LABORATORY CHEMICAL SAFETY

AND

PROCEDURES MANUAL

University of Lethbridge

Campus Safety – Safety Services

Faculty of Arts & Science

2019

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Note: The official version of this document is online on the U of L Safety Services website.

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1. Introduction

The University of Lethbridge's **Environment, Health and Safety (EHS) Policy** is the governing document for health and safety at all University of Lethbridge (UofL) worksites. The University's **Environment, Health and Safety Management System (EHSMS)** has been developed to assist with implementation of the EHS Policy and enables the University to meet its obligation to provide a healthy and safe place for work and study.

The **Laboratory Chemical Safety and Procedures Manual** is a reference manual that provides information on safe use, storage and disposal of laboratory chemicals and general laboratory operations. It incorporates general guidelines as well as in-depth information on many laboratory safety best practices. It is not meant to be all-inclusive. Since there is a wide range of hazards present in laboratories, laboratory specific safe work procedures will be required to supplement the information provided in this manual. Laboratory supervisors and faculty members must ensure that lab specific standards and procedures are developed that address the hazards associated with the equipment, chemicals and work procedures in their particular laboratories.

This manual also references the **Chemical Safety Standard** which outlines general requirements for the University. Together, these documents are 'administrative controls' that mitigate hazards and assist with implementation of the EHS Policy with respect to laboratory and chemical safety.

This manual applies to all laboratory spaces where chemical and related laboratory hazards exist. There is a great diversity of work performed in laboratories at the University of Lethbridge and parts of this manual will not apply to all laboratories. It is the responsibility of supervisors to inform their workers and students as to which parts of this manual apply.

In addition, individuals working with biological and/or radioactive materials are required to comply with all requirements identified in the Biosafety Code of Practice and the Radiation Safety and Procedures manual. Other specific manuals, such as the Cryogen Safety manual, will also need to be consulted.

Adherence to the guidelines and best practices in this manual bring the University into compliance with relevant sections of the Occupational Health and Safety Act and demonstrate due diligence on the part of employers in maintaining a safe working environment.

1.1 Responsibilities

In accordance with the AB OHS Act, safety at the work site (i.e. in the laboratory) is the shared responsibility of everyone in the lab. General responsibilities are defined in the University's **EHSMS Responsibilities Summary.** Additional laboratory responsibilities are listed below:

Principal Investigator/ Laboratory Supervisor

- Take all precautions necessary to protect the health and safety of every laboratory worker under their supervision and report all unsafe acts or conditions.
- Identify hazards and implementing appropriate control measures (e.g. ventilation, safe work practices and personal protective equipment) to minimize or eliminate the hazards.
- Establish standard operating and/or safe work procedures appropriate for the work.

- Ensure laboratory workers are advised of all known or reasonably foreseeable hazards to health and safety in the area where work is performed.
- Provide training specific to the hazards and processes in the laboratory to all laboratory workers prior to starting work or prior to undertaking new work. This includes the safe handling, use, storage and disposal of chemicals and hazardous laboratory procedures.
- Conduct periodic formal and informal inspections of their areas for hazardous conditions, and promptly correcting unsafe work practices or hazardous conditions.
- Provide the required personal protective equipment and ensure laboratory workers properly use and maintain PPE.
- Ensure that all safety equipment (e.g. fume hoods, emergency eye wash and showers) is in working order.
- Ensure that laboratory workers under their supervision are not subjected to or participate in harassment or violence at the work site.

Laboratory Workers

- Fulfill their obligation under the AB OHS Act to protect their own health and safety and that of other workers present while they are working.
- Observe established safety policies and procedures established by the University and any safe work procedures or guidelines established by the laboratory supervisor.
- Participate in laboratory-specific training prior to starting work in the laboratory.
- Report incident, injury, unsafe conditions, insecure conditions or threats to personal security and property to supervisor as soon as possible.
- Properly use and adequately care for personal protective equipment.
- Seek clarification from supervisor on laboratory procedures.

Campus Safety

- Provide advice and assistance to departments and supervisors to help them meet their requirements under the law in order to provide a healthy and safe work environment.
- Monitor regulatory compliance and help departments and supervisors identify areas where corrective action is required.
- Provide advice and guidance on laboratory hazard assessments, laboratory design (including ventilation), selection, use and maintenance of personal protective equipment, and safe work procedures.
- Coordinate the **Workplace Hazardous Materials Information System (WHMIS) program** at the University and facilitates training for personnel whose work involves the use of hazardous chemicals.

1.2 Laboratory Safety Plans

The University's **Environment, Health and Safety System (EHSMS)** outlines standards and procedures for integrating health and safety into all University operations. Laboratories must have a written safety plan in accordance with the EHSMS. Safety Services provides resources, such as the EHSMS Manual binder and EHSMS Guide that can be used to develop **Laboratory Safety Plans**. Contact Safety Services for advice and assistance.

In a university setting, all work is pursued in a collegial environment and the safety of the individual is affected by the action of others in the laboratory. It is in everyone's best interest to be familiar with the work of others and to insist that fellow workers in the laboratory follow safe work practices.

1.3 Setting up A New Laboratory

In addition to the EHSMS Manual and Guide, the **Safety Checklist for Laboratory Researchers** is a useful tool for:

- starting up a new lab,
- providing an orientation to new lab staff or
- annual lab safety plan review.

The checklist is available on the Safety Services webpage.

1.4 Lab Orientation and Training

In addition to the University's general **Health and Safety Orientation**, Principal Investigators (PI)/laboratory supervisors or their designates must provide a lab-specific orientation for all lab employees that addresses specific hazards inherent to the lab.

A **Site-specific Orientation Template** is provided on the Safety Services webpage.

PIs/lab supervisors must also provide **laboratory-specific training** that covers hazards and emergency procedures in the laboratory. Lab personnel may also need specialized training to operate lab equipment. When a laboratory or core piece of equipment is shared by multiple user groups, the PI or Laboratory Supervisors of these groups should work together to provide cross-training on the various hazards associated with their individual projects. PIs should use a combination of the following to develop training:

Safety Resources and Equipment: review Laboratory Safety Plans. List the documentation, manuals, Safety Data Sheets, and other safety resources that are available to the worker and information that the worker should be aware of. Review Hazard Assessments, Standard Operating Procedure(s) (SOPs) for hazardous materials and related procedures identifying hazards associated with a specific experiment or process. Ensure required personal protective equipment (PPE) is available and provide instruction on its use, care and storage.

Emergency Procedures: review local/building safety information. List emergency equipment and lab specific emergency procedures. It is extremely important that all workers are aware of the location of emergency equipment and know how to operate it before they start work so they are able to access it without delay in the event of an emergency.

Chemical, Radiation and Biosafety: list the training and instruction that is required for workers working with chemicals, radioisotopes or biohazardous materials.

Hazardous Waste Disposal: identify hazardous waste storage and disposal procedures in the lab.

Laboratory Equipment: lab workers must be trained on the use of laboratory equipment they will use. For example:

- Centrifuges
- Ovens
- Rotary evaporators
- Autoclaves
- Ultraviolet (UV) emitting equipment
- Designated radiation equipment (lasers, x-ray emitting devices)
- Biosafety cabinets

Review the health and safety requirements for laboratory equipment and instrumentation (e.g. manufacturer's operating manual).

PIs can use the **Lab Personnel Training Record** to document training requirements and learning objectives.

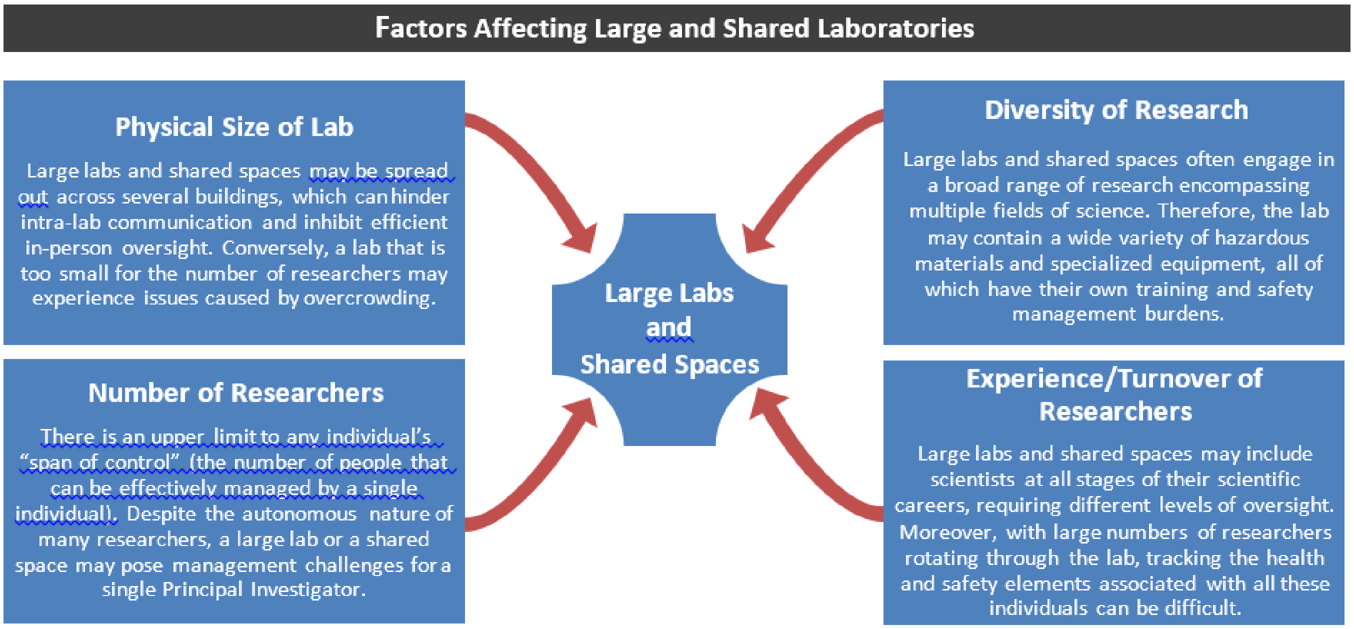
Health and safety work procedures and **standard operating procedures (SOP)** are also required.

Refer to **Section 7, Hazard Control Measures**, for details.

1.5 Strategies for Managing Shared Laboratories

Collaborative benefits result from researchers sharing lab spaces, in addition to improved space efficiency for laboratory facilities and equipment. Shared labs facilitate good stewardship of research funds and campus resources and can yield positive returns for all involved.

Large laboratories and shared spaces also present challenges. There may be significant number of lab personnel conducting different types of work in the same space at the same time. The following guide provides information and best practices for maintaining core health and safety elements in large laboratories (i.e. >20 members) and/or shared laboratory spaces.



Challenges

Common challenges encountered by large labs and shared spaces can include:

- poor general housekeeping
- accumulation of unneeded research samples/chemicals/supplies
- hazardous materials and waste which are not properly labeled, stored, or disposed of
- lack of individual accountability
- lack of mechanisms for resolving health and safety matters

Strategies for managing these challenges in large labs and shared spaces, along with all labs, are provided on the next page.

Management Strategies for Principal Investigators

	Demonstrate a Commitment to Safety	Delegate	Formalize Onboarding and Departure Processes	Establish Housekeeping Guidelines	Monitor Lab Spaces
For All Labs	• Include **discussions of safety** at lab meetings, one-on-one discussions, planning of experiments, etc. • Walk through your lab on a regular basis and use this as an opportunity to **reinforce safety** as a high priority. • Wear **proper personal protective equipment** (PPE) while in the lab. • **Enforce rules**, updating them when new conditions are introduced	• Assign "lab coordinators" (LCs) to assist in **managing routine tasks.** • Transition outgoing and incoming LCs over a **six month period;** • **Inform all lab members** what duties you have delegated to the LCs. • Ensure LCs have the **authority and respect** needed to enforce lab rules.	• **Create a training plan** to ensure all lab members obtain general health & safety training, as well as lab-specific training and orientation. • Ensure lab members are mentored and supervised while learning new procedures until they are ready to work independently. • Use the Lab **Closeout Procedure** to ensure that researchers remove their hazardous materials before leaving the laboratory.	• Establish criteria for **good housekeeping** and ensure rules are consistently enforced across the entire lab. • Share **photos** of what constitutes good housekeeping. • **Use signage** to label experiments in progress and/or equipment use.	• Perform **laboratory self-inspections** each semester. • **Rotate** self-inspections through all lab members. • Focus particularly on lab equipment and spaces **utilized by multiple researchers** when conducting self-inspections. • Self-inspection **checklists are available online** via Safety Services website and the CHEMATIX Lab Inspection Module.
For Large Labs/Shared Spaces		• Assign a LC for each main area in labs spread across multiple buildings.		• Conduct frequent **lab clean ups** (e.g., at least monthly). Identify and plan for removal of unneeded supplies, equipment, hazardous waste, etc.	• Perform **additional self-inspections** more frequently (e.g. weekly). • Assign researchers to provide **extra monitoring** for specific areas of the lab such as shared spaces.

Reference: Stanford EHS, Managing Large Laboratoris and Shared Laboratory Spaces

2. General Laboratory Safety

The **Laboratory Rules Poster** outlines general rules for laboratory safety and must be posted in each lab space. Refer to the Safety Services webpage to download a copy for posting. Additional lab safety information is provided below.

2.1 Personal Health and Hygiene

Exposure to hazardous chemicals may occur by **four main routes**: **inhalation, ingestion, injection and absorption through eye or skin contact.** The goal of personal hygiene in the lab is to prevent unnecessary exposure by minimizing routine contact with chemicals in the lab. Some ways to do this include:

- Avoid direct contact with any hazardous chemical. Know the hazards of the chemicals used and wear the appropriate personal protective equipment.
- Avoid inhalation of chemicals. Transfer solvents in the fume hood, vent apparatus that may discharge chemical vapours into local exhaust devices, and avoid "sniffing" chemicals.
- Always assume that a mixture of chemicals is more hazardous than its most hazardous component and treat it accordingly. Unknown substances should always be treated as hazardous.
- Wash hands thoroughly with soap and water after working with any lab chemicals, even if gloves were worn.
- Do not pipette by mouth.

Care must also be taken to prevent unintentional chemical exposure of others and the spread of chemical contamination, both in and out of the lab:

- Lab coats and aprons should not be worn outside the lab, except when necessary (getting chemicals from storerooms, walking from one lab to another, etc.) They should never be worn in eating areas, restrooms, or offices.
- Remove gloves before leaving the lab or handling objects such as telephones, computer keyboards, and pens to prevent the spread of chemical contaminants.
- If it is necessary to wear gloves outside the lab (for example, when transporting chemicals), then another person should accompany to open doors, press elevator buttons, and similar operations.

2.2 Housekeeping

Clutter in the laboratory is both detrimental to efficient work and a serious safety hazard. Always keep areas clean and tidy, and free of unnecessary chemicals and apparatus. Make clean up a part of your normal work routine. Some ways to keep the lab tidy and orderly include:

- Store equipment not in active use in a designated area, away from the work area.
- Clean equipment and glassware as soon as possible.
- Return chemicals to storage after use.
- Clean work surfaces regularly to prevent accumulation of dust and spilled chemicals.

- Keep all exits, aisles and walkways in the lab clean and unobstructed to allow safe movement throughout the lab. **A minimum of 1 meter clearance must be maintained in aisles.**
- Do not allow electrical cords or tubing for gas or water to trail across aisles or out of fume hoods. Also, do not hang cords and gas tubing from the ceiling.
- Clean up all spills immediately.
- Do not block access to emergency equipment and utility controls.
- Do not store boxes and excess equipment and personal belongings in the lab.

The ***Alberta Fire Code*** requires that all means of access to and egress from the work site be kept free of obstructions that may endanger workers or impede exit during an emergency.

2.3 Proper Laboratory Apparel

Proper choice of clothing and apparel helps minimize chemical exposure.

- Wear a lab coat when working with hazardous materials.
- Wear shoes that fully cover the feet to protect from spills. Do not wear open-toed or open-heeled shoes or sandals.
- Wear approved safety glasses/goggles.
- Confine long hair and loose clothing.
- Wear clothing which does not leave large areas of skin exposed (no shorts, skirts, or short sleeved shirts).
- Do not wear loose jewelry, as it may become ensnared on equipment. Rings that can damage protective gloves or make wearing/removing gloves difficult should also be removed prior to working in the lab.

2.4 Food, Drink and Smoking in the Laboratory

Eating, drinking and smoking in areas potentially contaminated by harmful substances is prohibited. In addition, activities such as applying cosmetics, inserting or removing contact lenses, or any other manipulations that could transfer hazardous chemicals into the body via the mouth or eyes, are prohibited in laboratories and chemical storage areas. University policy prohibits smoking in buildings or parts of buildings under the control of the University.

Do not use laboratory equipment (e.g. refrigerators, microwave ovens, glassware) to store, prepare or consume food. Laboratory water sources and deionized water should not be used as drinking water sources.

2.5 Non-Lab Personnel, Contractors, Visitors and Minors in the Laboratory

Only authorized persons should be permitted in University labs. "Authorized" in this case means someone who has a valid reason to be there, such as the students working in the lab or a person who has permission of lab supervisor or person in charge to be there. Casual visitors are not permitted in the lab.

In all cases, visitors must be made aware of hazards in the lab, emergency procedures in the event of spill, fire or alarm, and provided with appropriate personal protective equipment as necessary. Refer to the **Visitor Safety Standard** for further information.

2.5.1 Non-Lab Personnel and Contractors

Maintenance personnel performing work in University labs must contact the person in charge of that area prior to doing any work and should be supervised. A **Laboratory Clearance to Work** is required. In some instances, a **Laboratory Closeout** may be required.

The University's **Contractor Safety Program** outlines additional procedures that must be followed when contractors or service providers are required to perform work in a lab. Refer to these procedures and contact Campus Safety for more information.

2.5.2 Minors

Minors are defined as persons under the age of 18. Children – be they of faculty, staff, teaching assistants, graduate students or students - are not allowed in restricted areas or in laboratories at any time. Minors are only permitted in University labs as part of University sanctioned tours or visits authorized by a Department. In these instances, the tour leader or other knowledgeable personnel must exercise careful, direct supervision at all times. Persons wishing to bring minors into their work areas require special permission from the Department Head and must conduct a hazard assessment and implement appropriate corrective measures prior to bringing them.

2.5.3 Volunteers

The University's **Volunteers in Research and Creative Activities** Policy of Lethbridge must be followed for lab volunteers. Volunteers must receive the same health and safety orientation, hazard assessment review and training as employees; however, restrictions are placed upon the types of work volunteers can perform. Additional requirements apply to minors. Refer to the policy for details.

2.6 Experimental Planning and Hazard Management

A hazard assessment (HA) is required for all work. Thoroughly plan and assess each step of the process to identify and eliminate or control associated hazards. The HA must be updated any time new work, processes or equipment are used. The degree of documentation and formality of the planning process will depend on the level of potential hazard and the skill of the personnel involved.

> **It is the responsibility of all researchers to be familiar with and inform their lab staff of the health and physical hazards of all laboratory activities, equipment, chemicals, etc.**
>
> Additional information is provided in **Section 7. Hazard Control Measures** and on Safety Services' **Hazard Management webpage.**

Since the types of lab experiments are diverse and are conducted by a wide range of practitioners whose skills and backgrounds vary, the lab supervisor should establish the level of experiment planning and documentation appropriate for each situation.

Prior approval from the lab supervisor is required when:

- Working with chemicals that are carcinogenic, reproductive toxins, or highly toxic.
- Working with hazardous materials with regulatory requirements for use.
- Starting a new, unfamiliar experiment or procedure, or making significant changes to existing procedures.
- Leaving experiments unattended for a lengthy period of time or overnight.
- Continuing experiments in which there has been an unexpected result or incident (e.g. personnel becoming ill, or unexpected hazardous conditions developing during the course of the experiment.
- Working alone or after hours.

In some cases, working after hours or leaving experiments unattended is necessary. During the worker's introductory safety orientation, the lab supervisor must explain how and when such operations should be performed. Workers must obtain the lab supervisor's approval prior to undertaking these activities.

2.7 Off-Hours Work Practices

Working in the laboratory outside of traditional office hours or working without immediate access to a supervisor poses additional risks since there may be few, if any, other people around. It is necessary to be vigilant of potential health and safety concerns at these times, since assistance may not be readily available in the event of an emergency. Therefore:

- New or unfamiliar procedures should never be performed without supervision.
- Only work of relatively low risk should be performed without supervision.
- Lab supervisors must approve all after hour work in labs.
- Ensure appropriate personal protective and emergency response equipment such as first aid kit, emergency shower, eyewash and fire extinguisher is available.
- Ensure that a communication system is available, that contact numbers are known and a check in/out procedure is implemented.

2.8 Working Alone

Working alone is defined in Part 28 of the Alberta Occupational Health and Safety Act as to work alone at a work site in circumstances where assistance is not readily available if there is an emergency or if the worker is injured or ill. The legislation, which applies to all situations and not just laboratories, requires that:

- Operations are assessed for existing and potential safety hazards and a written hazard assessment be completed.
- Safety measures are taken to reduce or eliminate the hazards identified.
- A communication system is established or appropriate procedures developed so a person working alone can contact someone for aid in an emergency situation.
- All employees are trained in any procedures developed to manage working alone.

If you or someone in your lab works alone at any time of the day, especially outside of regular working hours when they may be alone, a working alone protocol must be developed as per the AB OHS Code. Forward a copy of this protocol to Campus Safety for review.

Anyone working alone on campus must register online:
https://www.uleth.ca/security/working-alone
For more information on working alone legislation and policies, refer the University of Lethbridge **Working Alone Protocol**.

2.9 Unattended Operations

Unattended operations pose a safety hazard if a problem occurs, especially outside of normal working hours, and should be kept to a minimum. Like working after hours, all unattended operations require prior approval of the lab supervisor.

For operations that require continuous or overnight operation, steps must be taken to prevent spills, floods and/or fires in the case of mechanical, power or water failure. Some typical precautions include:

- Operations that involve cooling water must have the hoses firmly attached and secured with hose clamps and water flow adjusted to the minimum flow necessary. Tygon or PVC (clear) tubing must be used since it is less likely to deteriorate and break.
- Set up unattended operations in a fume hood, so that in the event of system failure, no hazardous materials will be released into the lab space. Ensure all fume hoods will remain on during the experiment.
- A sign must be posted giving the name and phone number of someone who can be contacted in the event of a problem.

If an operation is to be left running unattended during regular working hours, it should be visited periodically (as determined by the lab supervisor) to ensure there are no problems.

2.9.1 Principal Investigator Absences/Leaves

The Principal Investigator (PI) is ultimately responsible for providing supervision to the workers in their laboratories. The PI must make arrangements for another person to provide supervision to students and workers in the PI's laboratory. This person must be knowledgeable of and competent in the work procedures and hazards of the PI's laboratory so that they can fulfill this important supervisory role.

2.10 Workplace Impairment – Hazardous Operations and Materials

When working with hazardous materials or conducting procedures with significant risk, workers need to be alert and focused on the operation that they carried out. Any impairment arising from previous consumption of drugs (e.g. cannabis, opioids, etc.) or alcohol can seriously endanger the worker and fellow workers in the laboratory. If a worker is found to be impaired, it should be immediately brought to the attention of the supervisor. Refer to the U of L Cannabis Use Policy for further information.

Drugs and laboratory research activities do not mix.

Lab personnel must be **"Fit to Work",** meaning that an individual is in a physical, mental, and emotional state which enables the individual to perform the essential tasks of their work successfully or in a manner which does not threaten the safety or health of oneself, co-workers, property, or the public at large.

2.11 Utility Shutdowns

Work with chemicals must not be performed during water shutdowns. In the event of an accident or chemical spill during a shutdown, there is no water supply available for emergency showers and eyewashes. Laboratory work that does not involve the handling of chemicals, such as setting up apparatus or recording data is permissible as long as the chance of chemical exposure is minimal. It is the responsibility of Facilities to disseminate information about scheduled utility interruptions.

In the event of a power failure or shutdown, evacuate the lab and close the doors. This is to prevent exposure to chemicals due to fume hoods and other exhaust system shutdown. Return to the lab only when authorized to do so by Facilities (after power is restored and the lab has been fully vented for at least one hour). Prior to evacuation, it may be prudent to perform whatever operations are necessary to leave reactions safely until you can return.

PIs are responsible for developing emergency procedures and for providing Facilities with advanced notification if there are lab procedures or equipment that are sensitive to unplanned utility interruptions. This ensures that notifications can be provided and accommodations can be made, as applicable.

3. Workplace Hazardous Materials Information System (WHMIS) 2015

The Workplace Hazardous Materials Information System (WHMIS) is "**right to know**" legislation that ensures workers are informed of the risks associated with the hazardous materials found at the worksite, including laboratories. It is an information delivery system developed by the collective effort of labour, industry and government. WHMIS consists of both federal legislation, which mainly regulates the supplier aspects of the program, and provincial legislation (Part 29 of the AB OHS Code) that regulates WHMIS at the worksite.

This section provides a summary of WHMIS requirements applicable to university laboratories. Refer to the Safety Services website for further information on **WHMIS and WHMIS training**.

WHMIS 2015

Amendments to the federal Hazardous Products Act and the new Hazardous Products Regulations came into effect February 11, 2015 under the authority of Health Canada. These changes integrate Workplace Hazardous Materials Information Systems (WHMIS) with the Globally Harmonized System of Classification and Labelling of Chemicals (GHS) (WHMIS 2015). Full compliance was required by December 1, 2018.

WHMIS 2015 has three components:
1. Labels
2. Safety Data Sheets (SDSs)
3. Worker Education and Training

3.1 Identification (classification) of hazardous products

WHMIS 2015 applies to "hazardous products". A hazardous product is any product that meets the criteria to be classified in a category or subcategory of one or more of the hazard classes as described in the federal Hazardous Products Regulations (HPR).

WHMIS 2015 applies to two major groups of hazards:
- physical hazards, and
- health hazards.

Each hazard group includes hazard classes that address specific hazardous properties. Products in the physical hazards group are classified based on characteristics such as flammability or reactivity. Health hazards are grouped based on their ability to cause a health effect, such as cancer or skin irritation. Both groups are divided into classes of materials with similar properties. There are 19 distinct classes in the physical hazards group and 12 classes in the health hazards group. The WHMIS 2015 hazard classes are listed below.

Classes in the Physical Hazards Group are:

1. Flammable gases
2. Flammable aerosols
3. Oxidizing gases
4. Gases under pressure
5. Flammable liquids
6. Flammable solids
7. Self-reactive substances and mixtures
8. Pyrophoric liquids
9. Pyrophoric solids
10. Self-heating substances and mixtures
11. Substances and mixtures which, in contact with water, emit flammable gases
12. Oxidizing liquids
13. Oxidizing solids
14. Organic peroxides
15. Corrosive to metals
16. Combustible dusts*
17. Simple asphyxiants*
18. Pyrophoric gases*
19. Physical hazards not otherwise classified*

Classes in the Health Hazard Group are:

1. Acute toxicity
2. Skin corrosion/irritation
3. Serious eye damage/eye irritation
4. Respiratory or skin sensitization
5. Germ cell mutagenicity
6. Carcinogenicity
7. Reproductive toxicity
8. Specific target organ toxicity – single exposure
9. Specific target organ toxicity – repeated exposure
10. Aspiration hazard
11. Biohazardous infectious materials*
12. Health hazards not otherwise classified*

** These hazard classes are part of WHMIS 2015 but are not part of the GHS.*

Most hazard classes are further subdivided into categories and subcategories based on the severity of the hazard. Most categories are identified by a number and subcategories by a number and letter.

The lower the category number, the more severe the hazard, for example, a product classified as a Flammable Liquid-Category 1 is more hazardous than a Flammable Liquid-Category 2.

3.2 Labels

There are two types of labels: supplier and work site labels.

3.2.1 Supplier labels

Supplier Labels are attached by the supplier and must contain the following information*:

1. **Product identifier** – the brand name, chemical name, common name, generic name or trade name of the hazardous product.

2. **Initial supplier identifier** – the name, address and telephone number of either the Canadian manufacturer or the Canadian importer*.

3. **Pictogram(s)** – hazard symbol within a red "square set on one of its points".

4. **Signal word** – a word used to alert the reader to a potential hazard and to indicate the severity of the hazard.

5. **Hazard statement(s)** – standardized phrases which describe the nature of the hazard posed by a hazardous product.

6. **Precautionary statement(s)** – standardized phrases that describe measures to be taken to minimize or prevent adverse effects resulting from exposure to a hazardous product or resulting from improper handling or storage of a hazardous product.

7. **Supplemental label information** – some supplemental label information is required based on the classification of the product. For example, the label for a mixture containing ingredients with unknown toxicity in amounts higher than or equal to 1% must include a statement indicating the percent of the ingredient or ingredients with unknown toxicity. Labels may also include supplementary information about precautionary actions, hazards not yet included in the GHS, physical state, or route of exposure. This information must not contradict or detract from the standardized information. (*source: www.ccohs.ca)

Most hazard classes have a pictogram assigned to them. A few hazard classes have more than one pictogram (i.e. one pictogram is used for certain categories, and a different pictogram is used for other categories). Some hazard classes and some categories within a hazard class do not have a pictogram (for example, combustible dusts, simple asphyxiants, and flammable liquids – Category 4).

The table on the following page provides a list of pictograms and their associated hazards. For the Physical and Health Hazards Not Otherwise Classified hazard classes, the supplier must use a WHMIS 2015 pictogram appropriate for the hazard.

An example of a compliant supplier label is provided on the following page.

WHMIS 2015 PICTOGRAMS

	**Exploding bomb** (for explosion or reactivity hazards)		**Flame** (for fire hazards)		**Flame over circle** (for oxidizing hazards)
	**Gas cylinder** (for gases under pressure)		**Corrosion** (for corrosive damage to metals, as well as skin, eyes)		**Skull and Crossbones** (can cause death or toxicity with short exposure to small amounts)
	**Health hazard** (may cause or suspected of causing serious health effects)		**Exclamation mark** (may cause less serious health effects or damage the ozone layer)		**Environment*** (may cause damage to the aquatic environment)
	**Biohazardous Infectious Materials** (for organisms or toxins that can cause diseases in people or animals)				

* The GHS system also defines an Environmental hazards group. This group (and its classes) was not adopted in WHMIS 2015. However, you may see the environmental classes listed on labels and Safety Data Sheets (SDSs). Including information about environmental hazards is allowed by WHMIS 2015.

COMPLIANT SUPPLIER LABEL

Product K1 / Produit K1

Danger

Fatal if swallowed.
Causes skin irritation.

Precautions:

Wear protective gloves.
Wash hands thoroughly after handling.
Do not eat, drink or smoke when using this product.

Store locked up.
Dispose of contents/containers in accordance with local regulations.

IF ON SKIN: Wash with plenty of water.
If skin irritation occurs: Get medical advice or attention.
Take off contaminated clothing and wash it before reuse.
IF SWALLOWED: Immediately call a POISON CENTRE or doctor.
Rinse mouth.

Danger

Mortel en cas d'ingestion.
Provoque une irritation cutanée.

Conseils :

Porter des gants de protection.
Se laver les mains soigneusement après manipulation.
Ne pas manger, boire ou fumer en manipulant ce produit.

Garder sous clef.
Éliminer le contenu/récipient conformément aux règlements locaux en vigueur.

EN CAS DE CONTACT AVEC LA PEAU : Laver abondamment à l'eau.
En cas d'irritation cutanée : Demander un avis médical/consulter un médecin.
Enlever les vêtements contaminés et les laver avant réutilisation.
EN CAS D'INGESTION : Appeler immédiatement un CENTRE ANTIPOISON ou un médecin.
Rincer la bouche.

Compagnie XYZ, 123 rue Machin St, Mytown, ON, N0N 0N0 (123) 456-7890

Small Container Labels

Supplier labels for hazardous products in small containers may carry less information. Containers with a capacity of 100 ml or less are not required to have hazard statements or precautionary statements on the label. An example is provided below:

3.1.2 Work site labels

These labels are to be placed on secondary containers when **decanted** from supplier containers and must contain the following information:
1. Product name that matches the product name on the SDS or original supplier label.
2. Safe handling precautions (may also include pictograms, hazard or precautionary statements or other supplier label information.
3. A reference to the SDS

Work site labels must also be used on **hazardous products produced for use** on the worksite and on supplier containers to **replace missing or illegible supplier labels**.

(Image provided by CCOHS 2015)

There are two situations when a work site label is not necessary. When a hazardous product is:

- poured into a container and it is going to be used immediately, or
- "under the control of the person who decanted it".

For example, when the person who poured the product into another container will be the only person who will use it, and the product will be used during one shift, a full workplace label may not be required. However, the container must still be identified with the product identifier (name).

If the product is not used right away or if more than one person will be in control of the product, a full work site label is required.

A WHMIS label can also be a mark, sign, stamp, sticker, seal, ticket, tag, or wrapper. It can be attached, imprinted, stencilled or embossed on the hazardous product or its container. Workers must be trained to be able to identify these alternate systems if they are used in the workplace.

Hazardous Products Produced in the Lab

If products developed in the laboratory will be used, handled, or stored in a workplace and if these products meet any of the criteria for the WHMIS 2015 hazard classes, the laboratory must classify the product hazards and provide a label and SDS.

For many newly created products, the hazards of the product may be unknown until testing is completed. In this case, the newly created product may be treated as a **laboratory sample** until it is analyzed and evaluated.

Laboratory Sample Label

For hazardous products sent to the laboratory for analysis or for products that are in the process of being developed, exemptions could apply if certain conditions are met. A laboratory sample is defined as a sample of a hazardous product that:

- is packaged in a container that contains less than 10 kilograms of the hazardous product,
- is intended solely to be tested in a laboratory, and
- does not include a sample that is to be used by a laboratory for testing other products or for educational or demonstration purposes.

Examples of laboratory samples include:

- samples for quality control testing,
- samples provided for the development of industrial processes,
- diagnostic specimens (e.g., blood or tissue samples), and
- industrial hygiene samples.

Laboratory samples do not require an SDS and have reduced label requirements if they are **'bailed'** and:

- the chemical name and concentration of the hazardous product or its ingredients are not known, or
- the hazardous product is not yet available on the market (i.e., has not been offered or exposed for transfer of ownership).

'Bailed' means transfer of possession without transfer of ownership. In this situation, the laboratory does not own the laboratory sample, but has possession of the sample while conducting testing on behalf of the owner.

When products are sent to a laboratory for analysis, it is not always clear how to label the samples because the owner of the sample may not yet know if a product is a hazardous product. It is expected that the owner of the sample will use their best judgement based on known information, and will label the sample accordingly.

At a minimum, a laboratory sample must be labelled with the following information:

- the product identifier,
- the chemical name or generic chemical name* of any material or substance in the sample that would have to be disclosed on an SDS, if it is known,
- the initial supplier identifier, and
- the statement "Hazardous Laboratory Sample. For hazard information or in an emergency call …" followed by an emergency telephone number for the person who can provide information that would be required on a SDS.

*The generic chemical name may only be used when a claim for Confidential Business Information (CBI) has been filed or granted.

This is for use on samples sent to an outside laboratory for analysis. Whenever possible, these should have a basic supplier label. In instances where there is not enough information about the composition of the sample to prepare a full supplier label, it should be labeled with the following information:

Laboratory Sample Label

- Sample Identifier
- Identity of Known Ingredients
- Sender's Name and Address

Statement of, "Hazardous Laboratory Sample. For hazard information or in an emergency call ____"

- An emergency telephone number

XYZ Sample

XYZ Company, 123 Anywhere St., Toronto, ON

Contains: Toluene and Sulfuric Acid

Hazardous Laboratory Sample For hazard information or in an emergency call: (306) 555-5555

3.3 Safety Data Sheets (SDS)

Safety Data Sheets (SDS) are documents that provide detailed hazard, precautionary and emergency information on a product. SDSs provide more detailed hazard information about a product than the label. They are an important resource for workplaces and workers to help learn more about the product(s) used. Use this information to identify the hazards of the products that are used and to protect the worker from those hazards, including safe handling and emergency measures.

SDSs tell users what the hazards of the product are, how to use the product safely, what to expect if the recommendations are not followed, how to recognize symptoms of exposure, and what to do if emergencies occur.

Every SDS must provide a date of last revision in Section 16 – Other Information. You will know if an SDS has been updated by checking this date, and comparing it to any previous SDS you have.

A SDS must be available for each hazardous material regulated under WHMIS that is present in the laboratory, except in the following cases:

- Chemicals from a laboratory supply house that are labelled with all the information required on an SDS.
- Controlled products produced in the laboratory that will remain in the laboratory.
- Intermediate products in reaction vessels.

The **CHEMATIX Chemical Inventory Management System** includes a provision for linking inventoried chemicals to the supplier SDS. Inventories and SDS must be updated whenever new products are brought into the laboratory or are no longer used.

Consumer products that are used in the workplace are also partially exempt from the WHMIS legislation. In practice, however, Campus Safety recommends that there be access to SDS for all hazardous products, including consumer products, in the lab.

SDSs cannot be kept in locked cabinets/rooms/desks, they must be accessible to anyone that works on or near the controlled product. An SDS may be kept in either hard (i.e. paper) or soft (i.e. electronic) format as appropriate, with the following requirements.

SDS can be made available in several ways, as long as they are readily accessible. Labs may have:

- Paper copies of SDS on hand
- Access to a central file of SDS
- Computer access to SDS
- A combination of these three options

If a laboratory is relying on computer access to provide SDS, it must ensure that:

- A computer is accessible at all times to lab personnel
- All lab personnel know how to access and retrieve the SDSs
- Hard copies can be produced if necessary

The WHMIS legislation normally requires that the SDS available for a controlled product be from the supplier of that product. Since many common reagents may be ordered from several different suppliers, there is a slight variation in SDS requirements for lab reagents:

- The reagents have exactly the same composition
- The product identifier on the SDS matches that on the label
- The hazard information does not vary from the suppliers SDS (e.g. one SDS states the reagent is carcinogenic, while the other does not)
- The original suppliers SDS can be produced upon request

Ensure there are website links to several SDS sources in case the primary source's server is not available. If a password / login are required, ensure this is set up in advance. An emergency situation is not the time to be setting up a user account.

3.4 Worker Education & Training

WHMIS legislation requires employers to educate anyone who works with or in proximity to controlled products. New staff and students must be trained before using any controlled products, and periodic refresher training is highly recommended. The legislation requires workers to participate in the training provided.

WHMIS Training at the University of Lethbridge is delivered in two stages:

1. Campus Safety offers **generic** WHMIS training. This training includes information about WHMIS labeling and SDSs, other requirements under the legislation, and practical advice on implementing and administering WHMIS at the departmental level.

2. In order to meet the legislated training requirements, generic training must be supplemented by **specific worksite WHMIS training** dealing with the hazards in individual laboratories. Such training covers hazard information for the controlled products used and lab-specific procedures for safe use, storage, handling, spill cleanup and disposal. Because it is so specific, this training will need to be provided by the Principle Investigator, laboratory supervisor or instructor.

Worker education must be documented, and a record kept of all those who have received WHMIS and other related training.

4. Working with Chemicals

There are **four basic principles** to consider when working with chemicals in the lab:

- **Plan** - determine the potential hazards associated with an experiment before beginning work. Always review the SDS before using a new chemical.

- **Minimize Exposure to Chemicals** - Avoid skin contact with all laboratory chemicals. Use laboratory fume hoods and other local ventilation to prevent exposure to airborne chemicals.

- **Never Underestimate Risks** - Always assume any mixture of chemicals is more toxic than its most toxic component. Treat all unknown chemicals or substances of unknown toxicity as toxic substances.

- **Be Prepared for Accidents** - Know what actions to take in the event of a spill, especially one on the body or in the eyes.

The following must be applied when working with chemicals in the laboratory.

For chemical exposures resulting in skin or eye contact:

1. Wash thoroughly with water for 15 minutes using the nearest emergency shower, drench hose or eyewash station. Remove any overlying clothing that may retain the chemical and/or prevent through washing of the skin.

2. Depending on the seriousness of the spill, additional medical treatment may be required. Consult the SDS for further information. All chemical splashes to the eye should receive immediate medical attention.

3. If in doubt, 24/7 first aid response is provided by Campus Safety - Security Services (403) 329-2345.

4. Report the incident to your supervisor and to Campus Safety. Submit an on-line **Campus Accident/Incident Report Form (CAIR).**

For chemical spills (without bodily contact):

Chemical spills need to be cleaned up immediately to avoid further contamination.

Whenever a chemical spill occurs, dealing with it requires an assessment of its hazards and location. Whereas spills in fume hoods, for example, can usually be dealt with easier, spills in the open lab require additional precautions.

Even small quantities that release toxic vapours may require immediate evacuation by all lab occupants. Large volumes of low-hazard materials also require great caution.

The minimum requirements are:

1. Small spills in a fume hood may be allowed to dissipate if volatile.
2. Locate the Chemical Spill Kit for adsorbents, containment and hazard labelling.
3. Liquids should be contained as much as possible to prevent running behind counters or into sinks (other than safe aqueous solutions.) Solids can be collected.
4. Dispose of all the collected materials according to standard chemical waste categories and procedures. The cleaning materials may need to be decontaminated or disposed as waste.
5. Clean the spill area in accordance with safe lab practices.

Refer to the Chemical Spill Guidelines for details.

If in doubt about how to mitigate a spill or if a spill is beyond the capacity of the workers involved, leave the lab and contact Security Services 24/7 emergency number (403) 329-2345 – Security will implement the Chemical Release Procedure and call the Chemical Release Officer for advice and assistance.

4.1 Highly Toxic Chemicals

Highly toxic chemicals include those with high acute systemic toxicity, and substances with chronic toxic effects such as carcinogens, reproductive or developmental (embryotoxins, teratogens) toxins, and mutagens. Information on the potential carcinogenicity, mutagenicity, or reproductive toxicity is generally, available on the SDS.

If you are pregnant, think you may be pregnant or are trying to conceive, you should consult your supervisor and/or Campus Safety to ensure that your duties do not involve exposure to teratogenic materials.

Chemicals with high acute toxicity may be identified using the criteria presented in Table 4.1 (see next page).

Table 4.1. Criteria for Identifying Chemicals with High Acute Toxicity

Table 1: Toxicity Classes: Hodge and Sterner Scale					
		Routes of Administration			
		Oral LD_{50}	Inhalation LC_{50}	Dermal LD_{50}	
Toxicity Rating	Commonly Used Term	(single dose to rats) mg/kg	(exposure of rats for 4 hours) ppm	(single application to skin of rabbits) mg/kg	Probable Lethal Dose for Man
1	Extremely Toxic	1 or less	10 or less	5 or less	1 grain (a taste, a drop)
2	Highly Toxic	1-50	10-100	5-43	4 ml (1 tsp)
3	Moderately Toxic	50-500	100-1000	44-340	30 ml (1 fl. oz.)
4	Slightly Toxic	500-5000	1000-10,000	350-2810	600 ml (1 pint)
5	Practically Non-toxic	5000-15,000	10,000-100,000	2820-22,590	1 litre (or 1 quart)
6	Relatively Harmless	15,000 or more	100,000	22,600 or more	1 litre (or 1 quart)

Adapted from Canadian Centre for Occupational Health and Safety (CCOHS)

LC50 is the lethal concentration in air of a substance that produces death in 50 percent of the exposed test population within a specified time. LD50 is the dose required to produce death in 50 percent of the exposed test population within a specified time.

Before starting experiments with extremely or highly toxic chemicals, examine all stages of work including acquisition, storage and handling, experimental protocol, decontamination, disposal, and clean up of spills. Each experiment should be evaluated individually, as the circumstances and amounts of the toxic chemical used will affect the types of precautions required. Experimental work should be carried out in a designated area of the lab, preferably in a fume hood or glove box.

Other lab work may be carried out in this area, provided lab personnel are made aware of the nature of the toxic chemical(s) being used and the necessary precautions to take. Post warning signs to alert others in the area and clearly define boundaries. In addition:

- Ensure fume hoods are working properly.
- Use HEPA filters, chemical scrubbers and/or cold traps to prevent the release of toxic dusts, vapours or aerosols into the atmosphere or apparatus such as vacuum pumps and lines.
- Wear long sleeved clothing and appropriate PPE, and take special care to select gloves that are impervious to the chemical(s) being handled. Wearing double gloves of different materials may be appropriate in many circumstances.
- Never work alone with highly toxic materials.

4.2 Flammable and Combustible Liquids

Flammable (or Class I) liquids are defined in the Alberta Fire Code as those liquids with a flashpoint below 37.8°C. Combustible (Class II or III) liquids are those with a flashpoint between 37.8°C and 93.3°C. The greatest danger associated with handling of these liquids in the lab is the potential for fire or explosion. Never heat an open vessel containing flammable liquids with an open flame or on a hot plate. Handle them in an area free of ignition sources.

Use appropriate ventilation to prevent the formation of flammable or explosive gas mixtures in air. Carry out transfers in a fume hood or other areas with sufficient ventilation. Keep containers of flammable liquids closed except during transfer of contents.

Bond and ground metal lines and containers used to dispense flammable liquids to prevent the build-up of static electricity. This is especially true of nonconductive liquids. Bonding is achieved by making an electrical connection from one metal container to the other by means of a bonding wire or strap attached to both containers. In a flammable liquid storage area, drums should also be grounded during dispensing. Drums are grounded by connecting the container to an already grounded object that will conduct electricity (e.g. metal water piping, grounded metal building framework). Ensure all grounding and bonding connections are made to bare metal.

The Alberta Fire Code requires containers 5 gallon (25L) or greater to be grounded and bonded when dispensing from them.

Static electricity can also build up in plastic or other non-conductive containers. The splashing and turbulence of the liquid can cause a static charge to build up in the liquid. To minimize static build-up, use a slow pour rate and limit freefall when transferring flammable liquids.

4.2.1 Handling Pyrophoric Substances

Pyrophoric substances are materials that can spontaneously ignite in air. Special procedures are required for the safe use of pyrophorics and researchers should not work with these materials unless they are certain they have enough information and training to use them without significant risk. Details on safe handling of pyrophoric compounds can be found in the supplier's information.

When working with pyrophorics, safety goggles, gloves, and a lab coat made of fire retardant Nomex material should be worn. A Class D fire extinguisher or powdered lime should be kept on hand when working with pyrophors.

Researchers using pyrophoric chemicals must have written procedures for use and handling. The **Handling Pyrophoric Reagents SOP (Sigma Aldrich)** provides general information on handling pyrophors and can be used as a starting point for developing lab-specific SOPs.

4.3 Highly Reactive and Explosive Chemicals

Highly reactive and explosive chemicals are those that may be detonated by mechanical shock, elevated temperature, or chemical action to produce a violent release of energy and a large volume of gas, heat, and possibly toxic vapours. In many cases, it is not the total energy released that is a concern, but the extremely high rate of reaction. Even milligram quantities of some highly reactive substances can turn small fragments of glass or other material into seriously injurious or lethal missiles. It is therefore very important to use only minimum amounts of these materials with adequate shielding and personnel protective equipment.

Some examples of highly reactive and explosive chemicals encountered in the lab include:

- **Shock sensitive materials:** Examples include acetylides, azides, organic nitrates, nitro compounds, perchlorates and peroxides.

- **Peroxides:** Catalysis of the violent decomposition of hydrogen peroxide by metal ions. The instantaneous, heat induced decomposition of some peroxides. Many peroxides are highly explosive.

- **Highly Reactive or Unstable Chemicals**: Vigorous polymerization, decomposition, condensation or self-reactivity of highly reactive chemicals.

- **Water Reactive Chemicals:** Active metals such as sodium, magnesium, lithium, and potassium and organometallics such as Grignard reagents and alkyllithiums are serious fire and explosion hazards due to reactivity with water and alcohols.

- **Oxidizers:** Violent reaction of oxidizing agents (halogens, oxyhalogens, permanganates, nitrates, chromates, persulfates, peroxides, perchloric acid, nitric acid) with reducing materials, trace metals and ordinary combustibles.

Precautions to take when working with highly reactive or explosive materials:

- Written SOPs are required for using highly reactive/explosive chemicals. Plan experiments to minimize the need for handling of reagents and equipment while experiment is in progress. Identify equipment and PPE required, safe storage for reactive chemicals, and determine how wastes will be safely disposed **before work starts**.

- Assemble apparatus in such a way that if the reaction starts to run away, immediate removal of heat source, cooling or quenching of the reaction, cessation of reagent addition, and closing of the fume hood sash are possible.
- Use barriers such as shields, barricades and guards. These should completely surround the hazardous area. Note that a laboratory fume hood sash is designed to protect against chemical splash and minor explosions. Additional shielding will be necessary for higher hazard work.
- Use the smallest quantities of reactants necessary.
- Wear a face shield when working with explosive or highly reactive chemicals.
- Wear heavy gloves or use remote manipulation if necessary to reach behind a shielded area while a hazardous experiment is underway.
- Other personnel in the lab require, at minimum, a lab coat and safety glasses or goggles.

4.4 Corrosives

Corrosive chemicals can be defined as those which result in an immediate, acute erosive effect on body tissue. Strong acids and bases of 1M or greater concentration, non-metal halides, dehydrating agents, halogens, and oxidizing agents are all corrosive.

Precautions to take when working with corrosive chemicals include:

- Always add acid to water, not water to acid.
- Wear eye protection and gloves whenever working with any corrosive. In some instances, a face shield and acid resistant rubber apron will be warranted.
- Ensure there is an eyewash and a safety shower available.

4.5 Compressed Gases

Compressed gases differ from other hazardous materials in the laboratory because of the additional physical hazard of a high-pressure vessel in the laboratory. A cylinder can easily become a lethal missile if mishandled.

Precautions to take when working with compressed gases include:

- Ensure that the valve cap is in place during transport, and remove it only after the cylinder is securely chained to a fixture or wall.

- Transport cylinders using a suitable handcart equipped with a restraining strap.

- Never drag, roll or slide cylinders. The only exception is to roll a cylinder on its' bottom edge ("milk churning") to move it a very short distance, such as from a hand cart to a wall strap.

- Use only Compressed Gas Association (CGA) approved regulators. Regulators are gas specific and should be used only with the gases for which they were designed. Do not use an adapter or resort to cross threading to get a regulator to fit.

- Do not lubricate oxygen regulators, as the cylinder contents may oxidize the oil or grease and cause an explosion.

Check cylinders, connections, hoses and gas lines regularly for leaks. Use a commercial leak detector or leak-test solution (such as Snoop), or a soapy water solution around all joints and watch for bubbles. If a leak is detected, shut off the gas before attempting any repairs. If shutting off the cylinder valve does not stop the leak, treat the situation as an emergency uncontrolled release.

To prevent possibly dangerous flash back or back flow of air or other contaminants, **cylinders should not be completely emptied.** Discontinue use of a cylinder when the pressure drops to 172kPa (25psi). When removing a cylinder from use:

- Close the main valve

- Bleed the system

- Shut off and remove the regulator, and replace the valve cap

- Mark the cylinder "empty" or "MT", and return to the appropriate storage area for pickup

4.6 Cryogenic Liquids

Cryogenic liquids (or cryogens) are defined as those liquids with a boiling point less than –73°C. In the laboratory, the most common cryogenics are liquid nitrogen, liquid helium, and dry ice/organic solvent slush baths. Cryogens are normally gases at standard temperature and pressure, and all have two properties in common:

- they are extremely cold, and
- small amounts of liquid expand rapidly into very large amounts of gas.

This rapid expansion to gas can result in **pressure build-up** in vessels containing cryogens, and also presents the **danger of asphyxiation** as oxygen is displaced in enclosed spaces or small rooms.

Skin contact with cryogens can cause burns. Wear full coverage clothing. Jewelry such as rings and bracelets should not be worn because it may freeze to the skin. Use insulating gloves that are impervious to liquid but loose fitting so they can be thrown off quickly if any liquid spills in them. Always wear chemical splash goggles or a face shield if there is a chance the cryogenic liquids may splash and froth on contact with a warmer surface.

Many materials, particularly rubber gloves and tubing, become brittle due to the extreme cold. If cryo-frozen rubber tubing is bent, it will shatter. Ensure that materials designed specifically for cryogenic use are used.

Store and transport cryogens only in Dewar flasks designed for that purpose. Always fill Dewar flasks slowly to reduce temperature shock effects and minimize splashing. Similar precautions should be taken when cooling an object by immersion in a liquid cryogen. Open containers should never be immersed in liquid nitrogen or liquid helium. Cryogens should be kept covered to prevent condensation of atmospheric moisture, which can be especially dangerous if a plug forms in a narrow vessel neck, resulting in an over-pressurized vessel.

When using cold traps, ensure they do not become plugged with frozen material. When using liquid nitrogen or helium as the coolant, there is the added **danger of oxygen condensing from the air**. If this occurs, there is the danger of a serious explosion if any organic material is present as well. Be alert for the telltale blue, water-like appearance of liquid oxygen. If the presence of liquid oxygen is suspected, isolate the area and wait for the oxygen to vaporise and dissipate.

Refer to the **UofL Cryogen Safety Manual** on the **Cryogen Safety webpage** for further information. The **Cryogen Safety Training Procedure** outlines requirements for training.

4.7 Transporting Hazardous Materials

Many spills occur as a result of improper transport of hazardous materials from storerooms to labs, and between labs. When transporting hazardous materials outside the laboratory:

- Carry glass containers in specially designed bottle carriers or a leak resistant, unbreakable secondary container. "**Safety carriers" for 4L bottles must be available in each laboratory.**
- When transporting hazardous materials on a cart, **use a cart** that is suitable for the load and one that has high edges or spill trays to contain leaks or spills.

Hazardous materials should be transported by hand for short distances within buildings or between adjacent buildings. The Transportation of Dangerous Goods Act & Regulations govern transportation of hazardous materials by vehicle. Refer to the **Safe Transportation of Hazardous Materials Procedure** for details and contact Campus Safety.

5. Inventory and Storage of Chemicals

5.1 CHEMATIX Chemical Inventory Management System

Maintaining an inventory of the chemicals used and stored in the lab is the first step in their safe handling. A current record of hazardous chemicals assists in implementing proper storage and safe work procedures and is a necessary component of proper emergency planning.

The minimum information contained in the chemical inventory should include:

- Name of Chemical
- Storage Location
- Approximate Amount
- Date Received/expiry dates
- Supplier Name
- Hazard group
- SDS Availability and Date

The University has implemented the **CHEMATIX** chemical inventory system to facilitate the management and inventory of chemicals used for various academic and operational needs within its campus.

CHEMATIX uses barcodes as a unique identifier to track chemical containers. The system tracks hazardous materials from "cradle to grave" and will assist the University in achieving good business practices as well as meeting its regulatory requirements to maintain an inventory of all chemicals being used and stored within its facilities.

The CHEMATIX **"test"** system is used for training and the **"production"** system is used to access the chemical inventory. Training modules are available on Moodle and in hands-on workshops.

University departments using chemicals are required to register their chemical use and storage locations in **CHEMATIX** and ensure all chemicals are barcoded and entered into the inventory.

Contact Safety Services for registration with CHEMATIX and training on how to use the system.

5.1.1 Mandatory Inventory Reconciliation

Once an inventory has been prepared, it must be updated as new chemicals are received in the lab or chemicals are used or sent for waste disposal. The inventory must be reconciled at least once a year to ensure that it accurately reflects the chemicals in the lab. This process will help pinpoint those chemicals that are not being used and which can therefore be sent for disposal, and can also help prevent unnecessary acquisition of chemicals which are already on hand.

All chemicals should be labeled with the date of receipt. This helps track usage in the lab, as well as giving an indication of the "freshness" of the chemical. This is especially critical when dealing with substances that deteriorate over time (e.g. peroxide formation in ethers, drying out of picric acid). It is also good practice to label chemicals with their storage location, to ensure they are returned to the proper place after use.

Regulated chemicals that have annual reporting requirements (e.g. Chemical Weapons Convention) may be flagged in CHEMATIX. Contact Safety Services for assistance.

5.2 Storage of Laboratory Chemicals

Only minimum quantities of chemicals may be stored in the lab. Bulk storage of chemicals is located in Central Stores and managed by Science Facilities.

Chemicals must be stored according to chemical compatibility so that incompatible materials do not come in contact with each other in the event of breakage or accidental spill. The usual approach is to separate chemicals into compatible groups, and segregate these groups from each other by physical barriers or distance. **Generally, inorganic and organic chemicals are stored separately, and liquids are separated from solids. NEVER store chemicals solely alphabetically!** This is fine within a hazard group, but this should never be the primary storage system.

Some recommended compatibility groups for chemical segregation are:

- Perchloric Acid, Hydrofluoric Acid, and Nitric Acid are separated from other materials (including each other)
- Inorganic acids (except as noted above)
- Bases
- Water reactive chemicals
- Pyrophoric chemicals
- Strong oxidizing agents

- Strong reducing agents
- Flammable and combustible liquids

Representative lists of chemicals in several of the compatibility groups are included in **Appendix A. Appendix B** consists of a list of some common, chemical specific **incompatibilities**. These lists are general guidelines only. **Always refer to the SDS** for information about the hazards associated with or possible incompatibilities of a chemical before storing or using chemicals.

In many cases, it is not practical to store all chemicals in physically separate locations. In such cases, **segregate chemicals** using glass, porcelain or heavy gauge Nalgene™ or similar plastic container that is compatible with the material being stored. The secondary container must be large enough in volume so as to contain any spills.

It is good laboratory practice to **store liquids separate from solids** to minimize the possibility of mixing. Liquids are inherently more dangerous because they are much more mobile and susceptible to mixing if a spill occurs.

Dry chemicals may be grouped together by compatibility on separate shelves or areas of shelves separated by taping off sections to designate where chemicals of one type are stored. **Organic solvents, acids, and bases** should be physically separated from each other by storage in separate areas or through the use of secondary containment as described above. Ideally, **acids and bases** should be stored in dedicated caustic storage cabinets, and **flammables** in an approved flammable storage cabinet.

General storage principles:

- Do not store chemicals near exits.
- Ensure bottles are within easy reach of everyone in the lab, and no higher than eye level. In particular, large bottles and containers should be stored as close to the floor as is practical.
- Do not store chemicals directly on the floor unless they are in ULC approved safety cans, or if the chemicals are still in their shipping container.
- Shelves used to store chemicals should be chemical-resistant, secure and strong enough to support the weight, have a lip to contain spills, and bolted to the wall to prevent tipping.
- Store chemicals according to instructions on the label or SDS (i.e. should it be stored in the fridge, freezer, away from direct sunlight, etc).
- Do not store chemicals under sinks. This is to prevent corrosion of pipes, any potential problems in the event of a leaking or burst pipe, and minimizes chemical exposure of maintenance personnel working below the sink.
- Buy the smallest quantity of chemicals that will serve the purpose. For commonly used chemicals (i.e. acids, solvents), a good rule of thumb is to keep quantities in the lab to either a single bottle or a one-week supply, whichever is less. The rest should be stored in a designated chemical storage room.

5.3 Acids and Bases

- Store strong acids separately from bases. Reactions readily occur between ammonia or amine vapours and acid vapours (hydrochloric and nitric acids in particular), resulting in precipitates forming on the outsides of bottles and throughout the storage area.

- Inorganic acids (e.g. nitric acid) and organic acids (e.g. acetic acid, propanoic acid) should also be separated or segregated. Organic acids may be stored with flammable and combustible liquids, provided there are no specific incompatibilities.

- Perchloric acid, concentrated nitric acid and hydrofluoric acid should be separated or segregated from each other and all other chemicals. If an acid or corrosive cabinet is used for storage, polyethylene/polypropylene or Nalgene compartments can be used to isolate these acids from others in the same cabinet.

5.4 Flammable and Combustible Liquids

The volume of flammable and combustible liquids permitted in the laboratory is regulated by the Alberta Fire Code. **At the University of Lethbridge, the maximum volumes of flammable and combustible liquids permitted in open storage are:**

- 10 L of flammable liquids, including not more than 5L of Class I Liquids
- up to 250L, including not more than 60L of Class II, or 10L of Class I liquids

Open storage means any storage in the lab outside of a flammable storage cabinet. These are the maximum amounts permitted. In practice, volumes should be limited to a one week supply or a single container of each required flammable or combustible liquid**.**

As a rule of thumb when determining the flammable and combustible liquid load for a lab, nearly all-common non-halogenated organic solvents (e.g.. ethanol, methanol, hexane, diethyl ether, toluene, etc.) are classified as flammable liquids. Some combustible liquids commonly found in the lab include acetic acid, dimethylsulfoxide, N,N-dimethylformamide, formalin solution, and liquefied phenol.

Containers of flammable and combustible liquids must not exceed a capacity of 5L. The exception is in the case of ULC approved safety cans, which may be up to 25L in volume.

The maximum volumes that may be stored in the lab in flammable storage cabinets are:

- 250L of Flammable or Class I Liquids
- up to 500L of Combustible or Class II / III; for a combined total of no more than 500L

There is no restriction on the number of flammable cabinets permitted in laboratories, as long as the total volume stored in the cabinets does not exceed the volume noted above. Flammable cabinets are to be used for flammable and combustible storage only; other chemicals are not to be stored in them along with flammable and combustible liquids.

Cabinets must never be vented to the laboratory as they are designed to protect the contents from an external fire. If not vented to the outdoors using materials or piping that provides fire protection equivalent to the cabinet itself, then vents should be sealed.

Refrigerators and freezers used for storing flammable or combustible liquids must be rated as "flammable material storage" or "explosion proof" models.

5.4.1 Flammable Storage Rooms

The following rules of use apply to all those who access the flammable storage rooms in the Science & Academic Building. These rooms are located near Central Stores and the loading dock. Access is provided by Science Facilities to **trained and authorized** individuals.

1) At least two people must attend visits to the storage rooms, one of whom must remain outside the room at all times.
2) The key must remain outside the room at all times.
3) No electronic devices or other potential ignition sources are allowed in the storage rooms.

When transferring acetone or other flammables from a 5 gallon (25 L) or 45 gallon (208 L) drum to a portable storage container, ensure that the container is grounded to the drum using the cables provided.

In the unlikely case of a fire within the flammable storage rooms, a fire suppression system can be deployed to extinguish the fire. Instructions are posted and users will be trained on how to activate the system.

Contact Science Facilities to make arrangements for storage of flammables in the specialized storage rooms.

5.5 Compressed Gases

There are a number of steps that can be taken to minimize the dangers associated with storing compressed gas cylinders:

- Cylinders should always be secured in an upright position and chained to a cylinder bracket attached to a bench orwall at about 1/2 to 2/3 its height.
- Handcarts are not meant to secure cylinders when in use; use carts for transporting cylinders only.
- Cylinders should be individually secured; the use of a single chain around multiple cylinders is not always effective.
- Position cylinders so that the valve is easily accessible and the contents label clearly visible.

- Segregate compressed gases by compatibility group (i.e. flammable gases must be separated from oxidizing gases).

The laboratory should not be used as a storage area for gas cylinders. Only those cylinders in use should be in the lab. Keep cylinders in a cool, dry, well-ventilated area away from incompatible materials and ignition sources.

To eliminate any chance of accidental connection of an empty cylinder to a gas line or system, which could result in flashback or back flow, empty gas cylinders should be labelled as such and stored away from full cylinders.

5.6 Ethers and Other Peroxide Forming Chemicals

A number of inorganic and organic chemicals can become dangerous with age due to a tendency to form peroxides, especially on exposure to light and air. Chemicals which have undergone peroxidation are sensitive to heat, shock, and friction and may explode violently. Some common peroxide forming chemicals are listed in Table 5.6.1. Where there is the possibility that a chemical is contaminated with peroxide, it can be tested by applying a drop to a piece of wet potassium iodide/starch test paper. If the paper turns black within a minute, then peroxide is present. If peroxide contaminated material is identified, the Chemical Release Officer and Campus Safety should be notified immediately.

5.6.1. Common Peroxide Forming Laboratory Chemicals Table

Form Explosive Levels of Peroxides Without Concentration	**Form Explosive Levels of Peroxides On Concentration**
• Isopropyl Ether • Potassium Metal • Potassium Amide • Sodium Amide (sodamide)	• Cumene • Tetrahydrofuran • Diethyl Ether • Ethylene Glycol - Dimethylether • Dioxane

To avoid the formation of peroxides:

- Store peroxide forming chemicals away from heat and light.
- Ensure there are two dates on all containers of these chemicals: the date the container was received and the date it was opened.
- Peroxide formation can also be minimized by purchasing these chemicals in the smallest practical size containers.
- Check peroxide forming chemicals at least once a month for the presence of Peroxides. The presence of crystalline solids or viscous liquids in the bottom of a

bottle usually indicates high concentrations of peroxides. In such cases, contact Campus Safety and arrange for disposal immediately.

5.7 Perchloric Acid and Perchlorates

At room temperature, perchloric acid of 72% or less concentration is very much like any other strong acid. However, at higher concentrations or upon heating, it develops very strong oxidizing properties. At this point, it is prone to undergo spontaneous and explosive decomposition.

Due to these properties, perchloric acid of any concentration must be kept away from strong dehydrating agents, organic materials, and reducing agents.

This includes wooden cupboards and shelves; store perchloric acid in an appropriate secondary container. Any procedure that involves heating perchloric acid must be carried out in a properly designed perchloric acid fume hood.

Spills of perchloric acid represent a significant danger, especially if allowed to dry or come in contact with combustible material. Do not mop up or soak up the spill with dry combustibles, the absorbing material may dry out, and then explode or catch fire. The spilled acid should be neutralized with a weak base such a sodium bicarbonate, and then soaked up with a suitable absorbent. As an extra precaution, the used clean-up material should be kept wet and sealed in a plastic bag for disposal. If perchloric acid is spilled on a wooden laboratory surface, the wood should be physically removed to avoid the possibility of future spontaneous fire or explosion.

Perchloric acid waste must not be mixed with any other waste, and must be stored separately from other chemicals. If you happen to find a bottle of "old" perchloric acid sitting on a shelf, DO NOT open it. It may contain dry crystalline perchlorate salts. Contact Campus Safety for disposal.

Organic perchlorates and many heavy metal perchlorates are very sensitive to both heat and shock. Since anhydrous perchlorate salts are especially dangerous, the hydrated forms should be used whenever possible. The use of perchlorate salts should be avoided completely if suitable substitutes can be found.

5.8 Picric Acid and Nitro Compounds

Picric acid (trinitrophenol) is explosive and highly shock, heat and friction sensitive. It is usually stored as a water-wet paste, which is significantly less shock sensitive than the dry acid. Picric acid also forms a range of salts, many of which are even more reactive and shock sensitive than the acid itself.

If you discover old or previously unaccounted for bottles of picric acid:

- **DO NOT** touch the bottle. Depending on how long the bottle has been left and the state of the product inside, even a slight movement may be critical. Crystals may have formed within the threads of the bottle's lid, and any attempt to open it could result in enough friction to produce an explosion.

- Visually inspect the bottle for: expiration or receiving date; water content; and crystallization.
- If there is any sign of crystallization, or the water level is low, **DO NOT** attempt to open or handle the bottle.
- Isolate the area, and contact Campus Safety to arrange for proper disposal.

Store picric acid in a cool, dry place. Inspect every 6 months and add water as needed.
Dispose of picric acid after 2 years.
Records of inspection and maintenance must be kept and maintained.

5.9 Regulatory Reporting

5.9.1 Chemical Weapons Convention

In order to meet Canada's international obligations, institutions producing, consuming, processing, importing or exporting chemicals listed in the Schedules of the Chemical Weapons Convention (CWC) are required to submit up to two declarations a year to the Canadian National Authority: an Annual Declaration of Past Activities (ADPA) and an Annual Declaration of Anticipated Activities (ADAA).

The University of Lethbridge is required to submit a chemical weapons declaration to the Canadian National Authority annually as required by the CWC Implementation Act. PIs whose research and teaching activities that may involve producing, consuming, storing, transferring, importing and/or exporting chemicals listed in the schedules of the CWC must complete a Chemical Weapons Inventory Form annually and submit to Safety Services by January 15th. Safety Services will submit an Annual Declaration of Past Activities on behalf of the University to the Canadian National Authority prior to February 28th for the previous year's activities. **Refer to the Chemical Safety Standard for further information on reporting requirements.**

5.9.2 Other Regulatory Reporting Requirements

Compliance with other Acts and Regulations, such as the Prohibition of Certain Chemical Substances Regulation, may be required. It is the responsibility of PIs to ensure that their activities are conducted in accordance with regulatory requirements.

Refer to the Chemical Safety Standard and contact Safety Services for assistance.

6. Hazardous Waste Management

The procedures detailed in this section are for chemical waste only. Information on biohazardous and radioactive waste disposal is provided in the Biosafety Code of Practice and the Radiation Safety and Procedures Manual, The Hazardous Waste Disposal Procedure also provides general information. Contact Campus Safety for advice and assistance with waste disposal.

6.1 Definition of Chemical Waste

According to the Alberta Environmental Protection and Enhancement Act - Waste Control Regulation, **hazardous waste** includes any solids, liquids or gases containing or contaminated with:

- Flammable or combustible liquids (e.g. acetone, methanol, dichloromethane)
- Reactive chemicals such as oxidizers, reducing agents, inorganic cyanides, water-reactive, pyrophoric, explosive or unstable material (e.g. benzoyl peroxide, potassium permanganate, sodium borohydride)
- Acute or chronic toxic material (e.g. ethidium bromide, benzene, osmium tetroxide)
- Corrosives (pH less than 2.0 or greater than 12.5)
- Toxic leachate materials (e.g. heavy metals)
- Polychlorinated biphenyl's (PCB's)
- Unrinsed chemical containers which contained any of the above

Waste chemicals are generated as a result of reaction products or chemicals left over from experiments. Storing large quantities of leftover old chemicals is potentially hazardous to individuals in the lab and the environment. It is the responsibility of everyone in the lab to minimize the amount of chemicals used and subsequently, the amount of waste generated.

Practice the three principles of Reduce, Reuse, and Recycle:

Reduce:
- Order only the amount of chemical required for the experiment
- Use the smallest possible amount for the experiment
- Use dilute solutions whenever possible

Reuse:
- Pass chemical that you will not use to fellow researchers who will
- Before purchasing new chemicals which may or may not be suitable for the intended use, try borrowing from someone in the department to try it out

Recycle:
- Certain chemicals may be recycled through a local waste disposal company. Contact Campus Safety for more information

Campus Safety coordinates the hazardous waste disposal program for University labs. The CHEMATIX Waste Management module is used to track and itemize waste for collection, disposal and regulatory reporting purposes.   Laboratories must create a "**Waste Disposal Card"** in

Chematix to notify Campus Safety that wastes are ready for pick up. This system must be used to safely and legally dispose of laboratory waste.

Refer to the **University of Lethbridge Hazardous Waste Management Procedure** on the Safety Services webpage.

6.2 Handling and Storage

As a general rule, the same precautions used when handling, storing and using lab chemicals apply to hazardous lab waste. Hazardous waste is partially exempt from requirements of WHMIS. As described in the Alberta Occupational Health and Safety Code, an employer must ensure the safe handling and storage of hazardous waste generated at the worksite, through proper identification and worker education.

Laboratory supervisors must develop safe work procedures for the storage of hazardous waste until it is picked up for disposal, and must ensure all laboratory workers are trained in these procedures. Some specific points to keep in mind:

- Keep the exterior of the container free of chemical contamination.
- Segregate by chemical compatibility.
- Do not mix incompatible chemicals in the same container.
- Leave at least 20% air space in bottles of liquid waste to allow for vapour expansion, and to reduce the potential of spills occurring from moving overfilled containers.
- Dispose of hazardous waste regularly to avoid accumulation in the laboratory.

Note also that any flammable or combustible waste must be included when determining the maximum quantities of flammable and combustible liquids for a lab.

Waste containers should be kept closed at all times, except when contents are being added. Do not leave filter funnels in the open necks of containers, even if the waste is in a fume hood. Fume hoods are not to be treated as a worry free method of waste containment or disposal.

Wastes should be separated as follows:

- Separate liquid and solid waste
- Separate liquid organic waste from liquid aqueous waste
- Separate strong acids and bases from other aqueous waste

Note that halogenated wastes **must** be segregated from non-halogenated wastes.

6.3 Labelling Hazardous Waste

Do not label waste containers with generic, vague terms such as "chemical waste", "inorganic waste", or "solvent waste". **Use specific names that clearly identify the contents**, and do not use abbreviations, acronyms, trademarked names, and chemical formulas.

Attach a label to the container prior to being filled, and maintain a list of contents as waste is added to the container. Deface or remove old labels on containers used for chemical waste. There should never be any question of whether a container contains waste or the original contents. Old and unused chemicals should have their original label left attached, or relabeled to indicate the contents if the original is missing or illegible.

It is the responsibility of the waste generator to identify and then dispose of waste through the University's standard waste disposal process. Hazardous waste labels are available from Safety Services and Science Facilities.

6.4 Special Wastes

The procedures described above deal with common teaching and research chemical waste generated by University labs. Some types of waste require additional or special handling as described below.

6.4.1 Solvent Drums

Chemical suppliers often ship solvents in 19L (5 gal) drums which can present a problem when it comes to disposal. If these have been rinsed or evaporated clean and the labels defaced, they may be disposed of in the regular garbage.

6.4.2 Sharps

All needles and similar sharps (excluding clean glass which can be disposed in glass waste containers) must be dropped into a specifically designed sharps disposal unit or another appropriate puncture proof container.

6.5 Hazardous Waste Pickup

Hazardous waste is picked up from a central waste storage area and occasionally from individual labs. Check with your supervisor to determine the proper procedure for your lab.

7. Hazard Control Measures

All workers have the "right to know" about workplace hazards.
The AB OHS Act requires that a **Hazard Assessment** be conducted for all work activities and that appropriate controls be implemented to mitigate the hazards identified.

To determine the level and extent of protection required, a systematic process should be used to identify and evaluate the hazard, and implement the appropriate control measures. It is the responsibility of PIs and lab supervisors to lead the hazard assessment process and include input from the lab staff involved in the work.

The three major categories of hazard control measures include engineering controls, administrative controls and personal protective equipment. The type and level of control required depends on the hazard present, the level of exposure, the toxicity of the product, and other factors related to the process on hand.

Engineering Controls refer to substituting with a less hazardous material or process, isolating the hazard, enclosing it or using ventilation to remove the hazard at the source (e.g. fume hoods).

Administrative Controls include work scheduling changes to reduce the amount of time spent in contaminant areas, experiment planning process, use of safe work procedures and training.

Personal Protective Equipment (PPE) is generally used as a control method when it is not feasible to protect the worker using engineering and/or administrative controls. Since some hazards in a laboratory cannot be completely controlled through engineering or administrative controls, PPE such as eye protection, hand protection, lab coat and closed toed shoes is essential for work with chemicals.

Refer to the University's Hazard Management webpage and contact Campus Safety for assistance and training.

7.1 Fume Hoods

Fume hoods are designed to control worker's exposure to hazardous chemicals, and should be used for all but the most innocuous procedures. They should not, however, be treated as a worry free method of waste disposal.

Before beginning any work in the fume hood, confirm that the hood is operational. In the absence of an airflow gauge or velometer, tape a strip of inch wide tissue to the lower corner of the sash to qualitatively confirm the airflow by noting that the tissue is pulled gently into the hood. If there is any doubt whether a hood is operating properly, contact Campus Safety and Utilities. A fume hood that isn't performing properly is more dangerous than no hood at all since the user will likely have a false sense of security about its ability to provide protection.

Never carry out any work in a fume hood that is tagged as being out of service, as this could potentially result in exposure of maintenance workers to hazardous chemicals. If you are uncertain of the maintenance status of a hood, contact Utilities.

An average face velocity of 100 feet per minute (fpm) is recommended for a standard chemical fume hood at a sash opening of 30cm (12 inches). The face velocity at any point should not be less than 80 feet per minute. Fume hoods used for highly toxic chemicals require an average face velocity of 125 feet per minute with no less than 100 feet per minute at any point at the face.

Adequate airflow and the absence of excessive turbulence are necessary for safe operation. To ensure this:

- **Do not block the air baffles at the back of the fume hood**. Do not place anything closer than 3cm (1inch) to the back of the hood.
- **Keep apparatus at least 15cm (6 inches) from the front of the fume hood**. Use stands to elevate bulky apparatus to avoid interference with air flow through the hood.
- **Keep the fume hood clean and uncluttered.** Apparatus and chemicals should normally be kept in the fume hood only if they are a component of the operation for which the hood is being used.
- **Minimize foot traffic around the fume hood.** A person walking past a fume hood can create turbulence, causing vapours to flow out.
- **Keep windows and doors near fume hoods closed.** Open windows and doors can disrupt airflow.
- **Do not use fans near fume hoods.** Fans in the lab can cause turbulence which can disrupt proper air flow through the hood.

Perchloric acid hoods are specially designed for the hazards associated with working with perchloric acid. **All lab work with hot perchloric acid must be performed in a perchloric acid hood**. Hoods designated for perchloric acid work should be prominently labelled as such, and should not be used for any other procedures. These are made of welded stainless steel hood or PVC surfaces, ductwork, and fan to minimize the corrosive and reactive effects. There is a wash-down system of water fog nozzles dispersed throughout the hood and exhaust system. By washing down the hood following each use of heated perchloric acid, any materials deposited within the system are removed, preventing the build-up of hazardous perchlorates.

No perchloric acid hoods are available for use at the University of Lethbridge.

Contact Safety Services for advice if work involving heated perchloric acid is required.

Refer to the **Fume Hood User Guide** for detailed information.

7.2 Other Laboratory Ventilation

There are many types of laboratory equipment and apparatus that generate vapours and gases but cannot be used inside a traditional fume hood. Some examples include gas chromatographs, atomic absorption spectrometers and ovens. Local exhaust ventilation must be used to contain and remove potentially hazardous or noxious fumes and vapours. Ideally, a separate dedicated exhaust system should be used. If connected to an existing hood duct, the fan capacity must be increased and airflow to both hoods is properly balanced. Also note that each new exhaust hood requires provision of more make-up air supply to the lab.

The general laboratory ventilation system controls the quality and quantity of air supplied to the lab at such a rate that the air is continuously replaced to minimize the concentration of smelly or toxic substances. Labs are also designed so that they are at negative pressure to the rest of the building, to prevent movement of smelly or toxic substances to other parts of the building. Contact Safety Services and Facilities for lab ventilation assessments.

7.3 Health and Safety Procedures

Safe work procedures (also known as Standard Operating Procedures (SOP)) are step-by-step descriptions of how specific high risk work-related activities are performed safely. In the laboratory, hazards associated with chemicals, processes, equipment, etc. must be identified and assessed. The SOP are then developed based on the identified hazards. These must be written, readily accessible to everyone in the lab, and personnel should be made aware that procedures exist.

All labs are required to have SOP written out for the common chemical reactions and analytical procedures in the lab as well as the safe operation of lab equipment and all safety procedures.

SOP should be specific to the lab or research group so that the unique circumstances in the lab or research program can be addressed. Situations that require health and safety procedures include:

- Working with hazardous chemicals
- Working alone or after hours
- Emergency response (chemical spills, fire, etc.)

An SOP written for handling chemicals should include:

- information on the health hazard of the chemical
- how the procedure is done in step form
- what to do if there is an accident, and where to call for help in case of an injury.
- if there is specific first aid instructions in case of an injury, these should be noted on the SOP
- Identify what Personal Protective Equipment (PPE) is required to be worn to prevent exposure to the hazardous goods

An SOP written for the operation of Lab Equipment should include:

- any special safety hazards the equipment may have
- the PPE that should be worn while operating the equipment
- the steps required to operate the item safely
- information on what to do if something goes wrong and who to contact if the unit does not work properly.
- steps to take to shut down the equipment safely

A **Standard Operating Procedure (SOP) template** is provided on the Safety Services webpage.

SOP'S DO NOT REPLACE PROPER LAB TRAINING BY THE SUPERVISOR.

SOP'S are written to supplement the one-on-one lab training by the Supervisor or their designate.

All Lab Supervisors must keep **TRAINING RECORDS** of all personnel who work in their areas.

Lab workers must not work with any dangerous goods or operate equipment without proper training and authorization by the Lab Supervisor. Training records must be signed by the supervisor and worker.

7.3.1 Other Laboratory Hazards – Nuclear Radiation, Biological Pathogens and Toxins, Laser & X-Ray Equipment

Health and safety information for working with radiation hazards (e.g. nuclear radiation, lasers, and x-ray equipment), biological pathogens and toxins, and other laboratory safety hazards are not covered in this manual. **Refer to the Safety Services webpage for safety manuals and procedures. Contact the Biosafety Officer or Radiation Officer for further information.**

7.4 Personal Protective Equipment

Use of personal protective equipment in the lab must comply with requirements of Part 18 and other relevant sections of the AB OHS Code. This section provides an overview of laboratory PPE. Further information is provided in the **Personal Protective Equipment Standard**.

7.4.1 Eye and Face Protection

Eye protection must be worn in all labs when working with or around chemicals. It must meet the guidelines in the current Canadian Standards Association standard CSA Z94.3 standard, "Industrial Eye and Face Protectors".

The type of eye protection required depends on the hazard. For most situations, safety glasses with side shields are adequate. For more hazardous operations where there is potential for chemical splashing or explosion, safety goggles or a face shield which are rated for chemical splash protection should be used. This is especially important for work with corrosive chemicals.

Note that the use of a face shield still requires the use of safety glasses/goggles. The lab supervisor must determine the level of eye and face protection required.

Visitors are required to follow the same eye protection policy as everyone else in the lab. If they do not provide their own eye protection, it is the laboratory's responsibility to provide adequate protection for them or deny them entry.

7.4.2 Gloves and Hand Protection

The right type of glove provides the much needed hand protection in the laboratory. Appropriate gloves must be used when handling hazardous chemicals, toxins and materials of unknown toxicity, corrosives, and hot / cold objects. Particular attention should be given to chemicals that have a "Skin" notation on the SDS sheet or in Schedule 1 of the Alberta Occupational Health and Safety Code.

When choosing a glove, consider the circumstances under which the glove will be used. The degree of protection required will depend on the hazards associated with the chemical in question, the type and scale of experimental work being performed, and individual work habits.

Since disposable gloves are not designed for situations where contamination or permeation are more likely (for example, immersion in cleaning baths or handling corrosives, chemical spill cleanup), reusable gloves of heavy construction and suitable material should be used for such applications. Reusable gloves should be inspected before each use, replaced whenever they become discoloured or show signs of damage, and be cleaned and/or decontaminated after each use. For routine lab work with small amounts of chemicals, disposable gloves of a suitable material are generally acceptable. Remove and replace when they become contaminated.

Wearing the wrong type of glove when handling chemicals can be more hazardous than wearing none at all. If a chemical permeates the glove, it can be held in prolonged contact with the wearer's hand and potentially cause serious damage. **Selection guides, available from most suppliers or manufacturers, should be consulted when choosing a suitable glove**, and under some circumstances double gloves may be used when dealing with chemicals of high or multiple hazards to ensure maximum protection.

To protect the hands when handling hot or cold items in the lab, insulated gloves made of Kevlar™, Zetex™ or a similar heat insulating material should be used instead of those containing asbestos. If there are asbestos containing gloves in the lab, dispose of them as hazardous waste in accordance with the University's **Hazardous Waste Management Procedure**.

A list of glove selection websites is provided below. Note: this is not an exhaustive list and this information below is only provided as a guide. The manufacturer of the gloves to be purchased must be consulted regarding specific glove material protection properties.

MAPA:http://www.mapa-pro.ca/our-gloves.html
Best Manufacturing:https://www.superiorglove.com/en/glove-selector
Ansell:https://www.ansellpro.com/download/Ansell_7thEditionChemicalResistanceGuide.pdf

7.4.3 Lab Coats and Aprons

Lab coats or aprons are worn to absorb or deflect spills and prevent corrosive or toxic substances from reaching the skin. Cotton is the preferred material for a standard coat; it is inexpensive and is reasonably slow burning. Coats made of synthetic fibres are not recommended because they may melt and adhere to the skin in a fire.

For higher risk situations, (e.g. working with pyrophoric chemicals) use a chemical or flame resistant synthetic material such as "Tyvek" or Nomex™. Plastic or rubber aprons are recommended when handling large quantities of concentrated acids and other corrosives.

7.4.4 Respiratory Protection

Respiratory protection is not normally required when working in the lab, due to the combination of engineering controls (such as fume hoods), safe work procedures, as well as the relatively small amounts of chemicals used in the lab. To determine the need for a respirator, the lab supervisor or other competent individual must perform a hazard assessment.

If it is determined that respiratory protection is required, the lab supervisor must contact Safety Services to arrange for respirator fit-testing (Part 18, AB OHS Code.

Lab personnel requiring respiratory protection must:

- Complete a health screening questionnaire provided by Safety Services to determine personal fitness for respiratory use.
- Attend a fit-tested using the specific make and model of respirator chosen for use in the lab.
- Receive training on the proper use, care, and maintenance of respiratory equipment.

Campus Safety will arrange for the fit-testing appointment and will provide the necessary training. Additional information on respiratory protection is available from Campus Safety.

7.5 Emergency Showers and Eyewash Stations

In accordance with Part 4 of the AB OHS Code, all laboratories where corrosive or other chemicals hazardous to the eyes or skin are used must have an eyewash station and a safety shower in close proximity and accessible at all times. The need for an emergency shower/eye wash determined by a hazard assessment of the area which takes into account the concentration, quantities and frequency of use of corrosive chemicals. Lab personnel must be made aware of the location of safety showers and eyewashes, and how to use this equipment effectively. Desks, benches and lab equipment should not be stored beneath emergency showers, nor should access to safety equipment be blocked in any way, at any time.

Signs should also be posted to clearly indicate the location of showers and eyewashes. In the event of a chemical spill, flush the affected body part(s) immediately and thoroughly for at least 15 minutes. This supplies the large quantities of water necessary to dilute and wash away the contaminants. Remove all contaminated clothing. Clothing can absorb chemicals and hold them close to the skin, compounding the effect of a chemical burn. After flushing the affected body part(s), seek medical attention as soon as possible.

To a person standing under an emergency shower, 15 minutes may seem like an eternity. It is important that another person assists the victim to ensure he or she does not quit emergency flushing before all chemical contamination has been washed off. Similarly, there is a strong tendency for a person with chemicals in the eye to clamp the eyelid shut, increasing the risk and extent of damage. It may be necessary for the assisting individual to hold open the victim's eyelids to ensure proper flushing takes place.

Emergency showers are designed to flush the user's head and body, and should never be used for the eyes. Their relatively high flow rate could result in worse damage to the eyes than that caused by the chemical contamination.

Drench hoses are common fixtures in many labs and serve to supplement eyewashes and showers. They may be used for spot washing a small area when a full shower is not necessary, to assist a victim who is unable to stand up or is unconscious, or to irrigate under clothing prior to removal for a full emergency shower flush.

Eyewash bottles are meant to be a supplement to plumbed or self-contained stations. They permit immediate flushing of contaminants or small particles, which should then by followed by a regular 15-minute flush at a plumbed eyewash station.

Eyewashes and showers must be tested regularly. Emergency showers are tested annually by Faculties to ensure their mechanical functioning. Lab personnel must test eyewash stations by flushing them for 3 minutes, once per week. This verifies that it is operating properly, prevents growth of microbes in stagnant residual water, and flushes out any dirt, rust or pipe scale that may be present.

To avoid microbial growth once the original seal has been broken, water in eyewash bottles should also be changed regularly, as per manufacturer's instructions. A buffered saline solution preserved with a suitable antibacterial agent may also be used, which will prolong the shelf life of the wash bottle contents and tends to be less irritating to the eyes.

Use the **Emergency Eyewash Maintenance Record** to document all tests. Refer to the **Emergency Eyewash and Shower Standard** for further information.

If there is any concern about the operating condition of this equipment, contact Facilities.

7.6 Fire Extinguishers

Only those individuals trained in the use of fire extinguishers should attempt to use one. Fire extinguishers are designed for putting out small fires only. Each lab worker should be aware of the location and types of fire extinguishers available in the lab, as well as the limitations of those extinguishers.

There are four general classes of fires:

- Class A: Ordinary Combustibles
- Class B: Flammable Liquids

- Class C: Electrical Equipment
- Class D: Combustible Metals

Each class of fire has specific types of extinguishers that are most effective for extinguishing that fire. The following are the most common types of extinguishers:

- Class A Type: Water-based extinguishers. These should never be used in the lab, since they are not suitable for use on flammable liquid or electrical fires, two common fire types encountered in the lab.

- Class ABC Multipurpose Dry Chemical: Commonly found in many labs due to its versatility in fighting nearly all types of fires.

- Class BC Carbon Dioxide: Commonly found in labs that do not contain substantial amounts of Class A materials.

- Class D fires are unresponsive to the regular classes of fire extinguishers listed above. Special extinguishing agents must be used, or the fire smothered with dry sand extinguisher.

If you notice a fire extinguisher that has been discharged or is only partially charged, an extinguisher with the safety pin pulled, obstructed from view, not hanging in the proper location or missing from its wall plate, contact Campus Safety.

For more information on fire extinguishers, to attend a fire extinguisher training course, or for further information on fire and life safety in general, contact Campus Safety.

8. Laboratory Equipment

This section provides guidance on the use and selection of laboratory equipment. All equipment is subject to review by Facilities for utility requirements (water, power, ventilation, etc.) and weight-loading restrictions **PRIOR** to installation.

Completion of **Facilities' Equipment Installation Request Form** may be required. Regulatory approvals may also be necessary (e.g. CSA approval, laser and x-ray equipment inspection and registration certificates, biosafety cabinet inspection and certification). Contact Safety Services for further information.

8.1 Glassware

Laboratory glassware may be made of several different types of glass. Select the appropriate glassware based on the application:

- Borosilicate glass (ex: Pyrex™, Kimax™, or similar) for situations involving thermal and mechanical shock use.
- Vacuum work, use only round bottom or thick walled borosilicate glassware designed to withstand low pressures.

Before beginning any experimental work, check glassware for flaws such as chips, star cracks, scratches and etching marks, which may result in structural failure. Note also that repaired glassware is subject to thermal shock and subsequent failure, and should be used with caution. Choose glassware sizes that can properly accommodate the operation being performed. At a minimum, there should be at least 20% free space.

To prevent cuts from trying to force glass tubing into rubber / cork stoppers or tubing:

- Use appropriate hand protection and a soap solution, glycerine, water or other lubricant on the ends of glass rods or tubing before inserting into a stopper.
- The rod or tubing should be inserted into the stopper with a turning motion - never forced.
- Always aim the rod or tubing away from the palm of the hand which holds the stopper.
- The ends should be fire polished to remove sharp edges, and ensure that the stopper hole is large enough to accommodate the rod or tubing.

8.2 Electrical Equipment

Electrical equipment in the lab may cause electrical shock, and act as an ignition source for flammable or explosive chemicals. To minimize the possibility of either of these, a number of precautions can be taken:

- All laboratory receptacles and equipment should be equipped with 3-prong grounded plugs.
- Equipment should be located to minimize the possibility of chemical spills on or under it.
- Inspect cords on a regular basis for frayed and/or damaged connections.
- Devices equipped with motors used where there are flammable vapours present should be either non-sparking induction or air driven motors.
- Unplug electrical equipment before making repairs or modifications.
- All electrical equipment must be CSA approved. Imported equipment that has not received CSA approval, and equipment designed and assembled in the lab must be approved by Facilities.

8.3 Vacuum Pumps and Systems

Working at reduced pressure carries with it the risk of implosion, and the subsequent dangers of flying glass, splashing chemicals and possibly fire. Consider shielding any apparatus under reduced pressure to minimize that risk.

When using a rotary pump or a building vacuum line:

- Place cold traps between the apparatus and the vacuum source to minimize the amount of volatile material that enters the system.
- Vent rotary pumps to an air exhaust system, not directly into the laboratory
- Belt driven pumps must have protective guards, to prevent accidental entanglement.

8.4 Heat Sources

Whenever possible, use suitable electrically heated sources such as hotplates, heating tapes, heating mantles, or similar devices in place of gas burners as they are inherently safer. Steam baths are best for temperatures under 100°C, since they present neither shock nor spark risks and the temperature is guaranteed not to rise above 100°C.

8.4.1 Heating Mantles

Heating mantles enclose a heating element in layers of fiberglass cloth, and are free of shock or fire hazard if used properly. Some precautions that should be taken when using mantles include:

Do not use if the fiberglass cloth is worn or broken, exposing the heating element.
Take care to avoid spilling water or other chemicals on the mantle, as this presents a serious shock hazard. Depending on the spilled chemical, it may also present a fire or explosion hazard.
Always use with a variable transformer to control input voltage. Never plug directly into an electrical outlet. High voltage will cause the mantle to overheat, damaging the fiberglass insulation and exposing the bare heating element.

8.4.2 Oil, Sand and Salt Baths

Electrically heated oil baths are commonly used in situations where a stable temperature is required, or a small or irregularly shaped vessel must be heated. Some precautions that should be taken when using oil baths include:

- Take care to avoid spilling water or volatile substances into the bath, which may result in splattering of hot oil or smoking / ignition of the bath.
- Saturated paraffin oil is suitable up to 200°C, and silicone oil should be used for temperatures up to 300°C.
- Always monitor the temperature of the bath to ensure it does not exceed the flash point of the oil.
- Mix well to prevent "hot spots" from forming.
- Support with a lab jack or similar apparatus so the bath can be lowered and raised easily without recourse to manually lifting the hot bath.

Molten salt or metal baths can be treated similarly to oil baths, except that they have a higher operating range, up to 450°C. The bath container (and the reaction vessel being heated) must be able to withstand these temperatures. It is also imperative that the bath be kept dry, since hazardous sputtering and splattering may occur if the absorbed water vaporises during heat-up.

8.4.3 Ovens and Furnaces

Ovens are most commonly used for drying lab glassware and chemical samples. Only laboratory approved ovens that have the heating elements and temperature controls separated from the interior atmosphere should be used. Note also that lab ovens generally vent directly into the lab. If toxic vapours or gases may be released while using a lab oven, the vapours should be vented into a fume hood, a local canopy hood, or by some other means.

Furnaces are used for high temperature applications. Ensure reaction vessels and other equipment used are designed to withstand high temperature.

8.4.4 Centrifuges

The centrifuge is a commonly used tool in laboratories. It uses centrifugal force to separate substances in liquid or solid media according to particle size and density differences. All centrifuges (including microcentrifuges) can present various hazards.

Centrifuges operate at high speed and have great potential for injuring users if not operated properly. Unbalanced centrifuge rotors can result in injury or death. Sample container breakage can release aerosols that are harmful if inhaled.

Lab-specific standard operating procedures (SOP) for centrifuge use should contain information on training requirements, safe operation, emergency procedures in the event of hazardous materials spill/exposures or mechanical failure, and preventive maintenance requirements.

The **Centrifuge Use and Safety SOP,** available on the Safety Services webpage, outlines general requirements for centrifuge safety and can be used as a starting point for developing a lab-specific SOP.

8.5 Refrigerators and Freezers

Refrigerators and freezers used in the lab must be carefully selected for specific chemical storage needs. **Commercial refrigeration units are not designed to meet the special hazards presented by flammable materials.** The interior of a commercial refrigerator contains a number of electrical contacts that can generate electrical sparks. Frost-free models often have a drain, which could allow vapours to reach the compressor, and electrical heaters used to defrost the refrigerator are also a spark hazard.

For these reasons, only specially designed lab refrigerators should be used for cold storage of flammable chemicals. Those rated for **'flammable storage'** have no internal switches or unprotected wires which can act as an ignition source. An **'explosion proof'** unit has both interior and exterior switches and wires protected, and is suitable for use in environments where flammable vapours may reach explosive / ignition limits outside the refrigerator. For storage of flammable materials in most labs, a unit rated for 'flammable storage' is sufficient.

Commercial refrigerators and freezers are acceptable for storage of non-flammable materials, but must be prominently labelled as "not suitable for flammable storage". Labels are available from Safety Services.

A major concern with chemical storage refrigerators is that as tightly sealed spaces, they can allow build-up of toxic and/or flammable vapours. Containers must be adequately sealed to minimize the likelihood of this happening. Beakers, flasks, and bottles covered with aluminum foil or plastic wrap are unacceptable for storage of volatile chemicals in the refrigerator. Screw top caps with a seal inside are best suited for refrigerator storage. Refrigerators should also be regularly defrosted and cleaned to minimize accumulation of ice and hazardous vapours inside the unit. Chemicals no longer used must be disposed of as hazardous waste.

8.6 Warm and Cold Rooms (Environmental Rooms)

Warm and cold rooms, also referred to as environmental rooms, are designed to control temperature and humidity. Cold rooms can function as low as 35°F and warm rooms up to 120°F. They are used primarily for the growth of cells and organisms storage, but also for general chemistry and biology.

Ventilation: Environmental rooms typically have a closed air circulation. The only source of fresh air is when the door is opened and closed. Therefore, because environmental rooms have contained atmospheres, the release of toxic substances from spills or vaporization poses potential occupational health and safety hazards to occupants.

Preventing Mold Growth

Unabated mold growth on environmental room surfaces may lead to mycological contamination of research projects and pose potential health problems from inhalation of spores. Spores can also be tracked out of the room and around the entire floor of the building. Minimizing mold growth requires the control of moisture in the environmental room:

- Keep door firmly shut – if left open, water condensation on surfaces increases due to high relative humidity, promoting mold growth.

- Immediately clean up spilled laboratory liquids (e.g., buffers and media). Moisture may lead to rust, corrosion or degradation of environmental room integrity (e.g., shelves).

- Promptly dispose of wet or damp organic materials (e.g., paper products, cardboard, miscellaneous trash, etc.).

- Store paper products (e.g., Kim wipes) in closed plastic container. Do not use or store cardboard boxes or other absorptive material in cold rooms.

Special Requirements for Working in the Cold Room

The cold room work area like all the other lab space needs to be booked prior to use. All workers must read and sign the associated hazard assessment before commencing work.

As this is essentially a big fridge, it is vital that the door is only kept open for short periods of time, therefore anyone wishing to carry out prolonged work must do so with the door closed. This, of course, leads to the necessity for strict safety precautions being taken when undertaking work in the cold room.

Workers must wear appropriate clothing: ensure that you have warm clothing that will fit under a lab coat where appropriate.

No working alone: work inside the cold room must be carried out in pairs with a third person, who is aware of the work, outside of the cold room. Workers need to 'check in' with the third person at regular intervals. The workers must be able to contact the third person for assistance while working in the cold room.

Timers/alarms: two timers must be set when work commences, one to be kept inside the cold room and one to be kept by the third person. The timers will indicate the maximum time that the workers can stay in the room and when the alarm sounds the workers must take a minimum of 30 minutes break. The person outside of the cold room must ensure that the workers are out.

The contained atmosphere in environmental rooms and recirculation of most of the air creates a potential for retaining any aerosols that are formed during research procedures. This can lead to cross-contamination of research projects and personnel exposure. Keep these rooms as clean as possible.

NO DRY ICE, LIQUID NITROGEN OR COMPRESSED GAS
These may displace oxygen and cause a suffocation hazard. If compressed gas (other than breathing air or oxygen) is essential, contact Office of Health and Safety (O&HS) about identifying the correct oxygen or gas sensor and local alarm. Post the alarm procedure and train all room users to it.

NO FLAMMABLE LIQUIDS (e.g., solvents, alcohols)
Their vapors can accumulate, creating an explosive atmosphere, which can be ignited by electrical switches or other ignition sources.

NO HAZARDOUS OR VOLATILE CHEMICALS (e.g., chloroform, carcinogens, reproductive toxins, acutely toxic chemicals)

NO VOLATILE ACIDS (which can corrode metal)

8.7 Decontamination of Laboratory Equipment

Any equipment that has been used in a lab that contains hazardous materials will become contaminated over time. Thus lab equipment should be decontaminated prior to removal. This applies whenever equipment is transferred to another lab, sent for repair or calibration, or disposed of as waste or surplus equipment.

Decontamination includes the removal of all hazardous products, containers, or other potentially contaminated items from refrigerators, cabinets, etc. The equipment should then be visually inspected for stains, residues, or other evidence of chemical contamination, and this contamination removed by washing with soap and water, a decontaminating solution, or whatever other means necessary.

Further information and a more detailed procedure for decontaminating lab equipment is provided in the **Equipment Release Procedure.** . In addition, if equipment has been used for radioisotope or biohazards work, additional decontamination may be necessary. **Refer to the Biosafety Code of Practice and Radiation Safety and Procedures Manual** and contact Safety Services for details.

9. Laboratory Closeout Procedures

When an individual researcher leaves the University or transfers to another laboratory, his / her former laboratory must be properly "closed-out". That is, all hazardous materials must be removed from the lab, surfaces (benches, lab equipment, glassware, floors, fume hoods, etc.) cleaned and decontaminated, and the space inspected by representatives from Campus Safety to ensure these steps have been taken.

The intention of this procedure is to avoid situations where unknown chemicals or contaminated spaces and equipment are discovered after departing researchers have left the University, or after construction or renovation has started in a lab area. Completion of this procedure is, in the first instance, the responsibility of the principal investigator or researcher to whom a laboratory is assigned. Ultimate responsibility for hazardous materials management lies with department heads. If improper management of hazardous materials at closeout requires additional services from Campus Safety or from an outside contractor, the department responsible will be charged for this service. Any regulatory action or fines resulting from improper management or disposal of hazardous materials will accrue to the department responsible.

In addition to lab closeouts described above, individual labs should also implement a procedure to ensure that students and other researchers, upon completing their work and leaving the lab, close-out their own work areas. The basic procedure is an abbreviated version of the closeout procedures outlined above. The steps taken would include:

- Ensure all chemicals and lab samples are labelled, and containers securely closed.
- Clean and decontaminate all glassware, equipment and lab surfaces.
- Transfer responsibility for chemicals and lab samples to another individual or send for disposal.
- Check common lab areas such as refrigerators and freezers, cold rooms, stock rooms etc. for hazardous materials, and treat as above.
- Ensure hazardous waste has been appropriately disposed.

A final inspection by representatives from Campus Safety is not required for this type of closeout. The PI or supervisor should inspect the area to ensure the cleanup has been satisfactorily performed. Any hazardous materials left in the workspace become responsibility of the PI.

The **Laboratory Closeout Guidelines and Procedure form** are provided on the Safety Services webpage.

10. Clearance to Work in Laboratories Procedure

A **Clearance to Work in Laboratories** is intended to ensure the safety of “non-lab personnel” such as University Facilities maintenance staff or contractors hired to perform work in labs. PIs and supervisors are responsible for ensuring that the area in which non-lab personnel will be working has been made safe and is free from hazardous materials contamination. This includes ensuring laboratory equipment has been removed and a clear path of egress to the work area is maintained.

The **Clearance to Work in Laboratories Procedure form** is provided on the Safety Services webpage. Review and signoff by Safety Services is required in some instances. Contact Safety Services for further information.

11. Laboratory Inspections

Regular workplace inspections play a key role in preventing accidents and injuries by identifying hazards, implementing corrective measures and monitoring the effectiveness of the controls. Campus Safety performs audits and inspections of University laboratories to assess regulatory compliance and occupational health & safety issues. Laboratory supervisors are required to conduct general inspections of their work areas on a monthly basis. Formal inspections are required at least once per semester.

A lab inspection checklist and explanation guide are provided on the Safety Services webpage, “Workplace Inspections & Maintenance”. If an item doesn’t apply, do not delete it; just mark it as ‘not applicable’. Additional items can also be added to the checklist to meet the specific circumstances of the lab.

A lab inspection module is also available in CHEMATIX and administered by Safety Services. Lab supervisors will be notified when to access this module for conducting and documenting lab inspections.

12. Incident Reporting & Investigation

All accidents, incidents and near misses involving laboratories must be reported and investigated by the PI or Supervisor along with the personnel involved. This process is necessary to determine the causes of the incident, implement corrective measures to prevent re-occurrences and document the incident. The purpose of the investigation is not intended to be punitive, but provides an opportunity for learning and improving health and safety. Communication of “Lessons learned” with affected personnel should be documented as part of the incident follow up process.

Refer to the Incident Reporting and Investigation procedures provided on the Safety Services webpage. Use the on-line Campus Accident/ Incident Report (CAIR) Form to report incidents, injuries and near misses.

12.1 Health and Safety Concerns (Hazard Reporting)

Whenever there are health and safety concerns in the laboratory, the first step should be to bring the matter to the attention of the lab supervisor. Many concerns can be addressed at this level through changes in work procedures and practices, upgrading of equipment, or other methods.

If it is a concern related to building systems such as ventilation, lighting, access/egress, or indoor air quality, the supervisor should contact Facilities. Health and safety concerns for these issues must be reported to Safety Services. Additional information is provided on the Hazard Reporting webpage.

13. Emergency Procedures

In an emergency situation, it is important to call in help. Emergencies would fall into these categories:

- Fire/explosion
- Injury
- Chemical Release (spill or gas leak)

When to Call 911:

In the event of an explosion or uncontrollable fire:

- First, evacuate the immediate area.
- Trip a fire alarm and/or call 911 (no prefix necessary)
- Call Security (2345) and give:
    - Identity of the person making the report
    - Nature of the incident
    - Location of the incident (building and room number)
    - Presence of any injuries

If possible, warn others of the situation and seal off the area.

In the event of a serious injury requiring an ambulance:

- Call 911 (no prefix necessary)
- Call Security (2345) and give:
    - Identity of the person making the report
    - Nature of the incident
    - Location of the incident (building and room number)

The basic steps to be taken for all emergencies are the same:
Warn others, evacuate the area, and contact Security (403) 329-**2345 or call 911.**

13.1 Chemical Release Incidents

A chemical release is defined as an uncontrolled release of a hazardous chemical, either in the form of a gas, liquid or solid. In the case of a chemical release, evacuate the area and call Security (403) 329-**2345**.

- Stay clear and warn others in the immediate area of the spill. Isolate the area around the spill.
- Assist injured or contaminated persons if you are trained to do so, but do not place yourself at risk of injury or contamination in the process.
- Assess the situation, and determine (a) if it constitutes an emergency situation or (b) whether assistance is required to clean up the spill. In either case, contact Security (403) 329-2345 and provide the information listed above. Security will implement the Chemical Release Procedure and call the Chemical Release Officer. Give Security the:
    - Identity of the person making the report.
    - Nature of the incident and, if possible, the chemicals involved. If the chemical release poses an explosion threat (as in the case of a volatile solvent), then notify security of this fact and evacuate those areas that are affected.
    - Location of the incident (building and room number).
    - Presence of any injuries.
- If the spill is minor, and trained local personnel, personal protective equipment and spill abatement material are available, the spill may be cleaned up according to the procedures given in **Chemical Spill Response Guidelines and Flowchart** on the Safety Services webpage.
- Spill kit supplies will need to be replaced after the spill has been cleaned up. Contact Safety Services for assistance.

Reporting: All chemical releases must be reported in writing to Campus Safety. Use the online Campus Accident/Incident Report (CAIR) Form on the Incident Reporting and Investigation webpage. Include the date, time, location, description of the spill, personnel injuries or exposures, any property damage, escape of materials into the environment, witnesses, and persons involved in supervision and cleanup of the spill. The report should be submitted to Campus Safety within 24 hours of the spill occurring. In some instances, regulatory reporting by Campus Safety will also be required. Refer to the Incident Reporting & Investigation Standard for details.

13.2 Fire & Explosion

Ensure you are familiar with the locations and operation of fire alarms, fire extinguishers and emergency evacuation plans in your building. Know at least two exits out of your area and the building, and know which corridors are "dead-end" so you can avoid them in the event of a fire. Know where assembly points are located. These are locations designated as a place for building occupants to gather when evacuated from a building during an emergency situation.

In the event of a fire or explosion in the lab:

- Warn others in the immediate area of the fire or explosion.
- Activate the building fire alarm system.
- Contain the fire by closing doors and fume hoods in the area of the fire.
- Evacuate the area of the fire or explosion and the building. Use stairs, not the elevator.

- Contact Security (403-329-2345) and give:
  - Identify of the person making the report
  - Nature of the incident
  - Location of the incident (building and room number)
  - Presence of any injuries

Attempts should be made to extinguish a fire only if no imminent danger exists, you are trained in the use of a fire extinguisher, and only after the first two steps (warn others and active the fire alarm system) have been followed. Do not attempt to fight a fire unless you have a clear escape route available and do not spend valuable time attempting to fight the fire. Do not take risks or attempt to fight the fire alone. Your personal safety always comes first.

The University's Emergency Management Standard defines responsibilities and identifies resources for general emergency response. Emergency Instructions and emergency response plan information is provided on Campus Safety's Emergency Management webpage.

13.3 Compressed Gas Leaks

Uncontrolled release of compressed gas can be hazardous due to both the physical hazard of the high-pressure vessel and the specific chemical hazard of the contents. While the greatest danger comes from flammable, toxic and corrosive gases, even an inert gas such as nitrogen or argon may be deadly due to the danger of asphyxiation in a confined, poorly ventilated area. A leaking gas cylinder is an emergency if closing the cylinder valve cannot stop the leak.

In the event of an uncontrolled release of a flammable, toxic or corrosive gas, the following steps should be taken:

- Warn others in the immediate area of the gas release
- If possible, stop the flow of gas at the cylinder valve
- Activate the building fire alarm system
- Evacuate the area of the fire and the building. Use stairs, not the elevator
- Contact Security (403) 329-2345 and give:
  - Identity of the person making the report
  - Nature of the incident
  - Location of the incident (building and room number)
  - Presence of any injuries

Attempts to stop the gas flow at the cylinder valve should only be made if there is no personal risk. Otherwise, evacuate the area and let emergency response personnel handle the situation. Be aware that flammable gases may ignite due to the static electricity generated by the flowing gas.

REFERENCES

- American Chemical Society, Committee on Chemical Safety. Safety in Academic Chemistry Laboratories. 5th Ed. American Chemical Society, 1990.
- American National Standards Institute. ANSI Z358-1-1998 Emergency Eyewash and Shower Equipment. Arlington, VA: Industrial Safety Equipment Association, 1998.
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- Furr, A. Keith. CRC Handbook of Laboratory Safety. 5th Ed. New York: CRC Press, 2000.
- National Research Council, Committee on Prudent Practices for Handling, Storage, and Disposal of Chemicals in Laboratories. Prudent Practices in the Laboratory: Handling and Disposal of Chemicals. Washington, DC: National Academy Press, 1995.
- University of Alberta, Office of Environment, Health and Safety Website
- University of Calgary, Environment, Health and Safety Website
- Stanford University, Environmental Health and Safety Website

RESOURCES AND RELATED DOCUMENTS

Campus Safety webpage

Safety Services webpage

Campus Accident /Incident Report Form (CAIR):

UofL Environment, Health and Safety Policy

UofL Environment, Health and Safety Management System (EHSMS)

Chemical Safety Standard

Chemical Spill Response Guidelines

CHEMATIX Chemical Inventory Management System

Fume Hood User Guide

Hazard Assessment and Control

Hazardous Waste Management Procedures

Lab Safety Rules Poster

Lab signage template

Lab Personnel Training Record

Safety Checklist for Researchers

Visitor Safety Standard

Volunteers in Research and Creative Activities Policy

UofL Working Alone Protocol

UofL Working Alone Registration System

Working Alone Safely - A Guide for Employers and Employees (AB OHS)

WHMIS 2015 (AB OHS)

WHMIS 2015 (CCOHS)

APPENDICES

Appendix A: Laboratory Chemicals by Compatibility Group

When determining in which compatibility group a given chemical should be placed, it is often found that it will fall in to more than one category. In these situations, it is necessary to determine what the primary hazard associated with the chemical is, and whether there are any specific incompatibilities that preclude storing with other chemicals in a given hazard group. This is best determined through consultation with the SDS for specific reactivity and compatibility information.

Note that this is not meant to be an exhaustive list, but a guide.
For details on any chemical, always consult the SDS.

Pyrophoric Chemicals

Pyrophoric chemicals are those that may spontaneously ignite upon exposure to air. They should be kept in a tightly sealed container, and in many cases should be stored under an inert solvent or atmosphere to minimize the possibility of contact with air.

- Grignard reagents, RMgX
- Metal alkyls and aryls, such as RLi, RNa, R3Al, R2Zn
- Metal carbonyls, such as Ni(CO)4, Fe(CO)5, Co2(CO)8
- Alkali metals such as Na, K
- Metal powders, such as Al, Co, Fe, Mg, Mn, Pd, Pt, Ti, Sn, Zn, Zr
- Metal hydrides, such as NaH, LiAlH4
- Nonmetal hydrides, such as B2H6 and other boranes, PH3, AsH3
- Nonmetal alkyls, such as R3B, R3P, R3As
- Phosphorus (white)

Oxidizing Agents

The primary hazard associated with oxidizers lies in their ability to act as an oxygen source and thus readily contribute to the combustion of organic materials. Typical oxidizers include those chemicals with the following oxygen containing groups:

Bromates	Nitrites
Chlorates	Perborates
Chlorites	Perchlorates
Chromates	Permanganates
Dichromates	Persulfates
Hypochlorites	Peroxides
Nitrates	Superoxides

In addition, the halogens (fluorine, chlorine, bromine) also react as oxidizers and should be treated accordingly.

Reducing Agents

In practical, chemical safety terms, reducing agents are those chemicals that are good sources of hydride and thus react vigorously with many other substances: Some strong reducing agents typically found in laboratories:

- Hydrogen
- Metal Hydrides (ex: NaH, $LiAlH_4$)
- Grignard reagents, RMgX
- Sodium Borohydride
- Boranes
- Alkali Metals
- Alkyl Lithium, Alkyl Sodium

Water Reactive Chemicals

Water reactive chemicals should be stored in a dry, cool, location, protected from water and the fire sprinkler system.

- Alkali metals, such as Na, Li, K
- Alkali metal hydrides, such as LiH, CaH_2, $LiAlH_4$, $NaBH_4$, alkali metal amides, such as $NaNH_2$
- Metal alkyls, such as lithium and aluminum alkyls
- Grignard reagents, RMgX
- Halides of nonmetals, such as BCl_3, BF_3, PCl_3, PCl_5, $SiCl_4$, S_2Cl_2
- Inorganic acid halides, such as $POCl_3$, $SOCl_2$, SO_2Cl_2
- Anhydrous metal halides, such as $AlCl_3$, $TiCl_4$, $ZrCl_4$, $SnCl_4$
- Phosphorus pentoxide
- Calcium carbide
- Organic acid halides and anhydrides of low molecular weight (ex: acetylchloride, acetic anhydride)

Appendix B: Common Chemical Specific Incompatibles

The following list is a quick reference of incompatibilities of many chemicals commonly encountered in the laboratory. It is not a comprehensive list of all possible combinations and chemicals. For details on any chemical, check the SDS, and follow the segregation guidelines in section 5 *Storage of Chemicals.*

Chemical	Is Incompatible With
Acetic acid	Chromic acid, nitric acid, perchloric acid, peroxides, permanganates
Acetylene	Chlorine, bromine, copper, fluorine, silver, mercury
Acetone	Concentrated nitric acid and sulfuric acid mixtures
Alkali and alkaline earth metals	Water, carbon tetrachloride or other chlorinated hydrocarbons i.e., powdered aluminum or magnesium, carbon dioxide, halogens, calcium, lithium, sodium, potassium
Ammonia (anhydrous)	Mercury (in manometers, for example), chlorine, calcium hypochlorite, iodine, bromine, anhydrous HF
Ammonium nitrate	Acids, powdered metals, flammable liquids, chlorates, nitrites, sulfur, finely divided organic or combustibles
Aniline	Nitric acid, hydrogen peroxide
Arsenical materials	Any reducing agent
Azides	Acids
Bromine	See Chlorine
Calcium oxide	Water
Carbon (activated)	Calcium hypochlorite, all oxidizing agents
Carbon tetrachloride	Sodium
Chlorates	Ammonium salts, acids, powdered metals, sulfur, finely divided organic or combustible materials
Chromic acid and chromium trioxide	Acetic acid, naphthalene, camphor, glycerol, alcohol, flammable liquids in general
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
Decaborane	Carbon tetrachloride and some other halogenated hydrocarbons
Flammable liquids	Ammonium nitrate, chromic acid, hydrogen peroxide, nitric acid, sodium peroxide, halogens
Fluorine	Everything
Hydrocarbons (such as butane, propane)	Fluorine, chlorine, bromine, chromic acid, sodium peroxide
Hydrocyanic acid	Nitric acid, alkali
Hydrofluoric acid (anhydrous)	Ammonia (aqueous or anhydrous)
Hydrogen peroxide	Copper, chromium, iron, most metals or their salts, alcohols, acetone, organic materials, aniline, nitromethane.

Chemical	Is Incompatible With
Hydrogen sulfide	Fuming nitric acid, oxidizing gases
Hypochlorites	Acids, activated carbon
Iodine	Acetylene, ammonia (aqueous or anhydrous), hydrogen
Mercury	Acetylene, fulminic acid, ammonia
Nitrates	Sulfuric acid
Nitric acid (concentrated)	Acetic acid, aniline, chromic acid, hydrocyanic acid, hydrogen sulfide, flammable liquids, flammable gases, copper, brass, any heavy metals
Nitrites	Acids
Nitroparaffins	Inorganic bases, amines
Oxalic acid	Silver, mercury
Oxygen	Oils, grease, hydrogen, flammable liquids, solids, or gases
Perchloric acid	Acetic anhydride, bismuth and its alloys, alcohol, paper, wood, grease, oils
Peroxides, organic	Acids (organic or mineral), avoid friction, store cold
Phosphorous (white)	Air, oxygen, alkalis, reducing agents
Potassium	Carbon tetrachloride, carbon dioxide, water
Potassium chlorate	Sulfuric and other acids
Potassium perchlorate (also chlorates)	Sulfuric and other acids
Potassium permanganate	Glycerol, ethylene glycol, benzaldehyde, sulfuric acid
Selenides	Reducing agents
Silver	Acetylene, oxalic acid, tartaric acid, ammonium compounds, fulminic acid
Sodium	Carbon tetrachloride, carbon dioxide, water
Sodium nitrite	Ammonium nitrate and other ammonium salts
Sodium peroxide	Ethyl or methyl alcohol, glacial acetic acid, acetic anhydride, benzaldehyde, carbon disulfide, glycerine, ethylene glycol, ethyl acetate, methyl acetate, furfural
Sulfides	Acids
Sulfuric acid	Potassium chlorate, potassium perchlorate, potassium permanganate (similar compounds of light metals such as sodium, lithium)
Tellurides	Reducing agents

University of Lethbridge

REVISION CONTROL SHEET

LAB CHEMICAL SAFETY & PROCEDURES MANUAL

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