brought together or that give reaction products that can explode without apparent external initiating action.

This list is not all-inclusive but includes the most common incompatible combinations.

Shock Sensitive Compounds

- Acetylenic compounds, especially polyacetylenes, haloacetylenes, and heavy metal salts of acetylenes (copper, silver, and mercury salts are particularly sensitive).
- Acyl nitrates, particularly polyol nitrates such as nitrocellulose and nitroglycerine Alkyl.

- Alkyl perchlorates
- Amminemetal oxosalts metal compounds with coordinated ammonia, hydrazine, or similar nitrogenous donors and ionic perchlorate, nitrate, permanganate, or other oxidizing groups.
- Azides, including metal, nonmetal, and organic azides. Chlorite salts of metals such as $AgClO_2$ and $Hg(ClO_2)_2$ Diazo compounds such as CH_2N_2.
- Diazonium salts, when dry
- Fulminates. Silver fulminate, AgCNO, can form in the reaction mixture from the Tolens' test for aldehydes if it is allowed to stand for some time; this can be prevented by adding dilute nitric acid to the test mixture as soon as the test has been completed.
- N-Nitro compounds such as N-nitromethalymine, nitrourea, nitroguanidine, and nitric amide hydrogen peroxide becomes increasingly treacherous as the concentration rises above 30%, forming explosive mixtures with organic materials and decomposing violently in the presence of traces of transition metals.
- N-Halogen compounds such as difluoroamino compounds and halogen azide.
- Oxo salts of nitrogenous bases perchlorates, dichromates, nitrates, iodates, chlorites, chlorates, and permanganates of ammonia, amines, hydroxylamine, guanidine, etc.
- Perchlorate salts. Most metal, non-metal, and amine perchlorates can be detonated and may undergo violent reaction in contact with combustible materials.
- Peroxides and hydroperoxides, organic peroxides, transition-metal salts.
- Picrate, especially salts of transition and heavy metals such as Ni, Pb, Hg, Cu, and Zn; picric acid is explosive but is less sensitive to shock or friction than its metal salts and is relatively safe as a water-wet paste.
- Polynitroalkyl compounds such as tetranitromethane and dinitroacetonitrile
- Polynitroaromatic compounds, especially polynitro hydrocarbons, phenols, and amines.
- Potentially Explosive Combinations of Common Reagents
- Acetone + chloroform in the presence of a base
- Acetylene + copper, silver, mercury or their salts
- Ammonia (including aqueous solutions) + Cl_2, Br_2, or I_2
- Carbon disulfide + sodium azide
- Chlorine + an alcohol
- Chloroform or carbon tetrachloride + powdered Al or Mg
- Decolorizing carbon + an oxidizing agent
- Diethyl ether + chlorine (including a chlorine atmosphere)
- Dimethyl sulfoxide + CrO_3
- Ethanol + calcium hypochlorite
- Ethanol + silver nitrate
- Nitric acid + acetic anhydride or acetic acid
- Picric acid + a heavy metal salt such as Pb, Hg, or Ag Silver oxide + Ammonia + ethanol Sodium + a chlorinated hydrocarbon
- Sodium hypochlorite + an amine

Basic Chemical Segregation

Class of Chemical	Recommended Storage Method	Examples	Incompatibilities See SDS in all cases
Compressed Gases - Flammable	Store in cool, dry area, away from oxidizing gases. Securely strap or chain cylinders to a wall or bench top	Methane, acetylene, propane	Oxidizing and toxic compressed gases, and oxidizing solids
Compressed Gasses - oxidizing	Store in cool, dry area, away from flammable gases and liquids. Securely strap or chain cylinders to a wall or bench top	Oxygen, chlorine, bromine	Flammable gases
Compressed Gases - poisonous	Store in cool, dry area, away from flammable gases and liquids. Securely strap or chain cylinders to a wall or bench top	Carbon monoxide, hydrogen sulfide	Flammable and/or oxidizing gases
Corrosive - acids	Store in a separate acid storage cabinet	Mineral acids - hydrochloric, sulfuric, nitric, perchloric, chromic, chromerge	Flammable liquids, Flammable solids, bases, oxidizers
Corrosive - bases	Store in a separate storage cabinet	Ammonium hydroxide, sodium hydroxide	Flammable liquids, oxidizers, poisons, and acids
Shock Sensitive Materials	Store in a secure location away from all other chemicals	Ammonium nitrate, nitrourea, picric acid (in a dry state), trinitroaniline, trinitroanisole, trinitrobenzene, trinitrobenzene sulfonic acid, trinitrobenzoic acid, nitrourea, picric acid (in a dry state), trinitroaniline, trinitroanisole, trinitrobenzene, trinitrobenzene sulfonic acid, trinitrobenzoic acid,dinitrochlorobenzene	Flammable liquids, oxidizers, poisons, acids, and bases

Class of Chemical	Recommended Storage Method	Examples	Incompatibilities See SDS in all cases
Flammable liquids	In a grounded flammable storage cabinet	Acetone, benzene, diethyl ether, methanol, ethanol, toluene, glacial acetic acid	acids, bases, oxidizers, and poisons
Flammable solids	Store in separate dry, cool area away from oxidizers, corrosives, and flammable liquids	phosphorus	acids, bases, oxidizers, and poisons
General Chemicals Non-reactive	Store on general laboratory benches or shelving preferably behind glass doors or below eye level.	Agar, sodium chloride, sodium bicarbonate, and most non-reactive salts	See SDS
Oxidizers	Store in spill tray inside a noncombustible cabinet, separate from flammable and combustible materials	Sodium hypochlorite, benzoyl peroxide, potassium permanganate, potassium chlorate, potassium dichromate. The following are considered oxidizers, peroxides, perchlorates, chlorates, nitrates, bromates, superoxides	Separate from reducing agents, flammables, and combustibles.
Poisons	Store separately in a vented, cool, dry area in unbreakable chemically resistant secondary containers	Cyanides, cadmium, mercury, osmium	Flammable liquids, acids, bases, and oxidizers
Water reactive chemicals	Store in dry, cool, location, protect from water	Sodium metal, potassium metal, lithium metal, and lithium aluminum hydride	Separate from all aqueous solutions and oxidizers