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APPENDICES

1. INTRODUCTION

The St. John's University Chemical Hygiene Plan has been established as part of the overall Laboratory Safety Program in order to minimize the risk from laboratory use of hazardous chemicals to workers, other occupants, the university, the community and the environment.

1.1 PURPOSE

The purpose of this Chemical Hygiene Plan (CHP) is to define work practices and procedures to help ensure that faculty, staff, and other employees are protected from the hazards associated with the handling, storage and use of hazardous chemicals in laboratories.

This plan addresses the requirements of St. John's University Policy and the regulatory requirements of the Occupational Safety and Health Administration (OSHA) standard on "Occupational Exposure to Hazardous Chemicals in Laboratories" [29 C.F.R. 1900.1450], which is also referred to as the OSHA Lab Standard.

Although the OSHA standard requirements apply only to employees, based on the university mission of teaching, relevant safe working procedures and other safety practices should be applied to students working with hazardous chemicals in the laboratories.

1.2 SCOPE AND APPLICATION

This CHP applies to all St. John's employees engaged in the laboratory use of hazardous chemicals, including research faculty and staff, faculty members who are instructing academic laboratory classes, and university teaching and research assistants for science laboratories in the College of Liberal Arts & Sciences, and College of Pharmacy & Allied Health Profession. This includes laboratories in the departments of Biological Sciences, Chemistry, Clinical Pharmacy Practice, Pharmaceutical Sciences, Pharmacy and Administrative Science, Psychology and Physics.

"Laboratory use" of hazardous chemicals means handling or use of such chemicals in which all of the following conditions are met:

- Chemical manipulations are carried out on a "laboratory scale", which means that the containers used for reactions, transfers, and other handling procedures are designed to be easily and safely manipulated by one person;
- Multiple chemical procedures or chemicals are used;
- The procedures involved are not part of a production process, nor in any way simulate a production process; and
- Protective laboratory practices and equipment are available and in common use to minimize the potential for employee exposure to hazardous chemicals.

1.3 REGULATORY OVERVIEW

The Occupational Safety and Health Administration (OSHA) regulation on "Occupational Exposure to Hazardous Chemicals in Laboratories" [29 C.F.R. 1900.1450] requires all employers engaged in the laboratory use of hazardous chemicals to develop and implement a Chemical Hygiene Plan that is capable of protecting employees from health hazards associated with hazardous chemicals and keeping exposures below Permissible Exposure Limits (PEL). The standard outlines required elements of the CHP and provisions for exposure determination, medical consultation and examination, employee training and information, protective measures, recordkeeping, and annual program review.

The St. John's University Laboratory Safety Program and this CHP are intended to fully satisfy the requirements of this regulation, as well as the New York City Right to Know Law (Local Law 26, 1988) requirements for a hazardous substance inventory. The full text of the "Occupational Exposure to Hazardous Chemicals in Laboratories" standard is available through the link above and the list in Appendix D, or through the EH&S Department.

1.4 CHEMICAL HYGIENE ROLES AND RESPONSIBILITIES

All St. John's University employees covered under the scope of this plan must meet the responsibilities outlined under the Laboratory Safety Management Plan [insert link], and the specific requirements for safe use, handling and storage of hazardous chemicals outlined within the CHP.

There are several key roles involved in the management and continuous improvement of the CHP, including:

- The Laboratory Safety Committee (LSC) oversees and monitors the effectiveness of the CHP and participates in the annual review and update of the plan. Additional information on the roles and responsibilities of the LSC, as well as a roster of current members, is available in the Laboratory Safety Program.
- The Director of Science Environmental Health & Safety (EH&S) serves as the St. John's University Chemical Hygiene Officer (CHO). The CHO provides technical assistance on chemical hygiene, coordinates chemical hygiene training as part of the Laboratory Safety Program, maintains Material Safety Data Sheets and other references, and participates in evaluating and improving the overall chemical hygiene program.
- The St. John's University Director of EH&S serves as the program coordinator and provides oversight for the CHO, LSC and the overall Laboratory Safety Program.

1.5 PLAN AVAILABILITY, REVIEW & UPDATE

The Chemical Hygiene Plan is available through the EH&S website, the EH&S Department or through individual department web sites.

At least annually, the plan is evaluated to determine its continued effectiveness and identify opportunities for improvement. This evaluation is coordinated by the Program Coordinator, with assistance and input from the CHO, the LSC, and the department chairs, laboratory supervisors and principal investigators.

2. STANDARD OPERATING PROCEDURES

This section of the CHP focuses on standard operating procedures (SOPs) for work with hazardous chemicals. Additional SOPs are provided as part of the Laboratory Safety Management Plan, available on the EH&S web site.

This section of the CHP includes SOPs for: [insert hyperlinks to section SOP section]	The Laboratory Safety Management Plan SOPs address provisions for: [insert hyperlinks to SOPs]

• Emergency Procedures involving Hazardous Chemicals
• Chemical Procurement
• Chemical Inventory
• Material Safety Data Sheets
• Labeling of Hazardous Chemicals
• Preparation for Work with Laboratory Chemicals
• General Chemical Safety Rules
• Safe Work Practices by Chemical Hazard Class:
  o Flammables
  o Corrosives
  o Compressed Gases
  o Cryogenic Materials
  o Peroxide Forming Chemicals
	• General Laboratory Safety Rules
	• Dress Code
	• Minors, Pets and Other Visitors
	• Eating, Drinking & Food Storage
	• Hygiene and Housekeeping Practices
	• Glassware
	• Laboratory Signage
	• Certificate of Fitness
	• Fire Safety
	• Heating Operations
	• Vacuum Operations
	• Pressure Operations

Provisions for additional employee protection for work with particularly hazardous substances (e.g., carcinogens, reproductive toxins, highly acute toxins, etc.) are addressed in Section 8 of this CHP. [insert link]

2.1 EMERGENCY PROCEDURES

General emergency procedures include:

- When an emergency or potential emergency situation occurs, from a safe location, immediately contact Public Safety at Ext. 5252.
- Report the specific location of the emergency (building and room number), the nature of the emergency, the location of individuals with disabilities or others needing assistance, and your name and location.

- If the emergency is a fire, immediately sound the fire alarm, exit the building and notify Public Safety from a safe location.

Additional information on emergency procedures at St. John's is available through the EH&S website or EH&S Department. The sections below summarize procedures for dealing with emergencies specific to hazardous chemicals. Report all incidents to the laboratory supervisor or principal investigator, and to the CHO or EH&S Department.

2.1.1 Hazardous Chemical Exposure

Chemical exposures can occur through inhalation, skin or eye contact, or ingestion or injection of harmful chemicals.

In the event of exposure or potential exposure to a hazardous chemical:

- IMMEDIATELY call Public Safety (Ext. 5252) to report the incident.
- If an individual has inhaled a chemical, immediately move him/her to fresh air if feasible and safe to do so.
- If liquid chemical soaks clothing or skin, assist individual to the emergency shower, remove the affected clothing and drench the skin for 15 minutes to flush away the chemical.
- If eyes are splashed with liquid chemical or other chemical form, flush the eyes with water for at least 15 minutes at an eyewash station or as necessary with other potable water source.

Medical assistance is available through the University Health Services, Public Safety and/or local EMS will request an ambulance for transport to a local hospital, if appropriate based on the situation.

2.1.2 Hazardous Chemical Spill Response

Upon discovering that a chemical spill has occurred or has the potential to occur:

- IMMEDIATELY call Public Safety (Ext. 5252) from a safe location to report the incident.
- Provide as much information as possible regarding the type, nature and location of the chemical spill or release.

St. John's University employees are not authorized to respond to emergency spills and must rely on an external response team.

Laboratory personnel must be trained to contain and clean-up incidental spills of hazardous materials. An incidental spill is a release in which the substance(s) can be absorbed, neutralized, or otherwise controlled at the time of release by personnel in the immediate release area and where there is no significant risk of chemical exposure, fire or explosion. An incidental chemical spill should be cleaned-up according to the procedures reviewed as part of the Chemical Hygiene Plan training.

2.2 CHEMICAL PROCUREMENT

For procurement of hazardous chemicals, the Science Supply purchase requisition process must be followed. This requires the Department Chairperson or the Grant Office (depending on source of funds being used) to sign the purchase requisition form.

As part of the procurement process, Science Supply obtains a Material Safety Data Sheet. A copy is maintained in the Science Supply Office, and a copy is forwarded to the principal investigator. The principal investigator is then responsible for updating their MSDS file and Hazardous Substance Inventory list, and reviewing the hazard information on the MSDS with laboratory employees who will be working with the material.

2.3 CHEMICAL INVENTORY

As required by the New York City Right to Know Law, St. John's maintains an inventory of hazardous substances. It is the responsibility of each laboratory supervisor or principal investigator to maintain the ChemTracker chemical inventory for their laboratory. The ChemTracker chemical inventory is the new chemical database management system available through the EH&S website.

2.4 MATERIAL SAFETY DATA SHEETS (MSDSs)

Material Safety Data Sheets (MSDSs) are a valuable source of information on the hazards and protective measures for work with hazardous chemicals. Additional information on MSDSs is available through ChemTracker and the EH&S website.

Science Supply maintains a hard copy MSDS library for all chemicals delivered to campus. The Manager of Science Supply reviews the MSDS provided with each hazardous chemical shipment to ensure that the most recent version is maintained on file.

2.5 LABELING OF HAZARDOUS CHEMICALS

Labels provide an immediate visual warning of the chemical hazards. Labels on incoming containers of hazardous chemicals must not be removed or defaced. Each hazardous chemical container received at St. John's is required to be labeled with the identity of hazardous chemical, appropriate hazard warning (words or symbols), and the name and address of the chemical manufacturer, importer or other responsible party.

In the laboratory, if a hazardous chemical is transferred to a secondary container, the new container should be labeled with the identity of the chemical, and ideally with warnings as to the primary hazard.

In addition, FDNY requires [3 RCNY § 10-01(c)(3)] that expiration or shelf life dates be recorded on containers in a clear and legible manner for materials in the following functional groups:

1. Picrics originating at less than 10% hydration;
2. Perchlorates;
3. Peroxides;
4. Peroxidizable materials;
5. Polymerizers that react violently in polymerization or become hazardous after polymerization; and

6. Any other material stored or used in the laboratories or storage rooms which are known to deteriorate or to become unstable or reactive.

Labeling practices for laboratory chemicals include the following:

- Inspect incoming containers to be sure that they are labeled with the required information.
- Read the container label each time a newly purchased chemical is used. It is possible that the manufacturer may have added new hazard information or reformulated the product since the last purchase.
- Ensure that chemical container labels are not removed or defaced, except when containers are empty.
- Label secondary containers used in the laboratory.

2.6 PREPARATION FOR WORK WITH LABORATORY CHEMICALS

Preparation is essential for safe laboratory work with hazardous chemicals. Before beginning work involving hazardous chemicals, consider and plan for: the chemicals, equipment and other materials needed; the proper sequence of steps to be followed; and the necessary protective measures and other safety considerations.

Preparation for work with laboratory chemicals includes the following:

- Chemicals – Make sure employees are familiar with the hazards of the chemical(s) before beginning work (e.g., flammability, reactivity, volatility). Review MSDSs and/or consult supervisors/PIs or the EH&S Department as appropriate. Where feasible, consider how the procedure could be conducted using a less hazardous substitute, or using smaller quantities.
- Equipment – Ensure that equipment is assembled and/or functioning properly before use, and that affected employees understand procedures for safe use. Review specific information in the equipment operations & maintenance manual as necessary. Use equipment only for its intended use. Inspect equipment and materials to be sure they are free of defects or damage and that necessary guards are in place.
- Written Protocol – Develop/use written experimental protocols wherever feasible. Step-by-step instructions help to minimize the possibility of errors and identify steps where special precautions may be necessary.
- Set-up – Check that equipment and supplies are in place before actual work begins, including the necessary protective equipment. Check that there is sufficient working space and that the work area is uncluttered and orderly. Remove unnecessary materials, equipment and supplies. Avoid placement of chemicals and equipment on the floor of working areas where they may be knocked over or may create a tripping hazard.
- Clean-up – Think through ahead of time the necessary steps and materials for proper clean-up, including as appropriate: hazardous waste to be collected in satellite accumulation areas; surfaces to be decontaminated; glassware to be washed; other disposables to be generated; and similar considerations.

2.7 GENERAL CHEMICAL SAFETY RULES

In addition to the safe work practices and SOPs included as part of our general Laboratory Safety Management Plan, the following safety rules are specific to the use of hazardous chemicals in the laboratory:

1. Minimize exposure to all chemicals regardless of how familiar they are. Develop and encourage safe habits and avoid unnecessary exposure to chemicals by any route.

2. Be familiar with the symptoms of exposure for the chemicals in use and the precautions necessary to prevent exposure. The ability to recognize the signs and symptoms of chemical exposure is important. Then, if adverse effects do arise despite all precautions taken to avoid exposure, those effects can be recognized early and appropriate action taken. Actions to take if chemical exposure has occurred include:
    - Seek prompt medical attention at University Health Services or contact Public Safety for immediate assistance.
    - Report the incident to the laboratory supervisor or principal investigator, the CHO and EH&S Department.

3. Do not eat, drink, smoke, or apply cosmetics in areas where laboratory chemicals are present. Do not consume, store or handle food and beverages in the laboratory, with exceptions only as approved by the PI or department chair. [insert link to Lab Safety Mgmt Plan section]

4. Wash hands thoroughly after working with chemicals, or after contact with laboratory equipment and surfaces.

5. Do not use mouth suction for pipetting or starting suction.

6. Do not smell or taste chemicals.

7. Vent apparatus which may discharge toxic chemicals (vacuum pumps, distillation columns, etc.) into local exhaust devices.

8. Wear appropriate gloves when the potential for contact with hazardous chemicals exists. Use any other protective and emergency apparel and equipment as appropriate.

9. Follow the Laboratory Signage SOP [insert hyperlink]. This includes ensuring that a copy of the New York City Fire Department Laboratory Permit for each laboratory is prominently posted at the laboratory entrance. The laboratory permit lists the maximum storage amounts of flammable liquids, flammable solids, oxidizers, and unstable/reactives permitted in each laboratory.

2.8 SAFE WORK PRACTICES BY CHEMICAL HAZARD CLASS

The following sections outline safe work practice by the type of chemical hazard. Always consult the MSDS for the specific chemical formulation and concentration in use for additional details on hazards and appropriate safe work practices.

2.8.1 Flammables: Safe Work Practices

The hazard presented by flammable chemicals in the laboratory depends on the specific substance's characteristics (e.g., flashpoint[1]) and the conditions under which it is used (e.g., quantity). Flammable chemicals can be liquids, solids, or gases. Common flammable liquids found in laboratories include: isopropanol, ethanol, ethers, ketones, acetonitrile and toluene; flammable solids/dusts include sodium, aluminum, magnesium and metallic hydrides; and flammable gases include hydrogen, acetylene and methane. The following table defines the classes of flammable and combustible liquids.

Flammable and Combustible Liquids

	Flammables			Combustibles	
Class	IA	IB	IC	II	III
Flash Point	<73°F	<73 °F	73 °F - 100 °F	100 °F - 140 °F	>140 °F
Boiling Point	<100 °F	≥100 °F	<100 °F		

Source: OSHA 29 C.F.R. 1910.1450(b)

Potential hazards of flammable chemicals include:

Flammable Chemicals

Fire – For flammable liquids and gases, a sufficient concentration of vapors in air is required in order to be ignited and produce a flame. There is a range of concentrations in air for each material that is optimal for the ignition and the sustenance of combustion; this is called the flammable range (outside this range, the mixture is "too lean" or "too rich"). Within a material's flammable range, fire can result when an ignition source, including open flames, electrical sparks, friction sparks, etc., is present or introduced.

Autoignition – At temperatures above a material's autoignition temperature, fire can result from autoignition of flammable and combustible liquids without an obvious ignition source. Most common flammable and combustible liquids have autoignition temperatures in the range of about 570°F to 1000°F (~300°C -550°C). Some flammable liquids have very low autoignition temperatures, such as ethyl ether (356°F/160°C) where its vapors have been ignited by hot steam pipes.

Flashback – Flashback can occur with flammable gases. Many flammable compressed gases are heavier than air, so if a cylinder leaks in a poorly ventilated area, gases can settle and collect in low lying areas such as pits, sewers, or trenches. The gas trail can spread far from the cylinder. If the gas trail contacts an ignition source, the fire produced can flash back to the cylinder.

Fire Byproducts – Flammable liquid fires tend to burn very fast and may also give off a lot of heat and clouds of thick, black, toxic smoke. Certain chemicals may produce toxic decomposition products in the event of fire.

Other Hazards – Flammable materials may pose other hazards besides the risk of fire; they may also be toxic or corrosive, and many undergo dangerous chemical reactions in the event of contact with incompatibles such as oxidizing materials.

[1] The flashpoint of a liquid is the lowest temperature at which it gives off enough vapor to form an ignitable mixture with the air and produce a flame when a source of ignition is present.

Storage and use of flammable liquids within St. John's laboratories is also regulated by the Rules of the City of New York (RCNY) [Title 3 – Fire Department, Chapter 10]. Hazardous chemicals (flammable liquids, flammable solids, oxidizers, unstable/reactive) may be stored only in amounts that comply with the New York City Fire Department Laboratory Permit posted on the entrance of each laboratory. The maximum permitted amount ranges from 15 gallons to 30 gallons for flammable liquid and 3 pounds to 15 pounds for flammable solids depending on the laboratory type, which is determined by the fire rating and fire protection systems of the laboratory.

Safe work practices for flammable chemicals include:

1. Keep only working amounts of flammable chemicals in the laboratory.

2. Store flammable chemicals in flammable storage cabinets when not in use, or in other approved flammable storage containers. Do not store flammable liquids in refrigerators or freezers that have not been designated for that purpose; rather, store flammable liquids in flammable-safe or explosion-proof refrigerators or freezers.

3. Observe all posted limits for allowable quantities of flammable chemicals in laboratories.

4. Prohibit smoking and eliminate other possible sources of ignition (e.g., heat, direct sunlight, open flames, etc.) wherever flammable materials are stored or used.

5. Prevent accumulation of vapors through careful handling and use of ventilation. Conduct the procedure in a fume hood so that flammable vapors are exhausted from the laboratory.

6. Use proper bonding and grounding to avoid sparks from static charges generated when transferring flammable liquids in metal containers/equipment (e.g., metal lines and vessels bonded together and grounded to a common ground).

2.8.2 Corrosives: Safe Work Practices

Corrosive chemicals can damage or destroy body tissue, depending on the type and concentration of the chemical, the physical form, the body part(s) contacted, and the speed used in applying emergency measures, such as drenching and flushing. Common corrosive chemicals found in laboratories include: sulfuric acid, hydrochloric acid, nitric acid, sodium hydroxide, potassium hydroxide, and ammonium hydroxide, and gases such as chlorine, nitrogen dioxide and sulfur dioxide.

Potential hazards of corrosive materials include:

Corrosive Materials
Contact – Contact with corrosive chemicals can cause burns, ulceration or other damage to skin, mucus membranes, eyes and lungs. Acids, especially when in concentrated form, are most likely to cause immediate pain when they come into contact with the body. Contact with strong bases may go unnoticed since pain does not always occur, allowing the base time to react with the body part, and with potential for serious injury to result.
Embrittlement - Corrosives can etch or pit metals, such as stainless steel. Microscopic stress cracks not visible to the naked eye can form and can severely weaken or degrade the material, leading to unexpected failure (or explosions in the case of pressure vessels). Use containers designed for use with corrosive materials.

Safe work practices for corrosive chemicals include:

1. Purchase corrosives in the smallest container size practical. Where available, purchase corrosives in bottles with a safety coating, to minimize the risk of breakage and spills.

2. Wear appropriate personal protective clothing for handling corrosives (e.g., eye/face protection, buttoned lab coat or splash apron, and impervious gloves).

3. Store liquid corrosives on low shelves or in acid or caustic storage cabinets. Avoid storage of corrosives above the bench or on upper storage shelves.

4. Segregate corrosives from incompatible chemicals, using plastic storage bins as necessary to further segregate and provide secondary containment in storage:
   a. Check the MSDS for proper storage (e.g., segregate oxidizing acids from organic acids, and flammable and combustible liquids; segregate acids from bases and active metals such as sodium, potassium, magnesium, etc.).
   b. Local regulations [3 RCNY § 10-01(d)(10)] require that corrosive acids be stored so that there will be no contact with bare metals or of cellulosic material with nitric acid in event of spillage.

5. Use proper pouring techniques when pouring acids into water. Always add acids to water. Use cold water; add slowly in small amounts.

6. Use caution if transferring corrosives from one container to another. Dispense from only one container at a time. Finish all dispensing of one material before starting to dispense another. Make sure containers are tightly closed.

7. If transferring corrosives to secondary containers, be sure to use the type of containers recommended by the manufacturer or supplier. Corrosives can damage or destroy containers made of improper materials.

8. Protect containers against physical damage (e.g., banging, breakage) when transferring or using them. Make sure containers are tightly closed when not in use.

9. Always handle corrosive material carefully to avoid the generation of dusts or other aerosols for solid corrosives, and mists or vapors for liquid corrosives.

10. Use bottle carriers (or carts designed for chemical transport) for transporting corrosives in glass bottles.

2.8.3 Cryogenic Materials: Safe Work Practices

Cryogenic materials exist at temperatures of -100°F (-60°C) to -460°F (-266°C), and have a boiling point below 200°K (- 73.6°C) at one atmosphere. Cryogens are extremely cold and have large liquid-to-gas expansion ratios (> 700 for most). A small liquid spill produces a very large volume of gas that can displace air in a confined space. At these temperatures, tissue burns may be sustained after contact with the fluids, surfaces cooled by the fluids, or by evolving gases. Common cryogenic liquids include liquid nitrogen, oxygen, ammonia and carbon dioxide.

Potential hazards of cryogenic materials include:

Cryogenic Materials

Contact – Contact with exposed skin can produce a painful burn similar to thermal burns. A splash of cryogenic fluid to the eye can cause tissue damage and even loss of sight. Unprotected parts of the skin coming in contact with un-insulated items may also stick to them and the flesh may be torn on removal. Cold vapors or gases from cryogenic fluids may cause frostbite in the event of prolonged or severe exposure of unprotected parts.

Asphyxiation – Due to its large expansion ratio, a cryogenic liquid can displace oxygen if allowed to vent into a small closed space or other confined area. Do not use or store cryogenic fluids in a cold room or similar confined area (unless designed for such purpose and equipped with suitable controls and alarms).

Pressure Build-up – Since liquefied gases boil at room temperature, the resulting rapid increase in pressure can cause projectiles or container/system failure if cryogenic fluids are contained in a closed system. This is why it is critical for all personnel to wear safety glasses at a minimum (or other appropriate eye/face protection) when in a laboratory where cryogens are used. Certain cryogen handling tasks necessitate the use of a faceshield by the user. Wear appropriate PPE, use properly vented containers, work behind safety shields where appropriate, and be aware of the hazards of pressure build-up.

Embrittlement – Ordinary materials may not be able to withstand cryogenic temperatures without failure. Use containers designed for use with cryogenic materials. Materials exposed to cryogenic temperatures for long periods or which have undergone periodic warming must be examined for cracks and deterioration.

Hypothermia – Low air temperatures arising from proximity of cryogenic fluids or gases can cause hypothermia, depending on susceptibility, such as atmospheric temperature, length of exposure, and individual factors (e.g. older people are more likely to be affected).

Some types of cryogenic materials can also cause oxygen enrichment. Liquid nitrogen and liquid helium are capable of fractionally distilling air, causing liquid oxygen to collect in the cryogenic container. Liquid oxygen can increase the combustibility of many materials, and if vented into an enclosed space, can create potentially explosive conditions.

Safe work practices for cryogenic materials include:

1. Use only containers specifically designed for holding cryogenic liquids. Where appropriate, tape containers and cold traps to prevent flying glass in case of breakage.

2. Do not store cryogenic liquids in a container with a tight-fitting lid as the pressure will build-up as the cryogen boils and the container may fail.

3. Store cryogenic materials only in large and well-ventilated areas so that the rapid boil-off of fluids will not displace oxygen to create a potentially oxygen-deficient atmosphere. Never lower the head into a dry ice chest, as the oxygen content may be inadequate and suffocation can result.

4. Wear required PPE, such as safety glasses with side shields and/or a full-face shield to protect the eyes and face from splash hazards and potential projectiles from pressure build-up. Use suitable gloves to protect hands

from cryogenic materials. The gloves should be loosely fitting so that they can be quickly removed if the glove finger becomes frozen or if cryogenic liquid should spill into them.

5. Remove jewelry (or cover, if necessary), such as watches, rings, etc. to minimize the risk of cryogenic liquid being trapped beneath them, resulting in cold burns.

6. Put objects into a cryogenic liquid slowly, and pour liquids into containers slowly in order to minimize boiling and splashing. If using dry ice, add to liquid slowly and in small amounts to avoid foaming and boil over.

2.8.4 Compressed Gases: Safe Work Practices

Compressed gases pose the potential for both physical and chemical hazards. Common examples of compressed gases found in a laboratory include: helium, nitrogen, carbon dioxide and acetylene.

Potential hazards of compressed gases include.

Compressed Gases
Potential Energy - The large amount of potential energy resulting from compression of the gas makes a compressed gas cylinder a potential projectile if stored or handled improperly.
Contact – Compressed gases may also pose hazards based on their chemical contents (e.g., flammability, toxicity, reactivity, etc.).
Reactivity – Gases must be compatible with the materials used for the regulators and lines. For instance, copper should be avoided in systems with ammonia or acetylene.

Safe work practices for compressed gases include:

1. Keep all cylinders secured in place using chains, cages, straps, or special clamping devices.

2. Keep compressed gas container valves closed at all times except when in use. Keep removable caps and plugs on compressed gas cylinders at all times except when connected to dispensing equipment.

3. Always assume a cylinder is pressurized – handle it carefully and avoid bumping and dropping.

4. Ensure that the contents of any compressed gas cylinder can be clearly identified and know the identity of the gas in a cylinder. If a cylinder is unlabeled, return it to the vendor. Know the properties and potential of the gas to be used, and the procedures for using it.

5. Carefully inspect fittings, regulators, and apparatus for damage before using. Do not use damaged equipment.

6. Use only regulators, gauges, and connections with matching threads and which are designed for use with the gas and cylinders involved. Never lubricate, modify, force, or tamper with a cylinder valve. When opening cylinder valves, do not hold the regulator. Open valve slowly, directed away from the face. Do not force threads that do not fit. Make sure that threads on regulator connections match those on the container valve outlet.

7. Use only those tools approved by the cylinder vendor. Do not modify or alter cylinders or their attachments. Use cylinders and manifold systems only with their appropriate pressure regulators. Be careful not to exceed the design pressure of the apparatus.

8. Do not place cylinders in any area where they:
    a. Are subject to contact with a flame or temperatures above 125° F (51.7° C)
    b. Are subject to low temperature extremes (unless approved by the supplier).
    c. May become part of an electrical circuit.

9. Do not attempt to transfer compressed gases from one container to another. This must only be performed by the supplier or manufacturer.

10. When empty, tag empty cylinders appropriately and return to Science Supply, or other designated storage.

11. Do not drag compressed gas cylinders. Use a cart or manufacturer approved dolly with a restraining strap to move cylinders.

12. In storage, group cylinders by type of gas and the groups segregated as to compatibility. Store full and empty cylinders separately within the storage area.

2.8.5 Peroxide-Forming Chemicals: Safe Work Practices

Peroxide-forming chemicals react with oxygen to form peroxy compounds, with the potential to form explosive peroxide crystals. The reaction can be initiated by light, heat, contaminant or loss of an inhibitor; the rate of peroxide formation can be affected by exposure to air, light, heat, moisture, and contamination from metals. The explosion risk increases if the peroxide crystallizes or becomes concentrated by evaporation or distillation. Examples of peroxide-forming chemicals that may be found in a laboratory include: isopropyl ether, cyclohexene, ethyl ethers, and tetrahydrofuran (THF). There are four classes of peroxide-forming chemicals, based upon the peroxide formation hazard (see Appendix B):

- Severe Peroxide Hazard
- Concentration Hazard
- Shock and Heat Sensitive
- Other Potential Peroxide-Forming Chemicals

The list of peroxide-forming chemicals included in Appendix B is not intended to be all-inclusive; always consult the MSDS and/or label for a specific chemical.

Potential hazards of peroxide-forming chemicals include:

Peroxide-Forming Chemicals
Ignition/Explosion - Peroxides may be sensitive to shock, sparks, or other forms of accidental ignition, and in some circumstances, can become low power explosives with the potential to cause serious accidents.
Other Hazards - Some peroxide forming compounds (e.g., diethyl ether, tetrahydrofuran) are also extremely flammable. Some also have high vapor densities which mean that explosive airborne concentrations can accumulate in low spots.

Safe work practices for peroxide forming chemicals include:

1. Purchase only the quantity that will be used in a short time and in the smallest size of container that is practical. Purchase chemicals that have a peroxide formation inhibitor, where possible.

2. Upon receipt, use a permanent marker to label the container with the date received and initials.

3. Upon opening a new container of a peroxide-forming material, use a permanent marker to label the container with the date opened and initials. The length of time a peroxide-forming chemical can be safely stored depends on the particular material; some form peroxides on aging, others upon concentration. Refer to Appendix B, read the MSDS and other sources of hazard information, or contact the EH&S Department for assistance.

4. Do not open containers if the date of receipt indicates that it is past the recommended shelf life (or more than twelve months old), or if it's past the manufacturer's expiration date.

5. Inspect containers for peroxide formation before opening or moving the containers. Do not open, touch, or otherwise disturb any container if crystalline solids are observed in liquid peroxide-forming chemicals. From a safe location, immediately contact Public Safety and the Chemical Hygiene Officer.

6. Store peroxide forming chemicals in airtight amber glass containers. The amber glass container protects the substance from excess light exposure and allows the user visual access to the substance without opening the container. Once material is removed from the source container it must not be returned to the reagent container.

7. Before storing, ensure that bottles and caps are free of chemical residue. Keep containers tightly capped to minimize peroxide formation.

8. Store peroxide forming chemicals away from heat sources, sparks, direct light, flammables, and combustibles. Check the MSDS for any additional incompatibilities of the specific material.

9. Avoid the use of metal implements, since metals contamination can lead to explosive decomposition. Use implements made of alternative materials such as wood, ceramics or Teflon®.

10. Use extra caution when handling near-empty or empty containers of peroxide forming materials because the air space above the liquid can accelerate the formation of peroxides.

11. If antioxidant inhibitors are used, be aware that the inhibitor may be consumed with time, making the compound again sensitive to peroxidation.

12. Consider the need for additional controls, such as shielding of reactions. [*Note: Fume hoods sashes may provide some level of physical protection against minor explosions; however, most sashes are not explosion-proof.]*

3. LABORATORY OPERATIONS WHICH REQUIRE PRIOR APPROVAL

Certain laboratory use of hazardous chemicals requires prior approval, because of the hazards of the materials, equipment, or operations, or because of the waste materials and byproducts they generate, or for other serious health and safety concerns. There are two classes of laboratory operations which require prior approval:

I. Prior review and approval by the Laboratory Supervisor or Principal Investigator, or

II. Prior review and approval by the Laboratory Safety Committee.

I. Review and Approval by a Laboratory Supervisor or Principal Investigator:

1. For use of particularly hazardous substances, including carcinogens, reproductive toxins, and highly acute toxins.
2. For use of highly reactive or flammable chemicals that present a physical safety hazard to the user or other occupants.
3. For new or modified procedures involving moderately to highly hazardous chemicals, including those with a NFPA or HMIS rating of 3 or 4 for Health, Reactivity or Flammability.
4. For other new or modified procedures presenting a potentially serious risk to the laboratory worker or other occupants due to the materials, quantity, equipment, or nature of the operation.

II. Review and Approval by the Laboratory Safety Committee:

1. Where exposures have exceeded or are reasonably likely to exceed the permissible exposure limits (PELs) or other established exposure limits.
2. Where there is a failure of any of the equipment used in the process that did or could have resulted in injury, illness or exposure of a laboratory worker to a hazardous chemical, before the procedure may be undertaken again.
3. Where laboratory workers become ill, injured or suspect that they or others have been exposed to a hazardous chemical due to an experimental procedure.
4. Where the Laboratory Safety Registration and Assessment [insert link] process indicates the need for safety review.

4. CRITERIA TO DETERMINE AND IMPLEMENT CONTROL MEASURES

St. John's is required by the OSHA Lab Standard to ensure that employee exposures do not exceed permissible exposure limits (PELs) and to prohibit eye and skin contact where specified by any OSHA health standard. The sections that follow outline basic steps for exposure determination and control for hazardous chemicals used in laboratories. Refer to the Exposure Prevention, Assessment and Control section [insert link] of the Laboratory Safety Management Plan for further details.

4.1 EMPLOYEE EXPOSURE DETERMINATION

The use of properly inspected and certified fume hoods is expected to minimize exposure to airborne chemicals in the laboratory. The results of the Laboratory Safety Registration and Assessment process help determine if there is a need for exposure assessment. Industrial hygiene assessment techniques are used to evaluate employee exposures and institute control measures. If the Laboratory Safety Committee, CHO or EH&S Department receives information from laboratory supervisors, principal investigators or other reliable sources that constitutes a reason to believe that exposure to any substance routinely exceeds the action level or exposure limit, St John's will evaluate the employee(s)' exposure, using qualitative exposure assessment and quantitative monitoring techniques as appropriate. The CHO and EH&S Department will determine, on a case-by-case basis, the level of evidence needed to constitute a reason to believe that exposures routinely exceed permissible levels. The CHO will be responsible for arranging or conducting any industrial hygiene exposure assessments and monitoring, in accordance with the following provisions:

1. If initial monitoring conducted under this scenario discloses that employee exposure exceeds the OSHA action level (or in the absence of an action level, the established exposure limit), St John's will investigate and implement appropriate controls to reduce employee exposures to an acceptable level.

2. Periodic monitoring will be used to assess the effectiveness of the control measures and evaluate the level of employee exposures until they have reached acceptable levels.

3. Within 15 working days after the receipt of any monitoring results, the CHO or other designee will notify the employee(s) of these results in writing either individually or by posting results in an appropriate location accessible to employees.

4. For each employee, the CHO will establish and maintain an accurate record of any measurements taken to monitor employee exposures. These records will be kept, transferred, and made available in accordance with OSHA requirements for exposure records [29 C.F.R. 1910.1020].

4.2 SELECTION OF EXPOSURE CONTROL STRATEGIES

A critical method for control of hazardous chemicals in the laboratory is through facility design and the use of engineering controls such as chemical fume hoods. Other control methods may include safe work practices, training, medical surveillance, and use of personal protective equipment.

In determining the appropriate strategy for controlling potential exposures, the hierarchy of controls concept is applied, as described in the Laboratory Safety Management Plan section on Exposure Prevention, Assessment, and Control. [insert link]

The hierarchy of controls is as follows:

1. Elimination of material/process or substitution of less hazardous chemical. [insert link to solvent substitution]
2. Engineering.
3. Administrative.
4. Personal protective equipment.

The CHO, with assistance from the Laboratory Safety Committee and the EH&S Department, will work with laboratory supervisors and principal investigators to select and implement additional control measures, as necessary. This will be based on the results from: any industrial hygiene exposure assessments conducted; the Laboratory Safety Registration and Assessment process; laboratory inspections and audits; and knowledge of the material properties and conditions of use (e.g., vapor pressure, quantity and physical form, area of use). Section 5.0 of the CHP outlines requirements for fume hoods and other protective equipment.

For laboratory work involving particularly hazardous substances, including select carcinogens, reproductive toxins and/or substances with high acute toxicity, additional employee protection may also be necessary, such as:

1. Specification of designated area(s);
2. Use of containment equipment such as fume hoods;
3. Procedures for safe removal of contaminated waste; and
4. Decontamination procedures.

This is further described in Section 8 of the Chemical Hygiene Plan, Provisions for Additional Employee Protection for Work with Particularly Hazardous Substances.

5. REQUIREMENTS FOR FUME HOODS AND OTHER PROTECTIVE EQUIPMENT

Engineering controls are the preferred means for controlling exposure to hazardous chemicals used in the laboratory. Chemical fume hoods are the most common type of engineering control used in the laboratory environment.

In order to provide the anticipated level of protection, it is essential for fume hoods and other protective equipment to be properly used, inspected, and maintained. This is verified through a combination of formal certification programs as well as laboratory inspections/audits, and equipment pre-use inspections.

5.1 PROPER USE OF CHEMICAL FUME HOODS

Safe work practice requirements for proper use of chemical fume hoods include:

1. Use the hood for operations which might result in release of toxic chemical vapors or dust, as protection against the build-up of flammable vapors, and as physical protection against corrosives, reactives, or procedures presenting the potential for pressure build-up.

2. As a rule of thumb, use a hood or other local ventilation device when working with any appreciably volatile substance with an exposure limit (e.g., PEL, TLV) of less than 50 ppm.

3. Confirm adequate hood performance before use (e.g., flow indicator gauge, "telltale"). Never use a fume hood that is not functioning properly. Check that the hood has a current certification date – at least annually, all hoods are inspected, tested, and maintained as necessary.

If you suspect that your fume hood is not functioning properly, contact the EH&S Department (Ext. 5995) or Facilities Services Office (Ext. 6254).

4. Proper use of the chemical fume hood includes the following procedures:
   a. Set up work at least six inches from the face of the hood to avoid turbulence at the sash edge.
   b. Do not clutter the hood with unnecessary bottles or equipment. Do not use the hood for storage of chemicals or other materials. Only materials in use should be in the hood.
   c. For large pieces of equipment, separate and elevate each instrument by using blocks or racks to safely and securely position equipment so that air can flow easily around all apparatus.
   d. Work with the sash in a lowered position. The sash also provides a physical barrier to protect against splashes, sprays, fires or minor explosions. Lower the sash completely when no one is working in the hood.

5. Do not obstruct the slots at the back of the hood. Keep the hood baffles free of obstructions.

6. Do not dismantle or modify the physical structure of your hood or exhaust system in any way without first consulting the EH&S Department and the contract Facilities Services personnel.

7. Never put your head inside an operating hood to check an experiment. The plane of the sash is the barrier between contaminated and uncontaminated air.

8. Never use a hood for evaporation of chemical wastes.

9. Conduct heating of perchloric acid ONLY in a perchloric acid fume hood, or with other approval from the EH&S Department.

5.1.1 Fume Hood Certification Program

Chemical fume hoods (and any similar local exhaust ventilation systems in the laboratory) are inspected, tested, and maintained as part of a regular certification program. The effectiveness of a laboratory fume hood is evaluated using face velocity measurements and alternate testing protocols. Since face velocity alone may not be an adequate measure of fume hood performance, an evaluation of the hood's ability to capture airborne contaminants is qualitatively assessed using non-irritant smoke. Tracer gas studies to more rigorously assess fume hood performance are conducted on an as needed basis as determined by EH&S and/or the LSC (e.g., upon commissioning; existing hoods as appropriate based on risk level, etc.).

The inspections and tests are conducted by an outside contractor. Any deficiencies identified are forwarded to the CHO, who works with the Facilities Services group to resolve the issue. For equipment with an initial deficiency, the contractor will re-test and certify it after the identified deficiency has been addressed. Each fume hood is labeled to indicate the certification is current. Records of fume hood evaluations are also maintained by the EH&S Department.

The general process for fume hood inspection, testing and maintenance is as follows:

1. Laboratory fume hoods are inspected and tested at least annually by a qualified contractor, as coordinated by the CHO.

2. Laboratory fume hoods will be re-evaluated if the laboratory fume hood is modified or if the exhaust duct system connected to a hood has been modified, or as otherwise appropriate if there are hood performance issues.

3. During these evaluations, the average face velocity of the hood is measured and the air flow characteristics are evaluated by a smoke tube visualization test:
    a. To measure the face velocity of the hood, the opening of the hood is divided into equal grid areas and a face velocity measurement is taken with an anemometer from the center of each grid. The average face velocity is recorded over 10-20 seconds at each location. In order for a hood to pass the face velocity portion of the evaluation, the average face velocity must be 100 - 120 feet per minute (fpm) with the sash at a height of 18 inches. FDNY requirements [3 RCNY §10-01 (f)(6)] specify that the face velocity at any point may not be less than 75 fpm.
    b. For the smoke tube visualization test, a smoke tube is placed inside the middle fume hood, approximately six (6) inches from the plane of the sash. The smoke flow patterns are observed and noted. This test is repeated with the smoke tube on the right and left side of the fume hood as well. When conducting the smoke visualization test, there should be smooth flow with no apparent turbulence or "dead spots." The laboratory fume hood fails inspection if the smoke escapes.

4. Fume hoods passing the evaluation will be labeled with a fume hood certification sticker indicating the date of evaluation and/or the date the next evaluation is due.

5. Fume hoods that fail the evaluation will be re-tested after the necessary maintenance or repair is completed. In the interim, the hood must be removed from service, labeled with a "Do Not Use" sign, and the laboratory PI or supervisor informed of the situation.

6. Records on annual fume hood monitoring are maintained by the EH&S Department. The complete data for each evaluation will be retained for one year, with summary data retained for five years.

5.1.2 Additional Considerations for Fume Hoods in Laboratory Design and Operation

The location of the fume hood in the laboratory is important because air turbulence and cross-currents can cause airborne contaminants to escape from the fume hood. Foot traffic, open windows, air vents/diffusers, and doors and fans can create enough drafts to interfere with the hood's ability to effectively capture airborne contaminants. The following are additional considerations for laboratory design and fume hood operation:

1. In laboratory design, locate fume hoods in areas of minimal traffic and ideally at least 10 feet from doors and doorways, emergency exits exempted.

2. When workers spend most of their time working with chemicals, provide a laboratory fume hood with 2.5 linear feet of hood space per person for every two workers.

3. Avoid locating fume hoods where air supply or exhaust vents would be located directly above or in front of the hood, as it may cause air turbulence.

4. Identify a visible boundary to establish a work zone of 3 feet in front of laboratory hoods. Where feasible, do not position workstations where people spend most of their day, such as desks or microscope benches, directly in front of laboratory hood openings.

5. Keep doors and windows of the laboratory closed to maintain negative pressure of the laboratory.

5.2 FLAMMABLE STORAGE CABINETS

Approved flammable storage cabinets are to be used for the storage of compatible flammable liquids. The intent of these cabinets is to prevent those flammable liquids stored inside from being involved in a fire for a limited period so that occupants have time to evacuate. All cabinets must comply with OSHA and NFPA requirements, as well as the maximum permitted amounts per FDNY as specified in the laboratory permit. Flammable storage cabinets for flammable and hazardous chemicals will be ventilated only if required by the local Fire Marshall.

5.3 SPILL KITS

Each laboratory is equipped with a chemical spill kit, which may be used by laboratory occupants only where safe to do so for incidental spills. These kits must be periodically inspected to ensure accessibility and proper contents.

Mercury spill kits are maintained by the EH&S Department. Contact Public Safety for clean-up of any spills involving mercury.

St. John's employees are NOT authorized to clean-up emergency spills. In the event of an emergency, please vacate the laboratory and contact Public Safety (Ext. 5252).

6. EMPLOYEE INFORMATION AND TRAINING

Personnel working with hazardous chemicals in the laboratory must obtain training on the hazards of these chemicals and the procedures for working safely. Chemical hygiene information and training is covered as part of the Laboratory Safety Program training. Required information and initial training include:

1. The contents of the OSHA lab standard, Occupational Exposure to Hazardous Chemicals in Laboratories, and its appendices [29 C.F.R. 1910.1450].

2. The location, availability and applicable details of the ST. JOHN'S Chemical Hygiene Plan (this document) and standard operating procedures.

3. The Permissible Exposure Limits (PELs) for OSHA-regulated substances and the AGCIH Threshold Limit Values (TLVs) or other recommended limits for hazardous substances not given OSHA PELs.

   NOTE: A list of OSHA PELs and ACGIH TLVs is available from the CHO or EH&S Department, or the PELs may be accessed on-line at 29 C.F.R. 1910.1001 Table Z-1, Table Z-2, or Table Z-3. (From the OSHA web page at www.osha.gov click on Standards from right-hand menu, then on Part 1910, scroll down to Subpart Z, 1910.1001).

4. Signs and symptoms associated with exposures to hazardous chemicals used in the laboratory.

5. The location and availability of references, such as MSDSs, the EH&S website, the on-line links provided in Appendix D and hard copy references available through the EH&S Department.

6. Methods and observations that may be used to detect the presence or release of a hazardous chemical (e.g., monitoring, visual appearance, odor, etc.).

7. Physical and health hazards of chemicals.

8. Measures employees can take to protect themselves from chemical hazards, including specific procedures implemented at St. John's University.

Initial training is provided as part of the New Employee Orientation process, in conjunction with Human Resources orientation training. The Director of EH&S and the CHO present an annual refresher training seminar for all faculty, staff and graduate students. The training provides an overview of the CHP and good laboratory practices.

Records of chemical hygiene training are to be maintained for all workers. All training records for courses provided by the EH&S Department are maintained by the EH&S Department.

7. MEDICAL CONSULTATION AND EXAMINATIONS

This section outlines the requirements for medical consultation and examinations established by the OSHA Lab Standard.

7.1 NEED FOR MEDICAL CONSULTATION/EXAMINATION

St. John's is required to provide laboratory personnel who work with hazardous chemicals an opportunity to receive medical consultation and/or examination, including physician-determined follow-up examinations where applicable, when any of the following conditions are met:

- The worker develops signs or symptoms associated with a hazardous chemical used in the laboratory;
- Exposure monitoring reveals consistent worker exposure greater than the action level[2] (or in the absence of an action level, the applicable OSHA PEL[3]) for a chemical;
- Whenever a leak, spill, explosion or other occurrence results in the likelihood of hazardous exposure to the worker;
- When medical surveillance requirements for OSHA regulated-substances must be met. Refer to Appendix B [insert link] for a list of materials regulated by OSHA substance-specific standards.

Medical evaluation is also required prior to use of respiratory protection, except where only filtering facepieces (i.e., dust masks) are used on a voluntary basis.

Medical consultations and examinations will also be provided at the discretion of the Laboratory Safety Committee, CHO, or Director of EH&S.

7.2 EXPOSURE INFORMATION

A licensed physician providing care to a potentially exposed worker must be provided the following information:

- The identity of and MSDS(s) for the hazardous substance(s) to which the worker may have been exposed;
- The conditions that surrounded the exposure; and

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[2] Action Level (AL) – An airborne concentration designated in OSHA 29 CFR Part 1910 for a specific substance, calculated as an 8-hour time-weighted average, which initiates certain required activities such as exposure monitoring, medical surveillance and/or training.

[3] Permissible Exposure Limit (PEL) – The regulatory limit(s) on the amount or concentration of a substance in the air; may also contain a skin designation. OSHA PELs are based on an 8-hour time weighted (TWA) exposure, unless otherwise designated as a Short-Term Exposure Limit (STEL) or Ceiling (C) value.

- The signs and symptoms of exposure that the worker is experiencing, if any.

7.3 EVALUATION CRITERIA AND FREQUENCY

Medical evaluation criteria will be determined by the licensed physician performing the exam. Where specific medical evaluation guidance exists, such as for chemicals regulated by an OSHA substance-specific standard, these criteria will be included in the physician's exam.

Frequency of medical examinations is at the discretion of the physician, if the examination resulted from a potential overexposure to hazardous substances. If the examination resulted from an exposure to an OSHA-regulated substance, examinations will be at least as frequent as the period set in the OSHA standard for each particular substance. Medical evaluations provided for required respirator use must be performed at least annually, unless specified more frequently by the physician.

7.4 PHYSICIAN'S WRITTEN OPINION

The physician is required to submit a written opinion to the principal investigator and the CHO. This opinion must not reveal any specific findings or diagnoses unrelated to the chemical exposure. The written opinion must include the following information:

- Results of the medical examination, including any test results;
- Any medical condition, revealed during examination, which may place the worker at increased risk as a result of the chemical exposure or use of personal protective equipment;
- Recommendations for further medical follow-up; and
- A statement that the worker was informed of the medical examination results.

7.5 COST AND SCHEDULING

All required medical examinations and consultations are provided to St. John's personnel at no cost, without loss of pay, and at a reasonable time and place. University employees may receive non-emergency medical attention through the University Health Services. If appropriate, Public Safety can assist in arranging for emergency medical care.

8. PROVISIONS FOR ADDITIONAL EMPLOYEE PROTECTION FOR WORK WITH PARTICULARLY HAZARDOUS SUBSTANCES

Where tasks will involve work with particularly hazardous substances, including select carcinogens, reproductive toxins and/or substances with high acute toxicity, certain provisions for additional employee protection may also be necessary, such as:

- Specification of designated area(s);
- Use of containment equipment such as fume hoods;
- Procedures for safe removal of contaminated waste; and
- Decontamination procedures.

Types of substances that OSHA considers to be particularly hazardous are listed below, with additional details provided in Appendix C: [insert link]

Select Carcinogens – Substances regulated as select carcinogens by OSHA include any substance that is listed on:

1. Compounds regulated by Title 29, Code of Federal Regulations, Part 1910, Subpart Z - Toxic and Hazardous Substances (Refer to Appendix B for a list).

2. Compounds considered to be "Known Carcinogens" by the National Toxicology Program, (NTP) in their Annual Report on Carcinogens as well as some substances listed as "reasonably anticipated to be carcinogens."

3. Compounds designated as "carcinogens to humans" (Group 1) and some "reasonably anticipated to be carcinogens" (Group 2A or 2B) by the International Agency for Research on Cancer, (IARC).

Reproductive Toxins – Reproductive toxin includes any chemical that may affect the reproductive capabilities including chromosomal damage (mutations) and effects on fetuses (teratogenesis). Examples of chemicals with reproductive toxicity include: dibromochloropropane (DBCP), lead and ethylene oxide.

Substances with a High Degree of Acute Toxicity – Although the OSHA Laboratory Standard does not define substances with a high degree of acute toxicity, the rule's preamble describes them as those substances that are "fatal or cause damage to target organs as a result of a single exposure or exposures of short duration." Hydrogen cyanide, hydrogen sulfide and nitrogen dioxide are given as examples. Specifically, high acute toxicity includes any chemical that falls within any of the following categories:

1. A chemical with a median lethal dose (LD_{50}) of 50 mg or less per kg of body weight when administered orally to certain test populations.

2. A chemical with an LD_{50} of 200 mg or less per kg of body weight when administered by continuous contact for 24 hours (or less if death occurs within 24 hours) to certain test populations.

3. A chemical with a median lethal concentration (LC_{50}) in air of 200 parts per million (ppm) by volume or less of gas or vapor, or 2 mg per liter or less of mist, fume, or dust, when administered to certain test populations by continuous inhalation for one hour, provided such concentration and/or condition are likely to be encountered by humans when the chemical is used in any reasonably foreseeable manner.

Safe work practices for particularly hazardous substances include:

1. Evaluate whether a safer chemical alternative is feasible. [insert link to solvent substitution] If not, ensure the laboratory supervisor or principal investigator has reviewed and approved work with particularly hazardous substances.

2. Wherever feasible, conduct procedure in a fume hood. Otherwise, use equivalent engineering or combinations of other controls.

3. Use the smallest amount of chemical that is consistent with the requirements of the work to be done.

4. Wear appropriate personal protective equipment to prevent exposure.

5. Where work with carcinogens, mutagens, or reproductive hazards is to be conducted on a routine basis, establish designated areas (e.g., benches or hoods) for work with these materials, clearly label the designated area with a sign, restrict access, and implement special decontamination procedures.

6. Use care when weighing solids to avoid creation of aerosols. Where possible, use fume hoods or other vented enclosures for weighing highly hazardous chemicals.

7. Establish a schedule and procedure for decontamination of work surfaces and equipment (e.g., at the completion of the operation or at the end of the day). The decontamination solution must be compatible with the materials with which it is being used, and should be selected based on the properties of the materials it is being used to decontaminate.

8. Establish proper housekeeping procedures. Use a wet mop or a vacuum cleaner equipped with a HEPA filter instead of dry sweeping if the toxic substance is a dry powder.

9. Carefully handle waste generated from procedures involving particularly hazardous chemicals. Follow all waste procedures [insert link] (e.g., labeling of containers, keeping waste collection containers tightly closed when not in use, providing secondary containment for liquid waste containers, etc.) while waste is in storage prior to transfer to the Central Waste Storage Room.

10. For *Embryotoxins* (e.g., organomercurials, lead compounds, formamide), if you are a woman of childbearing age, handle these substances only in a hood whose satisfactory performance has been confirmed, using appropriate protective apparel (especially gloves) to prevent skin contact.

11. Store these chemicals in appropriately labeled, unbreakable, chemically resistant, secondary containers.

12. Review each use of these materials with the laboratory supervisor or principal investigator and review continuing uses annually or whenever a procedural change is made.

13. Notify laboratory supervisors and principal investigators and the EH&S Department of all incidents of exposure or spills. Call Public Safety (Ext. 5252) from a safe location for any emergency situations.

Know the hazards and safe work practices for the specific material and conditions of use. Ensure the laboratory supervisor or principal investigator has reviewed and approved procedures involving carcinogens, reproductive toxins, highly acute toxins, and other particularly hazardous substances.

Appendix A: Guidance for the Storage of Incompatible Chemicals

This list is provided to illustrative incompatibilities for common laboratory chemicals and is not a complete list; always consult the MSDS for the chemical or other chemical hazard reference. The material on the left should be stored and handled so that it does not come in contact with the incompatible chemical(s) on the right.

	Chemical Compound	Should Be Kept Out Of Contact With
A	Acetic Acid	Acetaldehyde, ammonium nitrate, chromic acid, nitric acid, hydroxyl compounds, ethylene glycol, perchloric acid, peroxides, permanganates
	Acetaldehyde	Acetic acid, acetic anhydride, ammonia (anhydrous)
	Acetylene	Chlorine, bromine, copper, fluorine, silver, mercury
	Acetone	Concentrated nitric and sulfuric acid mixtures
	Alkali and Alkaline Earth (e.g. Powdered Aluminum or Magnesium, Calcium, Lithium, Sodium, Potassium)	Water, carbon tetrachloride or other chlorinated metals hydrocarbons, carbon dioxide, halogens
	Aluminum	Ammonium nitrate, bromates, chlorates, iodates, bromine vapor, carbon disulphide vapor
	Ammonia (Anhydrous)	Mercury, chlorine, calcium hypochlorite, iodine, bromine, hydrofluoric acid (anhydrous)
	Ammonium Nitrate	Acids, powdered metals, flammable liquids, chlorates, nitrates, sulfur, finely divided organic or combustible materials
	Aniline	Nitric acid, hydrogen peroxide
	Arsenic	Any bromate, chlorate, or iodate
	Azides	Acids
B	Bromine	See chlorine
	Barium	Carbon tetrachloride
C	Calcium Oxide	Water
	Carbon (Activated)	Calcium hyperchlorite, all oxidizing agents
	Carbon Tetrachloride	Sodium
	Chlorates	Ammonium salts, acids, powdered metals, sulfur, finely divided organic or combustible materials, sulphides
	Chromic Acid	Acetic acid, naphthalene, camphor, glycerin, turpentine, alcohol
	Chlorine	Ammonia, acetylene, butadiene, butane, methane, propane (or other petroleum gases), hydrogen, sodium carbide, benzene, finely divided metals, turpentine
	Chlorine Dioxide	Ammonia, methane, phosphine, hydrogen sulfide
	Copper	Acetylene, hydrogen peroxide
	Cumene Hydroperoxide	Acids (organic or inorganic)
	Cyanides	Acids
F	Flammable Liquids	Ammonium nitrate, chromatic acid, hydrogen peroxide, nitric acid, sodium peroxide, halogens
	Fluorine	Isolate from everything
H	Hydrocarbons (e.g. Butane, Benzene)	Flourine, chlorine, bromine, chromic acid, sodium peroxide

	Chemical Compound	Should Be Kept Out Of Contact With
	Hydrocyanic Acid	Nitric acid, alkali
	Hydrofluoric Acid (Anhydrous)	Ammonia (aqueous or anhydrous)
	Hydrogen Peroxide	Copper, chromium, iron, most metals or their salts, alcohols, acetone, ferrous sulphide, lead IV oxide, lead II oxide, lead sulphide, organic materials, aniline, nitromethane, combustible materials, flammable liquids, oxidizing gases
	Hydrogen Sulfide	Fuming nitric acid, oxidizing gases
	Hypochlorites	Acids, activated carbon
I	Iodine	Acetylene, ammonia (aqueous or anhydrous), hydrogen
M	Maleic Anhydride	Magnesium hydroxide, lithium metal
	Magnesium Metal	Mercury II oxide, nitric acid
	Mercury	Acetylene, fulminic acid, ammonia
	Methanol	Lead perchlorate, mercury II nitrate
N	Nitrates	Sulfuric acid
	Nitric Acid	Acetic acid, aniline, chromic acid, hydrocyanic acid, hydrogen sulfide, flammable liquids, flammable gases, powdered magnesium metal, phosphorus, phthalic acid
	Nitroparaffins	Inorganic bases, amines
O	Oxalic Acid	Silver, mercury
	Oxygen	Oils, grease, hydrogen, flammable liquids, solids
P	Perchloric Acid	Acetic anhydride, aluminum, Bakelite, bismuth and its alloys, alcohol, paper, wood, plastics, nylon (polyamide), modacrylic ester (35-85% acrylonitrile), polyester, Lucite, cellulose-based lacquers, metals, copper and copper alloys, high nickel alloys, cotton, wool, glycerin-lead oxide, grease, oils
	Peroxides, Organic	Acids (organic or mineral), avoid friction, store cold
	Phosphorus (White)	Air, oxygen, alkalis, reducing agents
	Phosphorus Pentoxide	Water
	Potassium	Carbon tetrachloride, carbon dioxide, water
	Potassium Chlorate	Sulfuric and other acids
	Potassium Perchlorate (See Also Chlorates)	Sulfuric and other acids
	Potassium Permanganate	Glycerol, ethylene glycol, benzaldehyde, sulfuric acid
S	Silver	Acetylene, oxalic acid, tartaric acid, ammonium compounds
	Selenides	Reducing agents
	Sodium	Carbon tetrachloride, carbon dioxide, water
	Sodium Nitrate	Ammonium nitrate and other ammonium salts
	Sodium Peroxide	Ethanol, methanol, glacial acetic acid, acetic anahydride, benzaldehyde, carbon disulfide, glycerin, ethylene glycol, ethyl acetate, methyl acetate, furfural
	Sulfides	Acids
	Sulfuric Acid	Potassium chlorate, potassium perchlorate, potassium permanganate (or similar compounds of light metals, such as sodium, lithium)

Appendix B: Guidance on Peroxide Forming Chemicals

Severe Peroxide Hazard Substances: Form Peroxides on Exposure to Air	
*The following chemicals present severe peroxide hazards on storage with exposure to air and should typically be discarded within **3 months** of opening.*	
Butadiene (liquid monomer)	Potassium Amide
Diisopropyl Ether (Isopropyl Ether)	Sodium Amide (Sodamide)
Divinylacetylene (DVA)	Tetrafluoroethylene (liquid monomer)
Potassium Metal	Vinylidene Chloride(1,1-DiChloroethylene)
Concentration Hazard	
*The following chemicals present peroxide hazards on concentration. Do not distill or evaporate these chemicals without first testing for the presence of peroxides. These chemicals should typically be discarded or tested for peroxides within **6 months** of opening.*	
Acetaldehyde Diethyl Acetal (Acetal)	Ethylene Glycol Dimethyl (Glyme)
Cumene (Isopropyl Benzene)	Ethylene Glycol Ether Acetates
Cyclohexene	Ethylene Glycol Monoethers (Cellosolves)
Cyclopentene	Furan
Decalin (Decahydronaphthalene)	Methylacetylene
Diacetylene (Butadiene)	Methylcyclopentane
Diethyl Ether (Ether)	Tetrahydrofuran (THF)
Dioxanes	Vinyl Ethers
Shock or Heat Sensitive	
*The following chemicals present hazards of rapid polymerization initiated by internally formed peroxides. These chemicals should typically be discarded or tested for peroxides **within 6 months** of opening (gases should be discarded or tested for peroxides **within 12 months**).*	
Chloroprene (2-Chloro-1,3-Butadiene)	Vinyl Acetate
Styrene	Vinylpryidine
Butadiene	Vinylacetylene (MVA)
Tetrafluoroethylene (TFE)	Vinyl Chloride
Other Potential Peroxide-Forming Chemicals: Form Peroxides Under the Right Conditions	
There are a number of other compounds with the potential to form peroxide under the right conditions. For instance, compounds containing aldehyde or amide groups are easily peroxidizable, but may not necessarily accumulate peroxide at dangerous levels. Chemicals in this class should typically be discarded or tested for peroxides within 1 year of opening.	
Diethoxymethane	2-Methoxyethanol
1-Pentene	n-Propyl ether

Appendix C: Guidance on Particularly Hazardous Chemicals

This appendix has been developed as a supplement to the information on Particularly Hazardous Chemicals contained in Section 8 of this CHP. Additional information is available through the EH&S Department and by using the hyperlinks listed in Section 8, within this Appendix C, as well as in Appendix D.

Carcinogens

Carcinogens are agents that can cause cancer. There are a number of chemicals that are known or suspected carcinogens due to their ability to cause neoplasms (tumors) in humans and/or animals. Some carcinogens react directly with a cell's genetic information (DNA), causing changes (mutations) that are incorporated into subsequent generations of that cell.

OSHA defines a potential occupational carcinogen as: any substance, or combination or mixture of substances, which causes an increased incidence of benign and/or malignant neoplasms, or a substantial decrease in the latency period between exposure and onset of neoplasms in humans or in one or more experimental mammalian species as the result of any oral, respiratory or dermal exposure, or any other exposure which results in the induction of tumors at a site other than the site of administration. This definition also includes any substance which is metabolized into one or more potential occupational carcinogens by mammals. [29 CFR Part 1990, Identification, Classification and Regulation of Carcinogens]

Carcinogen lists include:

1. Compounds regulated by Title 29, Code of Federal Regulations, Part 1910, Subpart Z - Toxic and Hazardous Substances (see the text box on OSHA Regulations on the following page).

2. Compounds considered to be "Known Carcinogens" by the National Toxicology Program, (NTP) in their Annual Report on Carcinogens as well as some substances listed as "reasonably anticipated to be carcinogens."

3. Compounds designated as "carcinogens to humans" (Group 1) and some "reasonably anticipated to be carcinogens" (Group 2A or 2B) by the International Agency for Research on Cancer (IARC).

Examples of carcinogens include: acrylamide, acrylonitrile, benzene, ethylene oxide and formaldehyde.

Reproductive Toxins

Reproductive hazards are substances or agents that may affect the reproductive health of women or men or the ability of couples to have healthy children. These hazards may cause problems such as infertility, miscarriage, decreased physical or mental health of the baby and birth defects. The effects may include chromosomal damage (mutations) and effects on developing fetuses (teratogenesis). Reproductive toxins can affect both men and women.

Examples of reproductive toxins include carbon disulfide, lead (inorganic), and 2-methoxyethanol.

Highly Acute Toxins

Highly acute toxins are materials that may be fatal or cause damage to target organs from a single exposure or exposures of short duration. The specific effects depend on the material but may include: intense irritation that can result in pulmonary edema (fluid and swelling in the lungs), chemical asphyxia, and systemic (body-wide) poisoning.

Highly acute toxins include any chemical that falls within one or more of the following categories:

1. A chemical with a median lethal dose (LD_{50}) of 50 mg or less per kg of body weight when administered orally to certain test populations.

2. A chemical with an LD_{50} of 200 mg or less per kg of body weight when administered by continuous contact for 24 hours (or less if death occurs within 24 hours) to certain test populations.

3. A chemical with a median lethal concentration (LC_{50}) in air of 200 parts per million (ppm) by volume or less of gas or vapor, or 2 mg per liter or less of mist, fume, or dust, when administered to certain test populations by continuous inhalation for one hour, provided such concentration and/or condition are likely to be encountered by humans when the chemical is used in any reasonably foreseeable manner.

Examples of highly acute toxins include: hydrogen cyanide, dimethyl mercury, chlorine gas, phosgene gas, and sodium azide.

OSHA Regulations

There are a number of OSHA health standards [29 CFR 1910 Subpart Z] with specific requirements for certain carcinogens and particularly hazardous chemicals, including:

- Asbestos
- 13 Carcinogens: 4-Nitrobiphenyl, alpha-Naphthylamine, methyl chloromethyl ether, 3,3'-Dichlorobenzidine (and its salts), bis-Chloromethyl ether, beta-Naphthylamine, Benzidine, 4-Aminodiphenyl, Ethyleneimine, beta-Propiolactone, 2-Acetylaminofluorene, 4-Dimethylaminoazo-benzene, N-Nitrosodimethylamine
- Vinyl Chloride
- Inorganic Arsenic
- Lead
- Hexavalent Chromium
- Cadmium
- Benzene
- 1,2-Dibromo-3-chloropropane
- Acrylonitrile
- Ethylene Oxide
- Formaldehyde
- Methylenedianiline
- 1,3-Butadiene
- Methylene Chloride

However, where applicable, the OSHA Lab Standard supersedes the requirements of all other OSHA health standards in 29 CFR 1910 Subpart Z, except as follows:

1. For any OSHA health standard, only the requirement to limit employee exposure to the specific permissible exposure limit shall apply for laboratories, unless that particular standard states otherwise or unless the conditions listed in 3 below apply.
2. Prohibition of eye and skin contact where specified by any OSHA health standard shall be observed.
3. Where the action level (or in the absence of an action level, the permissible exposure limit) is routinely exceeded for an OSHA regulated substance with exposure monitoring and medical surveillance requirements paragraphs (d) and (g)(1)(ii) of the OSHA Lab Standard shall apply.

Appendix D: On-Line Chemical Safety Resources

General Chemical Hazard and Safety Information

1. NIOSH Pocket Guide to Chemical Hazards. Reference document that concisely summarizes key safety information (physical properties, potential routes of exposure, health effects, exposure limits, etc.) for thousands of chemicals.

   In addition to the information included in the body of the NIOSH Pocket Guide, the appendices also include information that may be useful: http://www.cdc.gov/niosh/npg/nengapdx.html (or control + click on appendix below)
   APPENDIX A - NIOSH Potential Occupational Carcinogens
   APPENDIX B - Thirteen OSHA-Regulated Carcinogens
   APPENDIX C - Supplementary Exposure Limite
   APPENDIX D - Substances with No Established RELs
   APPENDIX E - OSHA Respirator Requirements for Selected Chemicals
   APPENDIX F - Miscellaneous Notes
   APPENDIX G - 1989 Air Contaminants Update Project: Exposure Limits NOT in Effect

2. International Chemical Safety Cards; US Version.

3. OSHA Safety and Health Topics page: Carcinogens.

4. OSHA Safety and Health Topics page: Chemical Reactivity Hazards.

5. OSHA Safety and Health Topics page: Laboratories.

6. OSHA Safety and Health Topics page: Reproductive Hazards.

7. OSHA/EPA Occupational Chemical Database. Database compiling information from several government agencies and organizations, that includes a list of PELs and Carcinogens, with available reports that include: "Physical Properties," "Exposure Guidelines," "NIOSH Pocket Guide," and "Emergency Response Information."

8. NTP 11th Report on Carcinogens. This includes a list of known carcinogens and reasonably anticipated to be carcinogens, as well as specific substance profiles. NTP Candidate Substances for the 12th Report on Carcinogens.

9. Prudent Practices in the Laboratory: Handling and Disposal of Chemicals

In the early 1980s, the National Research Council (NRC) produced two major reports on laboratory safety and laboratory waste disposal: Prudent Practices for Handling Hazardous Chemicals in Laboratories (1981) and Prudent Practices for Disposal of Chemicals from Laboratories (1983). The NRC's Board on Chemical Sciences and Technology issued an update and revision of the earlier studies in 1993.

OSHA Lab Standard and Interpretive Guidance

1. OSHA "Occupational Exposure to Hazardous Chemicals in Laboratories" Standard [29 C.F.R. 1910.1450]

2. OSHA Standard Interpretations for the Lab Standard