Reed College Chemical Hygiene Plan

June 2024

Table of Contents

1.0 Purpose and Scope

The Chemical Hygiene Plan (CHP) provides a standard to protect employees from health and safety hazards while working in laboratories. This plan supplements department-and laboratory-specific safety manuals, standard operating procedures, and lab-specific chemical hygiene plans that already address chemical safety in laboratories. Standard Operating Procedures (SOPs) that include safety information are very important when planning lab experiments. This general chemical hygiene plan along with safety data sheets (SDS) may be sufficient as the primary source of information for pre-planning certain simple lab activities or experiments. However, others may require surveying additional safety information and preparation of a SOP that describes the hazards of the activity or hazardous material(s) as well as the safety measures needed to control the hazards. Developing approved SOPs with safety information is especially important when the material or process possesses inherently higher hazards or is regulated by OSHA or another regulatory entity. When determining what chemical or process needs an SOP, start with materials and processes that have the most potential for fire, exposure or acute adverse health effects, or injury.

A template to develop your laboratory-specific standard operating procedures is given within Appendix F.

All laboratories engaged in laboratory use of hazardous chemicals or any other facility which operates on a laboratory scale shall adhere to the requirements stated in the Chemical Hygiene Plan and all related programs.

Exceptions

The “Occupational exposure to hazardous chemicals in laboratories” 29 CFR 1910.1450 does not apply to the following:

- Use of hazardous chemicals which do not meet the definition of laboratory use.[1]
- Laboratory use of hazardous chemicals which provide no potential for employee exposure.

While the OSHA standard 29 CFR 1910.1450 applies to employees only, Reed College requires that students and visitors also follow the safety practices mandatory for employees.

[1] defined by the OSHA as use of hazardous chemicals which A. occur on a laboratory scale B. involve multiple chemical procedures or chemicals C. are not involved in nor simulate a production process and D. wherein protective laboratory practices and equipment are available and in common use.

2.0 Responsibilities of Positions

2.1 Environmental Health and Safety Department (EHS)

EHS Staff are Chemical Hygiene Officers for the College and have the following responsibilities:

- Work with the laboratory community, administrators, and other employees to provide adequate facilities and to develop and implement appropriate policies and practices.
- Monitor procurement, use, and disposal of chemicals in laboratories.
- Maintain appropriate audits of laboratories, stockrooms, and storage spaces.
- Provide technical assistance for complying with the CHP and answer chemical safety questions for employees.
- Know the current legal requirements concerning regulated substances.
- Seek ways to improve the chemical hygiene program.
- Review and update the CHP annually and as needed with departmental members.
- Provide routine inspections of emergency equipment.

2.2 Reed College Administration

The President and other Officers of Reed College have ultimate responsibility for chemical hygiene and provide continuing support for institutional chemical hygiene.

2.3 Department Chairs

Department chairs are responsible for reviewing, evaluating, and distributing the CHP to other departmental employees annually and as needed.

2.4 Laboratory Supervisors

Laboratory supervisors carry the overall responsibility for chemical hygiene within the laboratory. Laboratory supervisors include principal investigators in academic labs, researchers in charge of research labs, laboratory instructors for laboratory-based classes, and stockroom managers supplying hazardous materials to their departments. For the program to be effective, these individuals will expand the plan to cover the hazards and safe work practices unique to each lab. These modifications must be in writing and maintained with the laboratory copy of this manual. A template to develop a laboratory-specific chemical hygiene plan is given in Appendix F. Other responsibilities include:

- Acquiring the necessary information to recognize and control chemical hazards in the laboratory.
- Knowing the signs and symptoms of overexposure, as well as the physical and sensory characteristics (odor, appearance) of particularly hazardous chemicals.
- Using appropriate laboratory practices and controls, such as properly functioning engineering and personal protective equipment (PPE), to reduce the potential for exposure to hazardous chemicals.

- Supervising the performance of staff and all other persons in the lab so that everyone understands and follows safe laboratory practices and procedures.
- Providing and documenting training for employees and others to recognize and control chemical hazards and follow standard procedures for dealing with accidents involving hazardous chemicals.
- Understanding the current legal requirements regulating hazardous substances used in the laboratory.
- Consulting with the Chemical Hygiene Officers (EHS) before purchasing or producing any particularly hazardous substances.

2.5 Laboratory Workers

- Plan and conduct each operation according to chemical hygiene procedures. This requires working knowledge of this written CHP.
- Develop appropriate personal chemical hygiene habits.
- Use the PPE provided, keep it in working order, and inform supervisors when new equipment is required.
- Report accidents/incidents to supervisors as soon as possible.
- Participate in training on recognizing and controlling hazards.

3.0 General Principles

The CHP recommends the following standard operating procedures: appropriate laboratory practices, engineering controls, and use of safeguards when working with hazardous chemicals. While these safeguards will help protect laboratory workers from unsafe conditions in most situations, there is no substitute for personal knowledge and vigilance when working with hazardous chemicals. In some instances, the proposed use of a particular chemical requires additional controls to protect the laboratory worker. Professional judgment is essential in the interpretation of these standard operating procedures. A principal investigator or other supervisor may determine a need for modifications to these procedures to meet their specific uses and operational needs. These modifications must be in writing and maintained with the laboratory copy of this manual.

In addition, workers need to wear clothing that provides adequate coverage when working in the laboratory. A lab coat is strongly recommended and often required for certain laboratory activities. Sandals, and other open-toed or open-backed shoes, provide insufficient protection in the laboratory. Protective safety glasses provide only minimum eye protection when working in the laboratory. American National Standards Institute (ANSI) Standard splash goggles are mandatory for eye protection if the possibility exists for exposure from corrosive chemicals or organic solvents.

Fume hoods provide the best protection from airborne substances released into the laboratory environment during normal laboratory operations. Some chemicals require the use of a fume hood due to their toxicity.

4.0 Laboratory Facilities

4.1 Design

Reed College designed the laboratory facilities to include the following:

- A room ventilation system with air intakes and exhausts located strategically to avoid intake of contaminated air.
- Well-ventilated stockrooms.
- Laboratory hoods and sinks.
- Other safety equipment including fire extinguishers, emergency eyewash stations and emergency showers.

4.2 Usage

The type and scale of work conducted must be appropriate for the physical facilities available and quality of ventilation.

4.3 Ventilation

General laboratory ventilation provides both a source of air for breathing and for local ventilation devices and prevents toxic substances from accumulating. Airflow is drawn into the laboratory from non-laboratory spaces and exhausted out to the exterior of the building. Normally 4 -12 room air changes per hour provide adequate ventilation if local exhaust systems, such as hoods, are the primary method of control. Modifications to ventilation systems are acceptable only after thorough testing indicates adequate worker protection from airborne toxic substances.

However, one should not rely upon general laboratory ventilation for protection from toxic substances released into the laboratory. For this, chemical fume hoods should be utilized. Chemical fume hoods should be operated with their sash at the lowest height feasible for work. Allow a minimum of three linear feet of hood space per person. The quality of general airflow should not be turbulent and should be relatively uniform throughout the laboratory with no high velocity or static areas. Other local ventilation devices, such as ventilated storage cabinets, canopy hoods, and snorkels, are available as needed. For more on chemical fume hoods, see Section 5.9 “Use of Fume Hoods.”

4.4 Maintenance

After equipment installation and evaluation by the installer, Reed College provides the following maintenance on general laboratory ventilation and equipment:

- **Ventilation**: EHS personnel check the function of all chemical fume hoods annually. Facilities Services maintenance staff perform preventative maintenance on chemical fume hoods twice a year and as needed.
- **Safety Eyewashes and Showers**: All eyewashes throughout campus are tested weekly by running the water to assure function and to clear rust and other debris. EHS personnel inspect and test safety showers monthly by running the water to assure function and clear rust and other debris.

5.0 Standard Operating Procedures Guidelines

The CHP requires that laboratory workers know and follow its rules and procedures. In addition to the procedures mentioned above, the following rules apply.

5.1 Avoiding Routine Exposure

- Do not smell or taste any chemical.
- Vent apparatuses, such as vacuum pumps, distillation columns, and other devices, that may discharge toxic chemicals into fume hoods.
- Inspect gloves for leaks before use.
- Do not allow the release of toxic materials into cold rooms because these rooms have contained and re-circulated atmospheres.
- Mouth pipetting of any material presents a danger and is forbidden. Do not start siphons using mouth suction.

5.2 Accidents and Spills

Report all on-the-job accidents and incidents (near accidents) to your supervisor immediately. You must fill out an "Accident/Incident Report" form. Employee injuries requiring time off work or doctor's care must be reported to the college using a State of Oregon Worker's and Employer's Report of Occupational Injury or Disease (Form 801), also available from the Human Resources Department.

Eye contact: Use the eyewash promptly to flush eyes with water for 15 minutes. Seek medical attention.

Skin contact: Promptly remove any contaminated clothing and flush the affected area with water for 15 minutes. If symptoms of exposure persist after washing, seek medical attention immediately. Remember that some chemical exposures may have a delayed adverse reaction. Always report incidents to supervisors. If your exposure involves hydrofluoric acid, immediately flush with water until skin is free from hydrofluoric acid then apply magnesium oxide or calcium gluconate gel, and go directly to the hospital.

Ingestion: Drink large amounts of water. Do not induce vomiting unless specifically instructed by SDS or another knowledgeable source, such as the Poison Control Center at 1-800-222-1222. If needed, contact community safety (503-788-6666, ext. 6666) or emergency responders (911 for fire, police, and ambulance).

Inhalation: Move to fresh air. If an exposed person is unable to help themself, move them to a safe area and check their breathing. Call community safety (503-788-6666) or 911 for emergency medical assistance and keep the affected person calm and comfortable.

Fire: Activate the fire alarm pull station to alert occupants of the need to evacuate.Call Community Safety (503-788-6666, ext. 6666) from a safe place whenever you activate an alarm.

Spills: Only knowledgeable and experienced personnel should clean up a chemical spill. Contact Community Safety (503-788-6666, ext. 6666) to get assistance.

- A **minor** chemical spill is one that the laboratory staff is capable of handling safely without the assistance of safety and emergency personnel. Each lab has a spill kit with instructions, absorbents, and protective equipment for this purpose.
    - Do not leave spills covered with absorbent materials or neutralizing agents.
    - Thoroughly clean-up all spills before leaving the scene, unless relieved by someone with more experience.
- All other chemical spills are considered major and require the activation of the institutional spill response policy. Those trained in spill clean-up, who know the hazardous properties of the chemical, can promptly clean-up spills using appropriate PPE and equipment, and use proper disposal methods.
- **Note: mercury** and **hydrofluoric acid spills** require special procedures for cleanup. For assistance with these and other complex, large, or unknown spill substances/products, call EHS personnel (503-777-7788 or 503-517-7931) or an on-call emergency responder via Community Safety (503-788-6666).

5.3 Eating, Drinking, & Smoking

Do not eat, drink, smoke, chew gum, or apply cosmetics in or near areas where laboratory chemicals are present. Wash hands before conducting these activities. Do not eat or drink with utensils or glassware that are for laboratory operations. Keep food and beverages in “food only” refrigerators.

5.4 Glassware and Equipment

Handle and store laboratory glassware with care to avoid damage. Do not use damaged glassware. Place chipped beakers, flasks, test tubes, etc. in a broken glass receptacle. Do not use severely etched glassware for high or low- pressure work. Use extra care with Dewar flasks and other evacuated glass apparatus; shield or wrap them to contain chemicals and fragments should implosion or explosion occur. Use equipment for its designated purpose only.

5.5 Before Exiting the Laboratory

Return all glassware, chemicals, and apparatus to appropriate locations. For ongoing operations left unattended for several hours or overnight, write instructions that include:

- Contents and hazards.
- Name of responsible party.
- Procedures for contacting the responsible party should a mishap occur.
- Provisions to contain any solid or liquid chemical released in the event of breakage.

Decontaminate the bench space. At a minimum, wash the space with clean water. If the possibility of contamination with toxic or corrosive materials exists, neutralize or use other decontamination methods. In addition to the laboratory space, individuals must thoroughly wash areas of exposed skin before exiting the laboratory.

5.6 Horseplay

Do not play practical jokes, horseplay, or do other behavior that might confuse, startle, or distract another lab worker. Any of these inappropriate behaviors will result in removal from the laboratory setting.

5.7 Personal Protection

Personal apparel: Confine long hair and loose clothing. Wear shoes at all times in the laboratory. Never wear sandals, perforated, open toed, and open heeled shoes in any laboratory.

Eye Protection: All persons including visitors, who are in areas where chemicals are stored or handled, must wear appropriate eye protection. At a minimum, wear protective glasses. If the potential for splashes of corrosive chemicals or organic solvents exists, you must wear chemical splash goggles that meet the ANSI Z87.1-1989 standards.

Skin Protection: Wear a lab coat and clothing adequate to protect the legs from splashes and spills. Clean or discard laboratory coats upon significant contamination. Each laboratory will provide PPE compatible with the required degree of protection for each of the four main hazards – chemical, abrasions, cutting, and heat.

Wear appropriate gloves, especially when the potential for contact with toxic or corrosive materials exists. Consult SDSs and the Chemical Resistance Guide (Appendix A) to ensure the appropriate choice of glove material for use with each chemical. Inspect the gloves before each use. Replace gloves periodically, depending on frequency of use and permeability to the substance(s) handled. Rinse overtly contaminated gloves and then carefully remove after use. **Note**: Because of the occurrence of latex allergies, disposable nitrile gloves have replaced latex gloves for general use in the labs.

Wear gloves whenever it is necessary to handle rough or sharp-edged objects and very hot or very cold materials. The types of glove materials for these situations include leather, welder's gloves, aluminum-backed gloves, and other types of insulated glove materials.

Remember to protect your hands when working with tools and machinery with high rpm's such as a centrifuge or homogenizer. Power tools and machinery must have guards installed or incorporated into their design that prevent the hands from contacting the point of operation, power train, or other moving parts. To protect hands from injury from moving parts, it is important to do the following:

- Ensure that guards are always in place and used.
- Always lock out machines or tools and disconnect the power before making repairs.
- Treat a machine without a guard as inoperative.
- Use caution when wearing gloves around high rpm machinery.

The following lists the most common types of protective work gloves and the types of hazards they can guard against:

- Chemical Resistance Gloves – protect hands from corrosives, oils, and solvents; made from rubber, neoprene, polyvinyl alcohol, vinyl, or nitrile – the most common type found on campus.
- Disposable Gloves – guard against mild irritants; usually made of lightweight plastic.
- Fabric Gloves – generally used to improve grip when handling slippery objects and may help insulate hands from mild heat or cold; made of cotton or fabric blends.
- Leather Gloves – protect against injuries from sparks, heat, cold, scraping against rough surfaces; use in combination with an insulated liner when working with electricity.

- Metal Mesh Gloves –protect hands from accidental cuts and scratches while working with cutting tools or other sharp instruments.
- Aluminized Gloves – insulate hands from intense heat when working molten materials.

Respiratory Protection: Reed College uses engineering controls, such as fume hoods, to contain hazardous atmospheres. In the case of a spill or accident that creates a hazardous atmosphere, evacuate the building. Normal laboratory procedures should not result in atmospheres that require the use of a respirator. However, before employees use respiratory protection for normal laboratory procedures, investigate ventilation alternatives. All wearers of respirators must be familiar with Reed College's Respiratory Protection Program and complete a medical examination, respirator fit test, and training before wearing a respirator. Respirators should not be used to filter air if contaminant levels are below the PEL or TLV (see "Definitions" in Appendix D), unless all other avenues have been used or ruled-out.

5.8 Planning

Review all hazard information before beginning work with any hazardous material. SDSs are a good source of information and are required for all hazardous substances. SDSs are available for reference in departmental stockrooms, in the EHS office, and at reed.edu/ehs. For other sources of hazard information, waste disposal information, and laboratory safety information, see the references at the beginning of this document.

Always plan protective procedures before beginning work, for example:

- Have a supply of dry sand handy when working with water reactive materials.
- Use an explosion shield as a safety measure when appropriate.
- Use a glove box with an inert atmosphere when using air reactive materials.
- Plan equipment positioning before beginning work to ensure adequate bench space and to prevent breakage of unsupported apparatus.
- Check SDSs and use recommended PPE.

5.9 Use of Fume Hoods

Conduct all laboratory work in a fume hood, glove box, or similar device when:

- Systems use or produce toxic chemical vapors or dust, e.g., cyanides and chlorinated hydrocarbons.
- Action levels or worker exposure limits may be exceeded.
- Working with any appreciably volatile substance (as a general rule, a TLV ≤ 50 ppm).
- Working with chemicals that are malodorous (unpleasant to smell), such as isocyanides.
- Temporarily storing certain types of toxic chemicals, usually volatile toxic chemicals. Examples include acetyl chloride, thionyl chlorides, and acid halides in general; concentrated hydrochloric and concentrated nitric acids; and cylinders of toxic gasses such as carbon monoxide, nickel carbonyl, NOCl, NO_2, HCl, SO_2, H_2S, and phosgene.

Other use guidelines:

- Use a higher level of containment (such as a glove box) to protect against even minor contamination.
- If you are in doubt about the level of containment needed for your operation, ask the principal investigator, lab supervisor, or contact EHS personnel (503- 777-7788 or 503-517-7931).
- Confirm adequate hood performance before use.
- Keep materials stored in the hood to a minimum.
- Keep the front 6 inches at the front of the hood clear of all work and equipment. This minimizes the possibility of contaminants escaping from the hood.
- Any apparatus housed within the hood should fit completely inside.
- Operate the hood at a sash position that will provide splash protection for the user; e.g., keep sash heights to a minimum.
- Leave the hood in the "on" position if toxic substances are stored in it or if there is uncertainty about maintaining adequate general laboratory ventilation when it is "off."
- When working in a hood with two power settings, use the one marked “high” (green light).
- Avoid fans, window air conditioning units, or excessive movement that can cause air turbulence across the face of the hood.
- Place an “out of order” sign on the hood and contact EHS personnel (503-777- 7788 or 503-517-7931) if you suspect the hood is not working properly.

5.10 Working Alone

Do not work alone in the laboratory when conducting hazardous procedures. **Always have at least two people present** when using a highly toxic chemical or one of unknown toxicity.

6.0 Chemical Procurement, Storage, and Disposal

6.1 Choice of Chemicals

All chemicals already present on campus are inventoried in our online inventory system. In this system, you can find the location of chemicals and access the SDS for each chemical. If there is a chemical present on campus that is not included in the inventory system, please contact EHS@reed.edu.

Carefully choose chemicals based on ventilation, fire codes, and PPE. Know the proper handling, special precautions, storage, and disposal of a substance before it is ordered.

The use of high toxicity chemicals (chemicals that pose a special risk or require special hazardous materials handling) is strongly discouraged, especially in teaching laboratories. In general, select the least toxic chemical for each laboratory procedure.

Simplify procedures in order to limit exposures and decrease the high cost of waste disposal. If any substance requires special hazardous materials handling, consult with EHS personnel (503-777-7788 or 503-517-7931) before ordering.

6.2 Procurement

The stockroom manager will maintain information concerning the quantity and storage locations of chemicals. The manager will inform EHS, facilitate the distribution of SDSs (available through our inventory system), and keep hazardous materials inventories up to date.

6.3 Distribution

Before obtaining chemicals from stockrooms, students and employees must read the SDSs to familiarize themselves with the associated hazards. Do not accept any container without an adequate identifying label.

When hand carrying chemicals, place the container inside another container or bucket. Always handle gas cylinders as if they were full. Use only approved gas cylinder carts to transport cylinders (other than small cylinders and lecture bottles). Before moving the cylinder, turn off the valve, remove the regulator, and replace the cap. Secure all gas cylinders by means of a strap, chain, or other restraining device during transport, storage, and use.

6.4 Stockroom Storage

General chemical storage plans should take into account chemical incompatibilities. Use all appropriate means for safe storage including segregation, separation, and secondary containment. For example, segregate toxic substances and reactive chemicals in well-identified areas with local exhaust ventilation. The State Fire Marshal's Office requires this information for the annual "Hazardous Substance Information Survey," as well as the Portland Fire Bureau during their annual review of the facility.

See Appendix E for suggested storage shelf patterns. Examine stored chemicals at least annually for deterioration and container integrity, and replace those indicated. Pay special attention to chemicals that form organic peroxides (see Appendix C). Label peroxide-forming chemicals as such and store them away from heat and sunlight. Test stored peroxide-forming chemicals annually for organic peroxides before each use.

6.5 Laboratory Storage

The amounts of hazardous chemicals permitted in laboratories should be as small as possible and must comply with federal, state, and local safety and fire regulations. Do not store hazardous chemicals on bench tops, inside hoods, or above eye level. Follow the guidelines in Appendix E for segregating incompatible chemicals. Provide anti-roll-off lips on all shelves.

Return unused chemicals to the stockroom. Use flammable storage and acid storage cabinets as indicated. Never store chemicals on the floor.

6.6 Waste Disposal

Collect waste in clearly labeled containers. The label description should include the chemical name (no abbreviations), your department, and your location. Unlabeled chemical waste creates serious problems for our waste disposal personnel.

Only a small number of substances may be safely and legally disposed of by pouring them down the drain or placing them in the trash. If you are unsure whether a substance can legally be disposed of down the drain, in the trash, or as hazardous waste, bring the appropriately labeled container to the EHS waste room in Chemistry 211.

Do not discharge to the sink any substances with the following properties:

- Substances having a pH less than 5.5 or more than 9.
- Water insoluble materials.
- Highly toxic, malodorous, or lachrymatory substances.
- Substances which might interfere with the biological activity of wastewater treatment plants.
- Substances that can cause fire or explosion hazards.
- Substances that can cause structural damage or obstruct flow.

The following items are considered non-hazardous. Collect them in disposable containers or plastic bags, **clearly labeled as non-hazardous waste, and put into the regular trash**. If you are unsure whether any of these or other chemicals should go into the regular trash, consult with EHS.

- Organic chemicals – Solids only, no liquids
    - Acetates: Ca, Na, NH_4, and K
    - Amino acids and their salts
    - Citric acid and salts of Na, K, Mg, Ca, and NH_4
    - Lactic acid and salts of Na, K, Mg, Ca, and NH_4 Sugars

- Inorganic chemicals – Solids only, no liquids
    - Bicarbonates: Na, K
    - Borates: Na, K, Mg, Ca
    - Bromides: Na, K
    - Carbonates: Mg, Ca
    - Chlorides: Na, K, Mg, Ca
    - Fluorides: Ca
    - Iodides: Na, K
    - Oxides: B, Mg, Ca, Al, Si, Fe
    - Phosphates: K, Mg, Ca, NH_4

    - Silicates: K, Mg, Ca
    - Sulfates: Na, K, Mg, Ca, NH_4

- Laboratory Materials, such as:
    - Chromatographic adsorbents
    - Filter paper **without** hazardous chemical residue
    - Uncontaminated glassware
    - Uncontaminated gloves

For questions or more information, refer to the Reed College Hazardous Waste Management Policy or call EHS personnel (503-777-7788 or 503-517-7931).

7.0 Environmental Monitoring

Monitoring may be appropriate when storing or regularly using (e.g. 3 times or more per week) a highly toxic substance, or if there is reason to believe that exposure levels for any substance exceed the action level or permissible exposure limit.

8.0 Medical Program

8.1 Routine Surveillance

Any employee requiring use of respiratory protection for 30 days or more per year will receive medical surveillance at no cost to the employee.

8.2 Medical Surveillance

Anyone whose work involves regular and frequent handling of toxicologically significant quantities of a chemical should consult a qualified physician to determine, on an individual basis, whether a regular schedule of medical surveillance is desirable. Consult EHS and/or Human Resources to obtain the name of a qualified physician specializing in occupational medicine.

8.3 First Aid

Community Safety Officers are trained in CPR and First Aid and are available 24-hours a day by calling 503-788-6666 and can assist anyone on campus.

For **students**, Reed College Health & Counseling Services provides First Aid during open hours (Mon.-Fri. 9:00 am to 5:00 pm).

For **employees,** the closest hospital is:
Providence Medical Center Emergency, located at 4805 NE Glisan.

- Go north on Césare Chávez Blvd to the roundabout at NE Glisan, (five blocks north of Burnside).
- Turn right onto NE Glisan, and continue east to 47th Avenue.
- Turn left onto 47th and travel 1/2 block.
- Turn right to the Emergency Room parking area.

9.0 Signs and Labels

Prominent signs and labels include:

- Emergency contact telephone numbers for personnel/facilities, supervisors, and laboratory workers.
- Container labels showing their contents and associated hazards.
- Location signs indicating safety showers, eyewash stations, other safety and first aid equipment, exits, and areas where food and beverage consumption and storage are permitted and prohibited.
- National Fire Protection Association (NFPA) labels and warnings wherever special or unusual hazards exist.

10.0 Working with Particularly Hazardous Substances

"Particularly Hazardous Substances" include select carcinogens, reproductive toxins, and substances that have a high degree of acute toxicity. Consult SDSs and ANSI standards to ensure that the appropriate protective gear is in use. Avoid exposure to these toxic substances via various routes by using all reasonable precautions:

- Have at least two people present at all times.
- Always work in a designated area.
- Always use fume hoods, glove boxes, proper PPE, such as chemically compatible gloves, long sleeves, goggles, and other equipment as recommended.
- Protect surfaces from contamination.
- Use mechanical pipetting aids for all pipetting procedures. *Never use a mouth pipette*.
- Have appropriate measures in place for decontamination.
- Wash hands and arms immediately after working with these materials.
- Report all accidents, incidents, and near misses (those unplanned events that did not result in injury, illness, or damage – but had the potential to do so) to your supervisor and file a Reed College accident/incident form.
- Consult a qualified physician when appropriate.

10.1 Allergens

Allergens, substances that cause allergic reactions, and include isocyanates, penicillin, enzymes, aniline, bichromates, diazomethane, and latex among others. Because individuals may differ widely in their tendency towards sensitization to allergens, regard sensitizing compounds as highly toxic agents. Once sensitized to an allergen, subsequent contact to an extremely small quantity can lead to immediate or delayed allergic reactions. These may occur despite personal protection measures deemed adequate to protect against the acute effects of chemicals. Always wear suitable gloves to prevent hand contact with allergens or substances of unknown allergenic activity.

10.2 Embryotoxins

Embryotoxins have adverse effects on the embryo, especially during the first trimester of pregnancy. Examples include formamide, organomercurials, and lead compounds. The chemical hygiene officer will review annually the continuing uses of each of these materials and recommend any procedural changes. Women of childbearing age must use the following special procedures:

- Handle embryotoxins only in a fume hood with confirmed satisfactory performance and use appropriate protective apparel (especially gloves) to prevent skin contact.
- Store these substances, properly labeled, in an adequately ventilated area in an unbreakable secondary container.
- Report all incidents of exposure or spills to supervisors. Consult a qualified physician when appropriate.

10.3 Chemicals of Moderate Chronic or High Acute Toxicity

Exposure to substances with moderate chronic effects becomes evident only after repeated exposures and a long latency period, while chemicals of acute toxicity cause a harmful effect after a single exposure. Highly toxic chemicals fall within any of the following categories:

- A chemical that has a median lethal dose (LD50) less than 50 milligrams per kilogram of body weight (oral).
- A chemical that has a median lethal dose (LD50) less than 200 milligrams per kilogram of body weight (skin/dermal).
- A chemical that has a median lethal concentration (LC50) in air less than 500 parts per million (ppm) by volume (gas), or less than 2 milligrams per liter (vapor), or less than 0.5 milligrams per liter (mist, fume, or dust).

When working with these products, do the following:

- Always use a hood with these substances.
- Minimize exposure to these substances by using all reasonable precautions.
- Restrict access, use, and storage of these substances. Label them with special warnings.

- Use appropriate PPE such as gloves and long sleeves to avoid skin contact.
- Wash hands and arms immediately after working with these materials.
- Collect contaminated wastes and animal carcasses in impervious containers. Decontaminate them before removal from the work area. Properly labeled “biohazard” boxes are available from EHS or Chemistry room 211. The off-site disposal of this waste is the responsibility of EHS.

10.4 Chemicals of High Chronic Toxicity, Including Known and Suspected Carcinogens

In addition to the guidelines for chemicals of moderate chronic or high acute toxicity, the following rules apply for work with substances of known high chronic toxicity in quantities above a few milligrams to a few grams, depending on the substance (see Appendix B for a list of these chemicals).

Access
Conduct all transfers and work with these substances in a "controlled area," such as a restricted access hood, glove box, or portion of a lab designated for use of highly toxic substances. Inform all people with access to the substances used and their precautions. A current inventory of carcinogens is required.

Glove Boxes
For a negative pressure glove box, the ventilation rate must be at least two volume changes per hour with 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 gasses or filter them through a HEPA filter and then release them into the hood.

Decontamination
Decontaminate vacuum pumps and all other contaminated equipment in the hood before removing them from the controlled area. Decontaminate the controlled area before resuming normal work. Inactivate all other forms of the carcinogen before disposal.

Exiting
Remove any protective apparel and place it in an appropriately labeled container when leaving a controlled area. Thoroughly wash forearms, face, hands, and neck.

10.5 Additional Oregon Rules for Carcinogens in Laboratories (OAR 437-02- 391)

- Protect surfaces from carcinogen contamination.
- Protect laboratory vacuum systems with a disposal filter capable of retaining 99.97% of a monodisperse aerosol of 0.3µm particles (absolute filter).

- Laboratories where carcinogens are handled and bioassays performed shall be under negative pressure in relation to the pressure in surrounding areas.
- There shall be no connection between regulated areas and other areas through the ventilation system.
- For employees engaged in animal support activities:
    - Each day get clean and complete protective clothing to wear, including coveralls or pants and shirt, foot covers, gloves, and appropriate respiratory protection, if needed.
    - Before exiting from a regulated area, remove and leave protective clothing and equipment at the point of exit. At the last exit of the day, place used clothing and equipment in impervious containers for the purpose of decontamination or disposal.
    - Wash hands, forearms, face, and neck upon each exit from the regulated area and before engaging in other activities.
    - Take a shower after the last exit of the day.
- For employees not engaged in animal support activities:
    - Wear a clean change of appropriate laboratory clothing, such as a solid front gown, or full-buttoned laboratory coat.
    - Remove and properly store protective clothing and equipment before exiting from a regulated area. At the last exit of the day, place used clothing and equipment in impervious containers for the purpose of decontamination or disposal.
    - Wash hands, forearms, face, and neck upon each exit from the regulated area and before engaging in other activities.

Appendix B includes the definition and a list of these chemicals.

11.0 References

- Occupational Safety and Health Administration (OSHA). 29 CFR 1910.1450. Occupational Exposure to Hazardous Chemicals in the Laboratories. March 2012.
- Oregon Occupational Safety and Health Administration (OR-OSHA). Oregon Administrative Rules (OAR) 437-002-0391. Additional Oregon Rules for Carcinogens in Laboratories. 1993.
- Prudent Practices in the Laboratory: Handling and Disposal of Chemicals. Washington, DC. National Academy Press. 2011.
- U.S. Department of Health and Human Services. Public Health Service. National Toxicology Program. Report on Carcinogens. 13th edition. 2014.
- Working Safely with Hazardous Substances: Your Right to Know. Portland, OR, Reed College Environmental Health and Safety Office. April 2014.
- Flinn Catalog/Reference Manual. Batavia, IL. Flinn Scientific. 2015.

Appendix A: Chemical Resistance Guide

ASTM Breakthrough Times and CPC Rating
ASTM F739-91 Normalized Breakthrough in Minutes and CPC Rating for Best Gloves

Breakthrough detection times (BDT) are given in minutes. The Chemical Protective Clothing Performance Index Rating Summary (CPC) is based on the system of Forsberg that relies on both breakthrough times and permeation rates to establish a rating system for chemical protective clothing.1 The ratings range from 0 to 5 with 0 being the best and 5 the worst:

0 - Best safest selection for unlimited exposure (no breakthrough)
1 - Next best selection for unlimited exposure.
2 - Sometimes satisfactory (good for limited exposure).
3 - Poor choice (not for heavy exposure).
4 - Very poor (for splashes only).
5 - Not recommended

"ND" indicates "non detectable." No breakthrough detected after eight hours. "NR" indicates "not recommended."

Chemicals by Class	**Neoprene**		**Nitrile**		**Rubber**		**PVC**		**Butyl**		**Viton**	
	BDT	CPC	BDT	CPC	BDT	CPC	BDT	CPC	BDT	CPC	BDT	CPC
Aliphatic Solvents												
Cyclohexane	21	2	9	0	55	5	13	3	ND	4	NR	0
Gasoline (Unleaded)	46	3	46	0	NR	5	22	3	NR	5	ND	0
Heptane	ND	0	ND	0	24	3	39	4	23	4	ND	0
Hexane	173	2	234	0	21	4	29	3	13	5	ND	0
Isooctane	ND	0	ND	0	57	3	114	3	56	4	ND	0
Kerosene	ND	0	ND	0	NR	5	ND	0	94	4	ND	0
Petroleum Ethers	99	2	ND	0	5	5	19	4	15	4	ND	0
Acids, Organic												
Acetic 84%	ND	0	240	5	ND	0	300	2	ND	0	ND	0
Formic 90%	ND	0	75	0	ND	0	ND	0	ND	0	120	0
Acids, Mineral												
Battery 47%	ND	0	ND	0	ND	0	ND	0	ND	0	ND	0
Hydrochloric 37%	ND	0	ND	0	ND	0	ND	0	ND	0	ND	0
Hydrofluoric 48%	ND	0	60	3	45	3	110	2	ND	0	185	1
Muriatic 10%	ND	0	ND	0	ND	0	ND	4	ND	0	ND	0
Nitric 70%	ND	0	NR	5	ND	0	240	5	ND	0	ND	0
Sulfuric 97%	ND	0	180	3	ND	0	210	5	ND	0	ND	0

Chemicals by Class	Neoprene		Nitrile		Rubber		PVC		Butyl		Viton	
	BDT	CPC	BDT	CPC	BDT	CPC	BDT	CPC	BDT	CPC	BDT	CPC
Alcohols												
Amyl	ND	0	ND	0	ND	0	116	2	ND	0	ND	0
Butyl	ND	0	ND	0	ND	0	155	2	ND	0	ND	0
Cresols	ND	0	NR	5	371	2	ND	0	ND	0	ND	0
Ethyl	ND	0	225	4	ND	0	66	2	ND	0	ND	0
Methyl	226	1	28	3	82	2	39	4	ND	0	ND	0
Isobutyl	ND	0	ND	0	ND	0	ND	0	ND	0	ND	0
Aldehydes												
Acetaldehyde	21	3	NR	5	55	3	13	5	ND	0	NR	5
Benzaldehyde	93	3	NR	5	81	3	NR	5	ND	0	ND	0
Formaldehyde	ND	0	ND	0	ND	0	ND	0	ND	0	ND	0
Furfural	165	2	NR	5	ND	0	85	3	ND	0	298	3
Alkalis												
Ammonium Hydroxide	ND	0	240	3	120	3	60	4	ND	0	ND	0
Potassium Hydroxide	ND	0	ND	0	ND	0	ND	0	ND	0	ND	0
Sodium Hydroxide	ND	0	ND	0	ND	0	ND	0	ND	0	ND	0
Amides												
Dimethylacetamide	84	3	NR	5	29	4	51	4	ND	0	NR	5
Dimethylformamide	100	3	NR	5	ND	0	NR	5	ND	0	NR	5
N-MethylPyrrolidone	ND	0	34	3	ND	0	140	4	ND	0	NR	5
Amines												
Aniline	32	3	NR	5	1	4	71	3	ND	0	ND	0
Butylamine	NR	5	NR	5	45	3	15	3	45	3	NR	5
Diethylamine	23	5	60	5	60	5	107	4	30	3	9	5
Aromatic Solvents												
Benzene	15	5	16	4	NR	5	13	5	34	4	ND	0
Toluene	25	4	26	4	NR	5	19	4	22	4	ND	0
Xylene	37	4	41	4	NR	5	23	3	NR	5	ND	0
Chlorinated Solvents												
Carbon Tetrachloride	73	4	ND	0	NR	5	46	4	53	4	ND	0
Chloroform Methylene	23	4	6	5	NR	5	10	5	21	4	ND	0
Chloride	NR	5	4	5	NR	5	NR	5	20	4	113	3
Perchloroethylene	40	4	ND	0	NR	5	NR	5	28	4	ND	0
Trichloroethylene	12	5	9	5	NR	5	NR	5	13	5	ND	0
1,1,1-Trichloroethane	51	4	49	4	NR	5	52	3	72	4	ND	0

Chemicals by Class	Neoprene		Nitrile		Rubber		PVC		Butyl		Viton	
	BDT	CPC	BDT	CPC	BDT	CPC	BDT	CPC	BDT	CPC	BDT	CPC
Esters												
Amyl Acetate	110	3	77	4	NR	5	NR	5	158	3	NR	5
Ethyl Acetate	12	5	33	4	11	5	14	5	19	5	29	5
Methyl Methacrylate	27	3	NR	5	77	3	NR	5	63	3	NR	5
Ethers												
Cellosolve Acetate	228	3	47	4	107	3	64	4	ND	0	NR	5
Ethyl Ether	12	5	33	4	11	5	14	5	19	5	29	5
Tetrahydrofuran	13	5	5	5	NR	5	NR	5	24	4	NR	5
Gases												
Ammonia, Anhydrous	29	2	336	1	4	4	19	3	ND	0	ND	0
1,3-Butadiene Chlorine	33	3	ND	0	25	3	24	3	473	2	ND	0
Ethylene Oxide	ND	0	ND	0	ND	0	360	2	ND	0	ND	0
Hydrogen Fluoride	21	4	17	5	1	5	1	5	189	2	48	4
Methyl Chloride	210	2	1	5	142	1	1	5	ND	0	6	3
Vinyl Chloride	84	1	ND	0	52	2	ND	0	ND	0	ND	0
1,1,1-Trichloroethane	7	4	ND	0	2	4	19	3	268	1	ND	0
Ketones												
Acetone	35	3	3	5	9	5	7	5	ND	0	NR	5
Methyl Ethyl Ketone	30	3	NR	5	12	5	NR	5	202	2	NR	5
Methyl Isobutyl Ketone	41	3	5	5	38	4	NR	5	292	2	NR	5
Nitriles												
	65	3	6	5	16	3	24	4	ND	0	NR	5
	27	3	NR	5	48	3	14	5	ND	0	55	4

Reference: Forsberg and Keith (1997), Chemical Protective Clothing Performance Index Book. John Wiley and Sons. Best Manufacturing Company provided this information, which is applicable only to Best gloves.

Appendix B: Select Carcinogens

For the purposes of the Laboratory Standard, OSHA defines select carcinogens as any substance that meets one of the following criteria:

- OSHA regulates it as a carcinogen.
- The National Toxicology Program (NTP) (latest edition) lists it under the category,
- "known to be carcinogens," in the Annual Report on Carcinogens.
- International Agency for Research on Cancer (IARC) lists it in the latest edition of Monographs under Group 1 ("carcinogenic to humans") or as either Group 2A or 2B "reasonably anticipated to be carcinogens," and causes statistically significant tumor incidence in experimental animals…

The following list meets the above definition of "select carcinogens" that are known or probable human carcinogens. Check the Safety Data Sheet (SDS) to determine if a chemical not listed here is a select carcinogen.

- Acetaldehyde (associated with alcoholic beverage consumption)
- 2-Acetylaminofluorene
- Acid mists, strong inorganic
- Acrylamide
- Acrylonitrile Adriamycin
- Androgenic (anabolic) steroids
- Aflatoxins
- Alcoholic Beverages
- 4-Aminobiphenyl
- Areca nut
- Aristolochic acids (naturally occurring mixtures)
- Arsenic Compounds, Inorganic
- Asbestos
- Azacitidine
- Azathioprine
- Benzene
- Benzidine
- Benzidine-based dyes
- Benzo[a]pyrene
- Beryllium and Beryllium Compounds
- Betel quid with tobacco
- Betel quid without tobacco
- Biomass fuel (primarily wood), indoor emissions from
- Cobalt metal without tungsten carbide
- household combustion of Bromopropane
- Busulfan
- 1,3-Butadiene
- 1,4-Butanediol dimethanesulfonate (Myleran®)
- Cadmium and cadmium compounds
- Captafol
- Chlorambucil
- Chlornaphazine
- Chloramphenicol
- a-Chlorinated toluenes
- 1-(2-Chloroethyl)-3-cyclohexyl-1-nitrosourea (CCNU)
- N,N-Bis(2-chloroethyl)-2-naphthylamine (Chlornaphazine)
- Bischloroethyl nitrosourea (BCNU)
- bis(chloromethyl) ether and chloromethyl methyl ether (technical-grade)
- 4-Chloro-ortho-toluidine
- Chlorozotocin
- Chromium Hexavalent Compounds Cisplatin
- Clonorchis sinensis
- Coal, indoor emissions from household combustion of Coal Tar Pitches
- Coal Tars
- Cobalt and cobalt compounds
- Cobalt metal with tungsten carbide
- Creosote
- Cumeme
- Cyclopenta[cd]pyrene
- Cyclophosphamide
- Cyclosporin A
- Dibenz[a,h]anthracene
- Dibenzo[a,l]pyrene
- Diesel engine exhaust
- Diethylstilbestrol
- Diethyl sulfate
- Dimethylcarbamoyl chloride
- 1,2-Dimethylhydrazine
- Dimethyl sulfate
- Environmental Tobacco Smoke
- Epichlorohydrin
- Epstein-Barr virus
- Erionite
- Estrogens, Steroidal and Non-steroidal
- Estrogen-progestogen, oral contraceptives and

menopausal therapy, combined
- Ethanol in alcoholic beverages
- Ethyl carbamate (urethane)
- Ethylene dibromide
- Ethyleneimine
- N-Ethyl-N-nitrosourea
- Etoposide and in combination with cisplatin and bleomycin
- Ethylene Oxide
- Fission products
- Formaldehyde
- Gallium arsenide
- Certain glass wool fibers (inhalable)
- Glycidol
- *Helicobacter pylori*
- Herbal remedies containing plant species of the genus *Aristolochia*
- Hepatitis B Virus
- Hepatitis C Virus
- High-temperature frying, emissions from
- Household combustion of biomass fuel (primarily wood), from indoor emissions
- Human immunodeficiency virus type 1
- Human papillomaviruses
- Human T-cell lymphotropic virus type I
- Indium phosphide
- Ionizing radiation (all types)
- IQ (2-Amino-3-methylimidazo[4,5-f]quinoline)
- Kaposi's sarcoma herpesvirus/human herpesvirus 8
- Lead compounds, inorganic
- Leather dust Mate, hot
- Melphalan
- Methoxsalen with Ultraviolet A Therapy (PUVA)
- 5-Methoxypsoralen
- Methyl Chloromethyl Ether
- 4,4'-Methylene bis (2-chloroaniline) (MOCA)
- Methyl methanesulfonate
- N-Methyl-N´-nitro-N-nitrosoguanidine (MNNG)
- N-Methyl-N-nitrosourea
- Mineral Oils (Untreated and Mildly Treated)
- MOPP and other combined chemotherapy including alkylating agents
- Mustard Gas
- 2-Naphthylamine
- Neutron radiation
- Nickel Compounds
- Nitrate or nitrite (ingested) under conditions that result in endogenous nitrosation
- 4-Nitrobiphenyl
- Nitrogen mustard
- N-Nitrosodiethylamine N-Nitrosodimethylamine
- N'-Nitrosonornicotine (NNN) and 4-(N-Nitrosomethylamino)-1-(3-pyridyl)-1-butanone (NNK)
- 2-Nitrotoluene
- Non-arsenical insecticides
- Opisthorchis viverrini
- Pentachlorophenol and by-products
- Phenacetin, analgesic mixtures containing
- Phosphorus-32, as phosphate
- Polychlorinated biphenyls
- 2,3,4,7,8-Pentachlorodibenzofuran
- Plutonium
- Procarbazine hydrochloride
- beta-Propiolactone
- Radionuclides, internally deposited
- Radium
- Radon
- Riddelline
- Salted fish (Chinese-style)
- *Schistosoma haematobium*
- Semustine [1-(2-chloroethyl)-3-(4-methylcyclohexyl)-1- nitrosourea, Methyl-CCNU]
- Shale-oils
- Silica, Crystalline (Respirable Size)
- Solar Radiation Soots
- Strong Inorganic Acid Mists Containing Sulfuric Acid
- Styrene
- Styrene-7,8-oxide
- Sulfur mustard
- Sunlamps or Sunbeds
- Exposure to Talc containing asbestiform fibres
- Tamoxifen
- Teniposide
- 2,3,7,8-Tetrachlorodibenzo-p-dioxin (TCDD or Dioxin)
- Tetrachloroethylene (Perchloroethylene)
- Thiotepa
- Thorium and its decay products
- Tobacco, smokeless
- Tobacco smoke, second-hand
- ortho-Toluidine
- Treosulfan
- Trichloroethylene
- 1,2,3-Trichloropropane
- Tris(2,3-dibromopropyl) phosphate
- Ultraviolet Radiation, Broad Spectrum UV Radiation
- Vinyl Bromide
- Vinyl Chloride
- Vinyl Fluoride
- Wood Dust 276
- X-ray and Gamma Radiation

Exposure circumstances

- Aluminum production
- Arsenic in drinking-water
- Art glass, glass containers and pressed ware manufacture
- Carbon electrode manufacture
- Auramine, manufacture
- Boot and shoe manufacture and repair
- Chimney sweeping
- Coal gasification
- Coal-tar distillation
- Coke production
- Frying, emissions from high-temperature
- Haematite mining (underground)
- Hairdresser or barber (occupational exposure)
- Furniture and cabinet making
- Haematite mining (underground) with exposure to radon
- Involuntary smoking (exposure to secondhand or 'environmental' tobacco smoke)
- Iron and steel founding
- Isopropyl alcohol manufacture (strong-acid process)
- Magenta, manufacture
- Painter (occupational exposure as a)
- Paving and roofing with coal-tar pitch
- Petroleum refining
- Rubber industry
- Shiftwork that involves circadian disruption
- Strong-inorganic-acid mists containing sulfuric acid (occupational exposure)
- Tobacco smoking and tobacco smoke
- Ultraviolet-emitting tanning devices

IARC last updated: 21 December, 2021 For more information, see https://ntp.niehs.nih.gov/whatwestudy/assessments/cancer/roc
U.S. Department of Health and Human Services. Public Health Service. National Toxicology Program. Report on Carcinogens. 15th edition. 2021.
For more information, see Report on Carcinogens, 15th edition, 2021

Appendix C: Peroxide Forming Chemicals

Purpose

Organic peroxides are a special class of compounds that have unusual stability problems, making them among the most hazardous substances normally handled in laboratories. In addition, certain laboratory chemicals can react with the oxygen in air to form peroxides. Some may continue to build peroxides to potentially dangerous levels, while others accumulate a relatively low equilibrium concentration of peroxides, which becomes dangerous only after being concentrated by evaporation or distillation. The peroxide becomes concentrated because it is less volatile than the parent chemical. Stabilizers or inhibitors are sometimes added to the liquid to extend its storage life, but distillation will remove the inhibitor. Chemicals that can form peroxides include aldehydes, ethers, and numerous unsaturated hydrocarbon compounds (i.e. hydrocarbon compounds having double or triple bonds).

EXAMPLES of organic peroxides and peroxide forming compounds include:
Organic peroxides:

- Benzoyl peroxide
- Butyl Peroxydicarbonate
- Cyclohexanone Peroxide
- Methyl Ethyl Ketone Peroxide
- Methyl Isobutyl Ketone Peroxide

Peroxide formers:

List A Peroxides derived from the following compounds may explode without concentration.	**List B** Chemicals which are a peroxide hazard upon concentration (distillation/evaporation).	**List C** Unsaturated materials, especially those of low molecular weight, that may polymerize violently and hazardously due to peroxide initiation.
Divinyl ether Divinyl acetylene Isopropyl ether Vinylidene chloride Potassium metal Potassium amide Sodium amide (sodamide)	Acetal Cumene (isopropylbenzene) Cyclohexene Cyclooctene Cyclopentene Diacetylene (butadiyne) (gas) Dicyclopentadiene Diethylene glycol dimethyl ether (diglyme) Diethyl ether Dioxane (p-dioxane) Ethylene glycol dimethly ether (glyme) Furan Methyl acetylene (gas) Methylcyclopentane Tetrahydrofuran Tetrahydronaphthalene Vinyl ethers 2-Butanol Decahydronaphthalene (decalin) 4-Methyl-2-pentanol 1-Phenylethanol Acetaldehyde Chlorofluoroethylene 2-Cyclohexen-1-ol 4-Heptanol 3-Methyl-1-butanol 2-Pentanol Benzyl alcohol 2-Hexanol 4-Penten-1-ol 2-Propanol (isopropyl alcohol, IPA) 2-Methoxyethanol	Acrylic acid Acrylonitrile Butadiene Chlorobutadiene (chloroprene) Methyl methacrylate Styrene Tetrafluoroethylene (gas) Vinyl acetate Vinyl acetylene (gas) Vinyl chloride (gas) Vinyl pyridine Vinylidene chloride Chlorotrifluoroethylene (gas)
Recommended maximum storage time: 18 months unopened or stamped expiration date, whichever comes first; 3 months opened or evaluated for potential peroxides.	Recommended maximum storage time: 18 months unopened or stamped expiration date, whichever comes first; 12 months opened or evaluated for potential peroxides.	Recommended maximum storage time: 18 months unopened or stamped expiration date, whichever comes first; 12 months opened (if inhibited) or evaluated for potential peroxides, 24 hours opened (if uninhibited).

Potential Hazards/Toxicity

As a class, organic peroxides are low powered explosives, however they are particularly hazardous because they are sensitive to heat, friction, impact, light, and other forms of accidental ignition, as well as to strong oxidizing and reducing agents. The unusual stability problems of this class of compounds make them a serious fire and explosion hazard. This class of compounds is also highly flammable. In addition to the physical hazards, these compounds may also pose health hazards. They are irritating to eyes, skin and respiratory tract and their vapors may cause drowsiness and dizziness. Repeated skin exposures may cause dryness or cracking. As the hazards may vary by compound, users must familiarize themselves with the specific hazards of the compounds they are working with, which can be found on the chemical's Safety Data Sheet (SDS). SDSs are available through the link on EHS webpage (reed.edu/ehs) or by contacting the EHS office via phone (503-777-7788 or 503-517-7931) or email (EHS@reed.edu).

Hazard Controls

- Keep material under an inert atmosphere (e.g. nitrogen, argon) when not in use, except for those chemicals that contain an inhibitor that requires oxygen to function.
- Work in a properly functioning chemical fume hood when handling potentially explosive compounds. Work with the sash as low as possible.
- Eye protection must be worn whenever handling organic peroxides or peroxide forming compounds.
- Gloves must be worn when working with hazardous materials. Exam style nitrile gloves (minimum 4 mm thickness) are generally adequate for handling these compounds.
- Long pants or clothing that covers the body to the ankles and closed toe shoes must be worn when handling these compounds.
- Lab coats must be worn.

Storage and Handling

- Avoid friction, grinding, and all forms of impact near peroxides, especially solids peroxides. Do not use glass containers with screw caps or glass stoppers.
- Store peroxides at the lowest possible temperature consistent with their solubility or freezing point to minimize the rate of decomposition. Do not store them at or lower than the temperature at which the peroxide freezes or precipitates because peroxides in these forms are extremely sensitive to shock and heat.
- Store all peroxidizable compounds in tightly closed, air impermeable light resistant containers, away from light, heat, direct sunlight, sources of ignition, oxidizers and oxidizing agents.
- Do not use metal spatulas to handle peroxides because metal contamination can lead to explosive decomposition.

- Do not allow these compounds to evaporate to near dryness unless absence of peroxides has been shown.
- For peroxide forming compounds, mark the receipt date on a yellow peroxide sticker, if not already done. Stickers can be printed HERE or obtained from EHS (Chemistry 211) or the Stockroom.

WARNING: MAY FORM EXPLOSIVE PEROXIDES			
Date received:	Date opened:	Testing interval: **3 or 12 months** (circle one)	
Date:	Result: (in ppm)	Date:	Result: (in ppm)
Date:	Result: (in ppm)	Date:	Result: (in ppm)

- Peroxide forming chemicals should be disposed of by the end of the manufacturer expiration date, or tested for peroxide content. Expiration dates and testing frequency for the three classes of peroxide forming chemicals are in the above table.
- Never test containers of unknown age or origin. Older containers are far more likely to have concentrated peroxides or peroxide crystallization in the cap thread and therefore can present a serious hazard when opened for testing.
- Materials that are found to be older than the suggested shelf life and have peroxide concentrations less than 100 PPM may be retained but should be tested at regular intervals.
- Any container found to have peroxide concentration greater than or equal to 100 PPM will be disposed of.

Assessing Peroxide Levels:

<25 ppm	Considered safe for general use
25-100 ppm	Not recommended for distilling or otherwise concentrating
>100 ppm	Avoid handling. Contact EHS for assistance with removal.

Hazardous Waste Disposal

- Label all hazardous waste. Labels are located in Chemistry 211.
- All peroxide forming compounds that have been tested and show elevated peroxide levels (>100PPM) will be disposed of and replacement chemical ordered, if needed.

Appendix D: Chemical Hygiene Plan Definitions (Partial List)

Carcinogen - A chemical is considered a carcinogen if:

- The International Agency for Research on Cancer (IARC) has evaluated and found it to be a carcinogen or potential carcinogen.
- The National Toxicology Program (NTP) (latest edition) lists it as a carcinogen or potential carcinogen in the Annual Report on Carcinogens.
- OSHA regulates it as a carcinogen.

Corrosive - A chemical that causes visible destruction of, or irreversible alterations in, living tissue by chemical action at the site of contact.

Guides to Human Toxicity:

Inhalation (Lethal Concentration$_{50}$, LC $_{50}$)	**GHS Information**			
	Category	**Signal Word**	**Hazard Statement**	**Symbol**
Inhalation (gas) ≤ 100 ppm; or Inhalation (vapor) ≤ 0.5 mg/l; or Inhalation (dust, mist) ≤ 0.05 mg/l	1	Danger	Fatal if inhaled	
Inhalation (gas) > 100 but ≤ 500 ppm; or Inhalation (vapor) > 0.5 but ≤ 2 mg/l; or Inhalation (dust, mist) > 0.05 but ≤ 0.5 mg/l	2	Danger	Fatal if inhaled	
Inhalation (gas) > 500 but ≤ 2500 ppm; or Inhalation (vapor) > 2 but ≤ 10 mg/l; or Inhalation (dust, mist) > 0.5 but ≤ 1 mg/l	3	Danger	Toxic if inhaled	
Inhalation (gas) > 2500 but ≤ 20,000 ppm; or Inhalation (vapor) > 10 but ≤ 20 mg/l; or Inhalation (dust, mist) > 1 but ≤ 5 mg/l	4	Warning	Harmful if inhaled	
Criteria: ● Indication of significant effect in humans* ● Any mortality at class 4* ● Significant clinical signs at class 4* ● Indications from other studies.* *If assignment to a more hazardous class is not warranted.	5	Warning	May be harmful if inhaled	None

GHS – Global Harmonized System of Classification and Labeling of Chemicals. Developed by the United Nations in order to define health, physical, and environmental hazards of chemicals and to communicate hazard and protective information on labels and Safety Data Sheets (SDSs). OSHA adapted the GHS system in March 2012.

PEL - Permissible Exposure Limit. OSHA standard for allowable inhalation concentrations of airborne substances in workroom air

PPE – Personal Protective Equipment. Examples include gloves, goggles, boots, lab coats, face shields, and the like.

TC_{Lo} - The lowest concentration in air that causes any adverse effects in humans.

Toxic - A chemical falling within any of the following categories:

- A chemical that has a median lethal dose (LD50) ≤ 50 milligrams per kilogram of body weight when administered orally to albino rats weighing between 200 and 300 grams each.
- A chemical that has a median lethal dose (LD50) ≤ 200 milligrams per kilogram of body weight when administered by continuous contact for 24 hours (or less if death occurs within 24 hours) with the bare skin of albino rabbits weighing between two and three kilograms each.
- A chemical that has a median lethal concentration (LC50) in air ≤ 200 parts per million by volume of gas or vapor, or ≤ 2 milligrams per liter of mist, fume, or dust, when administered by continuous inhalation for one hour (or less if death occurs within one hour) to albino rats weighing between 200 and 300 grams each.

TLV - Threshold Limit Value. Guidelines, set by the American Conference of Governmental Industrial Hygienists (ACGIH) for allowable airborne concentrations of chemicals and conditions under which nearly all worker may repeated be exposed, day after day, over a lifetime of work without adverse health effects.

TWA - Time Weighted Average. Airborne concentrations of contaminants are calculated by averaging exposures over 8 hours/day, 40 hrs/wk, over a lifetime of 30 years without adverse health effects.

Appendix E: Suggested Shelf Patterns for Chemical Storage

Never store chemicals alphabetically because chemicals that can react violently with each other may be stored in close proximity. Manufacturers often recommend how to separate chemicals and store chemicals in compatible families.

For example, Flinn Scientific, Inc. recommends storing chemicals in the following way. Should shelf space be a problem, place more than one family on a shelf separated by a physical divider or a 3” space between each family.

Suggested Shelf Storage Pattern – Inorganic:

<table>
<tr><td>Inorganic #10
Sulfur, Phosphorus, Arsenic, Phosphorus Pentoxide</td><td>Inorganic #7
Arsenates, Cyanides, Cyanates (Store away from any water)</td><td rowspan="2">Isolate Ammonium Nitrate.
Store it away from all other substances</td></tr>
<tr><td>Inorganic #2
Halides, Sulfates, Sulfites, Thiosulfates, Phosphates, Halogens Acetates</td><td>Inorganic #5
Sulfides, Selenides, Phosphides, Carbides, Nitrides</td></tr>
<tr><td>Inorganic #3
Amides, Nitrates (Not Ammonium Nitrate), Nitrites, Azides</td><td>Inorganic #8
Borates, Chlorates, Manganates, Permanganates</td><td rowspan="3">Inorganic #9
Acids except Nitric Acid

Store acids in dedicated cabinets.

Store nitric acid away from other acids unless your acid cabinet provides a separate compartment for nitric acid.</td></tr>
<tr><td>Inorganic #1
Metals and Hydrides (Store away from any water)

Store flammable solids in flammables cabinet</td><td>Inorganic #6
Chlorates, Bromates, Iodates, Chlorites, Hypochlorites, Perchlorates, Perchloric Acid, Peroxides, Hydrogen Peroxide</td></tr>
<tr><td>Inorganic #4
Hydroxides, Oxides, Silicates, Carbonates, Carbon</td><td>Miscellaneous</td></tr>
</table>

Suggested Shelf Storage Pattern - Organic

<table>
<tr><td>Organic #2 non-flammable
Alcohols, Glycols, Amines, Amides, Imines, Imides</td><td>Organic #8 non-flammable
Phenol, Cresols</td><td>STORE SEVERE POISONS IN A DEDICATED POISONS CABINET</td></tr>
<tr><td>Organic #3 non-flammable
Hydrocarbons, Esters, Aldehydes</td><td>Organic #6 non-flammable
Peroxides, Azides, Hydroperoxides</td><td rowspan="4">STORE ALL FLAMMABLES IN A DEDICATED FLAMMABLES CABINET</td></tr>
<tr><td>Organic #4 non-flammable
Ethers, Ketones, Ketenes, Halogenated Hydrocarbons, Ethylene Oxide</td><td>Organic #1
Acids, Anhydrides, Peracids

Store certain organic acids in acid cabinet</td></tr>
<tr><td>Organic #5 non-flammable
Epoxy Compounds, Isocyanates</td><td>Organic #9 non-flammable
Dyes, Stains, Indicators</td></tr>
<tr><td>Organic #7 non-flammable
Sulfides, Polysulfides, etc.</td><td>Miscellaneous</td></tr>
</table>

The J.T. Baker Chemical Company uses a simple color coding scheme to address this problem. The code includes both solid and striped colors to designate specific hazards as follows:

Blue	Health Hazard	Store in a secure poison area.
Red	Flammable Hazard	Store in a flammable storage cabinet or area.
Yellow	Reactivity Hazard	Store separately and away from flammable or combustible materials
White	Contact Hazard	Store in a corrosion-proof area.
Green (previously orange)	Not characterized by above groups.	Store in a general chemical storage area.
Striped		Assess storage individually. A striped label indicates that the material is incompatible with other materials in the same color class, e.g., red stripe means do not store in the same area as other flammable substances

Appendix F: Lab Specific Standard Operating Procedures

Standard Operating Procedures (SOP) that include safety information are very important when pre-planning lab experiments.

Labs may use a standard SOP template provided below or create an equivalent procedure. Safety information can also be incorporated directly into each step of a written protocol for a particular procedure that the lab already possesses; in this case a separate SOP is not necessary.

The SOP needs to be approved by the PI or the lab supervisor. Each lab worker who will conduct an experiment covered by an SOP needs to have been trained using the SOP as training material. The approved procedures should be kept with the lab safety information. The SOP needs to contain the following information at a minimum:

- Description of the purpose for the SOP and what it covers
- List the hazardous chemicals
- Describe the potential hazards from chemicals or equipment
- List specific engineering controls or containment devices needed to control exposure to hazards
- Describe safe work, handling and storage practices necessary to control the hazards
- List specific personal protective clothing or equipment needed to minimize exposure to material hazards
- Describe spill management supplies to maintain prior to work and applicable spill and injury management procedures
- Describe waste management/disposal procedures
- List specific approvals required before using the material or conducting the process if applicable
- If the work requires a higher level of control, designate a specific location where the work will be conducted; list how hazards of the work will be communicated to all lab staff
- Describe specific procedures necessary to clean work areas or equipment after use or to keep hazardous material fully contained in the designated/controlled work area if applicable
- Document training on the SOP

Developing approved SOPs with safety information is especially important when the material or process possesses inherently higher hazards or is regulated by OSHA or another regulatory entity. Examples of materials with higher hazards are listed below.

Toxic chemicals, including carcinogens

- Carcinogenicity
- Acute Toxicity (Oral, Dermal, Inhalation)
- Skin and Eye Corrosion or Damage

- Respiratory or Skin Sensitization
- Specific Target Organ Toxicity
- Reproductive Hazards (mutagens, teratogens, developmental reproductive toxicity)
- Biological toxins with acute health hazards

Other potential or known hazardous chemical substances (physical and/or health hazards)

- Chemicals with OSHA Signal Word “Danger” including
    - Air-reactive, water-reactive, self-reactive other highly reactive chemicals;
    - Explosive chemicals;
    - Organic Peroxides;
- Flammable Gasses, Liquids, Aerosols, Solids;
- Pyrophoric chemicals; and
- Oxidizing Gases, Liquids, Solids.
- Engineered Nanomaterials/Nanoparticles
- OSHA-regulated chemicals

Example processes with potential physical or health hazards

- Processes under very low or high pressure
- Processes under extremes of temperature
- Processes using large volumes of chemicals

Spill Preparedness Planning

Spill preparedness is an essential step in planning before work with chemicals or other hazardous materials.

Standard Operating Procedure Form

TITLE: _____

PRINCIPAL INVESTIGATOR: _____

BUILDING: _____

ROOM: _____

DATE: _____

AUTHOR: _____

Prior Approval Required from PI: Yes_____ No_____

Approver:_____ Signature:_____ Date:_____

Peer Review Required: Yes_____ No_____

Approver:_____ Signature:_____ Date:_____

EHS Review Required: Yes_____ No_____

Approver:_____ Signature:_____ Date:_____

Procedure Type

_____Chemical _____Biological _____Mechanical _____Other:_____

Description

_____

_____

_____

_____

Potential Hazards (mark all that apply)

_____Chemical _____Flammable _____Corrosive _____Oxidizer

_____Toxic _____Reactive _____Explosive

_____Physical _____Biological _____Mechanical _____Temperature

_____Radiation _____Pressure _____Noise _____Electrical

_____Other: _____

Description

_____

_____

_____

_____