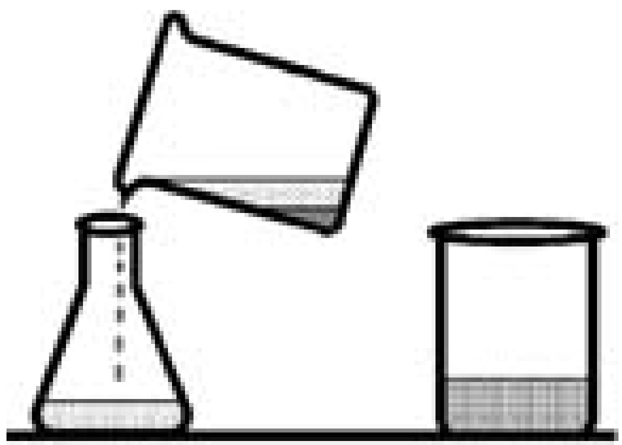
UNIVERSITY OF ALBERTA

Laboratory Chemical Safety Manual



Office of Environmental Health and Safety - Occupational Hygiene & Chemical Safety Unit

Issued: Feb. 2003
Revised: July 2005

Table of Contents

1. Introduction

The Laboratory Chemical Safety Manual is a reference manual developed to provide information on safe use, storage and disposal of laboratory chemicals. It is one component of the Chemical Safety Program at the University of Alberta. The Chemical Safety Program, as it is developed, will provide a comprehensive approach to the safe use, storage and disposal of chemicals. The Occupational Hygiene & Chemical Safety Division currently conducts laboratory audits, hazard exposure evaluation, and provides advice and consultation on laboratory design, including ventilation, selection, use and maintenance of personal protective equipment, and safe work procedures. It also coordinates the Workplace Hazardous Materials Information System (WHMIS) program at the University. Each department has WHMIS designate(s) who implement the program at the department level. The Occupational Hygiene & Chemical Safety Division provides training in WHMIS and spill response to departmental designates.

The Laboratory Chemical Safety Manual incorporates both general guidelines as well as more in-depth information on many laboratory safety practices involving laboratory chemicals. It is not, however, 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. In addition, individuals working with biological and/or radioactive materials are required to follow the policies and procedures identified by the Radiation Safety and Biosafety Divisions of the ***Office of Environmental Health & Safety.***

<u>Health and Safety Responsibilities</u>
Safety in the laboratory is the responsibility of every lab user. The ***Alberta Occupational Health & Safety (OHRS) Act*** requires the employer to ensure the health and safety of:
- workers engaged in the work of that employer,
- workers not engaged in the work of the employer, but present at the work site.

The Act also requires the employer to ensure that workers are aware of their health and safety responsibilities and duties under this Act, the regulations and the adopted code.

In the context of the Act, it is the responsibility of the **University of Alberta** as an employer, to take every reasonable precaution to provide a safe work environment. Administrative heads of units, line supervisors, and individual faculty members when involved in the supervision of staff members, students, post doctoral fellows or others are responsible for performing the duties specified under the Act as designated representatives of the University.

Under the OH&S Act, the workers also have an obligation to protect their own health and safety and that of other workers present while they are workingat the worksite. The workers are also expected required to cooperate with their employer for the purpose of protecting their health and safety and that of other workers. For the purposes of the Act, all individuals working in laboratories are considered workers. This includes, but is not necessarily limited to graduate students, post doctoral fellows, technicians, and visiting researchers.

The role of the ***Office of Environmental Health & Safety*** is twofold. Firstly, it is to provide expert advice and assistance to departments and supervisors to help them meet their requirements under the law and provide a healthy and safe work environment. Secondly, it is to monitor regulatory compliance and help identify areas where corrective action is required.

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.

2. General Laboratory Safety

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 chemical you're working with 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.
- Do not allow electrical cords or tubing for gas or water flow 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, excess equipment and personal belongings in the lab.

The ***Occupational Health and Safety Code (the OH&S Code), Section 185*** requires that the work site be kept clean, and free of clutter and slipping and tripping hazards. In addition, ***Section 119*** of the ***OH&S Code Occupational Health and Safety Code*** and the ***Alberta Fire Code,***

Section 2.7, 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 chemicals.
- Wear shoes that fully cover the feet to protect against spills. Do not wear open toed shoes or sandals.
- Confine long hair and loose clothing.
- Wear clothing which does not leave large areas of skin exposed (shorts, skirts, short sleeved shirts).
- Do not wear loose jewellery, 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

The ***Occupational Health and Safety Code, Section 25*** states that 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. Visitors and Minors in the Laboratory

Children of faculty, staff, teaching assistants, graduate students, volunteers or students are not allowed in restricted areas or in laboratories at any time. Children are only permitted in University labs laboratories as part of University sanctioned tours and visits 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 and must conduct a hazard assessment and implement appropriate corrective measures prior to bringing them.

Similarly, 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, maintenance personnel performing work, 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 should 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.

For more information, please contact the ***Office of Environmental Health & Safety***.

2.6. Experimental Planning and Hazard Management

Before starting new work, thoroughly plan and assess each step of the process to identify and eliminate or control associated hazards. 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. 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.
- 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, for example personnel becoming ill, or unexpected hazardous conditions developing during the course of the experiment.
- Working alone or after hours.

2.7. Off-Hours Work Practices

Working after hours in the laboratory poses additional risks not encountered during regular working hours since there are generally few, if any, other people around. It is necessary to be vigilant of potential health and safety problems at these times, since in the event of an emergency, assistance may not be readily available. Therefore:

- Keep the amount of laboratory work performed outside of regular work hours to a minimum.
- New or unfamiliar procedures should never be performed after hours.
- Only work of relatively low risk should be performed after hours.
- 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.

2.8. Working Alone

First and foremost, avoid working alone whenever possiblein laboratories. Working alone is defined in theAs per ***Occupational Health and Safety Code, Section 393***, as working alone is “to work alone at a work site in circumstances where assistance is not readily available in the event of an injury, illness or emergency. Futhermore, working alone is considered a hazard.” The regulation requires that:

- Operations are assessed for existing and potential safety hazards and a <u>written</u> 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 anytime of the day, especially outside of regular working hours when they may be alone, a working alone protocol must be developed as per the ***Occupational Health and Safety Code***. Forward a copy of this protocol to the ***Office of Environmental Health & Safety*** for review and approval. Further information or assistance with hazard assessment may be obtained from the ***Office of Environmental Health & Safety***.

2.9. Unattended Operations

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

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 clamped and water flow adjusted to the minimum flow necessary. Tygon tubing is preferable to rubber tubing 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.

Laboratory lights should be left 'on'ON', and a sign posted with a description of the operation, the chemicals being used, and the name and phone number of a contact person. It should indicate when the operation was started, and when it is expected to be complete.

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.

2.10. Utility Shutdowns

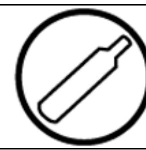
Work with chemicals must not be performed during water shutdowns. In the event of an accident or chemical spill during a shutdown, there is no water supply available for emergency showers and eyewashes. Laboratory work that does not involve the handling of chemicals, such as setting up apparatus or recording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

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 after power is restored and the lab has been fully vented (allow at least one hour).

3. WHMIS and the Laboratory

The **W**orkplace **H**azardous **M**aterials **I**nformation **S**ystem (WHMIS) is a "right to know" program designed to ensure workers are informed of the risks associated with the hazardous materials found at the worksite. 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 ***Occupational Health and Safety Code***) that regulates WHMIS at the worksite.

Table 3.1. WHMIS Classes and Hazard Symbols

Class	Description	Symbol
A	Compressed Gases	
B	Flammable and Combustible Material	
C	Oxidizing Material	
D	Poisonous and Infectious Material:	
D1	Materials Causing Immediate and Serious Toxic Effects	
D2	Materials Causing Other Toxic Effects	
D3	Biohazardous Infectious Material	
E	Corrosive Material	
F	Dangerously Reactive Material	

This section provides a summary of the aspects of WHMIS that are applicable to University laboratories. If you would like more information on WHMIS, please contact your departmental WHMIS designate or the ***Office of Environmental Health & Safety***.

A hazardous material that meets the criteria for inclusion in one or more of the WHMIS classes (see Table 3.1. for classes and symbols) is called a controlled product. However, not all products found in the laboratory are subject to WHMIS. Radioactive materials, pesticides, explosives, cosmetics, foods and drugs, and consumer products are covered by other legislation and are partially exempt from WHMIS. WHMIS requires employers to train workers on the safe handling, use and storage of these products.

The three major components to WHMIS are:

- Worker Education
- Labels
- Material Safety Data Sheets (MSDSs)

3.1. Worker Education

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

Training at the University of Alberta is delivered in two stages; first, ***Office of Environmental Health & Safety*** offers training aimed at departmental WHMIS designates. This training includes information about WHMIS labeling and MSDSs, other requirements under the legislation, and practical advice on implementing and administering WHMIS at the departmental level. Second, designates then offer training to the staff, students and faculty in their departments. This should include both generic and departmental specific training for hazards and procedures unique to the department. In order to meet the legislated training requirements, this training must be supplemented by specific worksite 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 clean up and disposal. Because it is so specific, such training cannot be provided on a global level, either from the ***Office of Environmental Health & Safety*** or the department; rather, it will need to be provided by the laboratory supervisor.

To aid designates and departments, the ***Office of Environmental Health & Safety*** offers a web-based training program, located at:

http://www.ehs.ualberta.ca/WHMIS

This can be used to train staff, students and faculty at the departmental level in the **generic aspects** of WHMIS. The designate is responsible for administering this web based training in the department, and the lab supervisor must ensure that worksite specific training is provided. For more information on the web based training, please contact the ***Office of Environmental Health & Safety***.

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

3.2. Labelling

Labels are designed to alert users to the hazards of the product and describe briefly the precautions to take. The two major categories of WHMIS labels are ***supplier labels*** and ***worksite labels***.

Supplier Labels
Supplier labels are those that must be present on controlled products in their original (supplier) containers. The basic supplier label must include the following information:

Supplier Label
• Product Identifier
• Supplier Name
• Hazard Symbols
• Risk Phrases
• Precautionary Measures
• First Aid Measures
• Reference to MSDS
• Hatched WHMIS Label

Small Container Labels
For controlled products packaged in containers less than 100mL, an abbreviated label is permitted:

Small (< 100mL) Container Label
• Product Identifier
• Supplier Name
• Hazard Symbols
• Reference to MSDS
• Hatched WHMIS Label

Laboratory Supply House Labels
Controlled products from a laboratory supply house, packaged in quantities of less than 10 kg and intended for laboratory use require the following label:

Laboratory Supply House Label
• Product Identifier
• Risk Phrases
• Supplier Name
• Precautionary Measures
• First Aid Measures
• Reference to MSDS

In all cases, the supplier label must be in both English and French.

Many laboratories have older chemicals on their shelves that predate the WHMIS regulations, or that have been imported into the country and not supplied with a label that meets Canadian regulations. In either case, the label must be updated to comply with WHMIS. In many cases, especially with older chemicals, the only change that is usually necessary is to include a reference to "See MSDS".

If the original supplier label has been damaged or defaced, the label must be replaced, either with a new one obtained from the supplier or with a ***worksite label***.

Laboratory Sample Label

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 labelled with the following information:

Laboratory Sample Label

- Sample Identifier
- Identity of Known Ingredients
- Senders Name
- Statement of "Hazardous Laboratory Sample. For hazard information or in an emergency call ____"
- An emergency telephone number

Worksite Labels

Worksite labels are used on containers into which controlled products have been transferred from the original supplier container, controlled products produced for use on the worksite, or on supplier containers to replace missing or illegible supplier labels. The basic worksite label must include the following information:

Worksite Label

- Product Identifier
- Information for Safe Handling
- Reference to MSDS

If a product will be used only in the lab in which it was decanted, it only needs to have a ***product identifier***. This can be:

- The name of the chemical.
- Sample number.
- Any other method that unequivocally identifies the substance.

The same ***product identifier*** labelling applies to controlled products produced in the lab, reaction vessels, mixtures undergoing testing or analysis, and hazardous waste. Note, however, that these simplified labels only apply as long as the controlled product is in the original lab. If a decanted product or lab produced controlled product is transferred elsewhere, then it should have a full worksite label.

3.3. Material Safety Data Sheets

A Material Safety Data Sheet (MSDS) is a document that provides detailed hazard, precautionary and emergency information on the product. It is meant to supplement the information contained in the supplier or worksite labels.

Information required on an MSDS:

- Hazardous Ingredients
- MSDS Preparation Information
- Product Information
- Physical Data
- Fire or Explosion Hazard
- Reactivity Data
- Toxicological Properties
- Preventative Measures
- First Aid Measures

A MSDS 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 MSDS.
- Controlled products produced in the laboratory that will remain in the laboratory.
- Intermediate products in reaction vessels.

MSDSs must be kept up to date. To ensure the hazard information is current, MSDSs MUST BE LESS THAN 3 YEARS OLD. An efficient way to ensure MSDSs are available for all hazardous materials and are up to date is to maintain an inventory of all hazardous materials. Inventories and MSDSs should 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, the ***Office of Environmental Health & Safety*** recommends that there be access to MSDSs for all hazardous products in the lab.

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

1) Paper copies of MSDS on hand.
2) Access to a central file of MSDSs.
3) Computer access to MSDS.
4) A combination of these three options.

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

1) A computer is accessible at all times to lab personnel.
2) All lab personnel know how to access and retrieve the MSDSs.
3) Hard copies can be produced if necessary.

Ensure there are WWW links to several MSDS sources in case the primary sources' 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. A list of WWW sites for the major chemical suppliers is given in **12. References** and on the ***Office of Environmental Health & Safety*** website at www.ehs.ualberta.ca.

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

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

4. Working with Chemicals

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

Plan - determine identify the potential hazards associated with an experiment before beginning work. Always review the MSDS 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 a 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.

1) In the event of a chemical splash on the body: 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 MSDS for further information. **All chemical splashes to the eye should receive immediate medical attention**.
3) If in doubt, contact the ***Office of Environmental Health & Safety***.
2)4)Report the incident to your supervisor and your WHMIS/Chemical Spill Designate. Fill out an ***Injury / Incident Report Form*** (see **Appendix D**).

These principles must be applied to all work involving chemicals in the laboratory.

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 MSDS. Chemicals with high acute toxicity may be identified using the criteria presented in Table 4.1.

Table 4.1. Criteria for Identifying Chemicals with High Acute Toxicity(1)

Oral LD_{50} (Rats, mg / kg)	< 50
Skin Contact LD_{50} (Rabbits, mg / kg)	< 200
Inhalation LC_{50} (Rats, ppm for 1 hour)	< 200
Inhalation LC_{50} (Rats, mg/m^3 for 1 hour)	< 2000

(1) Adapted from *US OSHA Standard 29 CFR 1910.1200AppA*

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

Before starting experiments with 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 all 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, and continue to monitor on a daily basis for the duration of the experiment.
- Operate glove boxes under negative pressure to prevent escape of toxic vapours, dusts or aerosols.
- Use HEPA filters, chemical scubbers 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.
- Choose equipment that allows ease of decontamination. For example, use vacuum pumps rather than vacuum lines. Equipment used should be labelled and isolated from the general lab equipment, and decontaminated before being removed from the designated work area.
- 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 flammable liquids with an open flame, and handle them in an area free of ignition sources. This includes open flames, electrical equipment, static electricity and for some liquids with very low flash points such as diethyl ether and carbon disulfide, hot surfaces.

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. Liquids which are water soluble can conduct electricity well enough that static build-up is usually not a concern. 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.

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.

4.3. 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 potentially 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 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, metal dust) with reducing materials, trace metals and ordinary combustibles.

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

- Plan experiments to minimize the need for handling of reagents and equipment while experiment is in progress.
- 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 if necessary to reach behind a shielded area while a hazardous experiment is underway.
- All personnel in the lab should wear 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 represented by the presence of a high-pressure vessel in the laboratory. A cylinder can easily become a lethal missile if mishandled.

Handling precautions:

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

Flammable gases should have a flash arrestor installed in the line to prevent flashback in the event of fire. All cylinders and gas lines and equipment used with flammable gases should be bonded and grounded to avoid the possibility of static ignition.

Check cylinders, connections, hoses and gas lines regularly for leaks. Use a commercial leak detector or leak-test solution, or a soapy water solution around all joints and watch for bubbles. Should a leak be 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:

1. Close the main valve.
2. Bleed the system.
3. Shut off and remove the regulator, and replace the valve cap.
4. Mark the cylinder "empty" or "MT", and return to the appropriate storage area for pickup by the supplier.

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 mixtures. Cryogens are normally gases at standard temperature and pressure., and They all have two properties in common; they are extremely cold, and small amounts of liquid expands 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.

Wear full coverage clothing with no cuffs, pockets, etc. which could catch the liquid in the event of a spill. Jewellery 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 become brittle due to the extreme cold. Only materials designed for low temperatures should be 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. Whenever possible, pre-cool the vessel. Similar precautions should be taken when cooling an object by immersion in a liquid cryogen. 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.

4.7.Transporting Chemicals

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

- Carry glass containers in specially designed bottle carriers or a leak resistant, unbreakable secondary container.
- When transporting chemicals 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.
- When possible, transport chemicals in freight elevators to avoid the possibility of exposing people on passenger elevators. Do not take the stairs.

Chemicals should be transported by hand for short distances only within buildings or between adjacent buildings.

The ***Transportation of Dangerous Goods Act & Regulations*** govern transportation of chemicals by vehicle. For details, please refer to the regulations or contact the ***Office of Environmental Health & Safety***.

5. Storage of Chemicals

5.1. Chemical Inventory

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. Once an inventory has been prepared, it should be updated as new chemicals are received in the lab or chemicals are used or sent for waste disposal. It should be reviewed 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.

The information contained in the chemical inventory will depend on the specific requirements of the each lab. At the very least, it should include:

- Name of Chemical.
- Storage Location.
- Approximate Amount.
- Date Received.

The inventory can also be used to keep track of other pieces of pertinent information, such as:

- Supplier Name.
- Hazard group.
- MSDS Availability and Date.

All chemicals should be labelled 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.

5.2. Storage of Laboratory Chemicals

Chemicals should 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 ***Concentrated Nitric Acid*** are separated from all 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**, and **Appendix B** consists of a list of some common, chemical specific incompatibilities. These lists are general guidelines only. Always refer to the MSDS 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 MSDS (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 and bases separately. Reactions readily occur between ammonia vapour and some acid vapours hydrochloric and nitric acids in particular), resulting in potentially hazardous precipitates forming on the outsides of bottles and throughout the storage area. If space limitations do not permit separate storage, segregate using secondary containment.
- Inorganic acids (e.g. nitric acid) and organic acids (e.g. acetic acid, propenoic 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 Alberta, the maximum volumes of flammable and combustible liquids permitted in **open storage** are:

- **25L** of **Flammable** or Class I Liquids;
- up to **300L** of **Combustible** or Class II / III Liquids;
  for a combined total of no more than **300L**.

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, whichever is less. 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 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 are not usually vented, and must never be vented to the laboratory, as they are designed to protect the contents from an external fire. Vents must either be sealed, or vented to the outdoors using materials or piping that provides fire protection equivalent to the cabinet itself.

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

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 by a chain or strap to a bench, wall or rack 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 strap or chain around multiple cylinders is not always effective.
- Position cylinders so that the valve is easily accessible and the contents label clearly visible.

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.

Table 5.6.1. Common Peroxide Forming Laboratory Chemicals

Form Explosive Levels of Peroxides Without Concentration	**Form Explosive Levels of Peroxides On Concentration**	
Isopropyl Ether	Acetaldehyde	Tetrahydrofuran
Butadiene	Benzyl Alcohol	Dicyclopentadiene
Potassium Metal	2-Butanol	Diethyl Ether
Potassium Amide	Cumene	Ethylene Glycol - Dimethylether
Sodium Amide (sodamide)	Cyclohexanol	Methyl Isobutyl Ketone
	Cyclohexene	
Autopolymerize as a Result of Peroxide Accumulation	3-Methyl-1-butanol	
	4-Heptanol	
	2-Hexanol	
Acrylic Acid	Isopropanol	
Arcylonitrile	2-Pentanol	
Butadiene	Many Other Secondary Alcohols	

- 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.

Office of Environmental Health & Safety
Phone: 492-6888 Fax: 492-7790
www.ehs.ualberta.ca

•Dispose of peroxide forming chemicals once they have exceeded their safe shelf life, as detailed in Table 5.6.2.
•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 the ***Office of Environmental Health & Safety*** and arrange for disposal immediately.

Table 5.6.2. Shelf Life of Peroxide Forming Chemicals

	Dispose After
Unopened Containers	18 months
Form Peroxides Without Concentration	3 months
Form Peroxides on Concentration	12 months

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 neutralised 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 the ***Office of Environmental Health & 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 crystallisation. If there is any sign of crystallisation, or the water level is low, **DO NOT** attempt to open or handle the bottle. Isolate the area, and contact the ***Office of Environmental Health & 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.

Similar precautions are necessary with other nitro compounds, such as 2,4-dinitrophenol, nitrogluanidine, hexanitrodiphenylamine, and nitrobenzene.

6. Hazardous Chemical Waste Management

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, 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 one 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 **R**educe, **R**euse, and **R**ecycle:

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
- University Chemical Recycle Program, operated by the Department of Chemistry.

THE INDISCRIMINATE DISPOSAL OF HAZARDOUS LAB WASTE DOWN THE DRAIN OR WITH THE REGULAR LAB TRASH IS UNACCEPTABLE. It is harmful to people and the environment, as well as illegal under the ***City of Edmonton Sewer Use Bylaw No.9675*** and the ***Alberta Environmental Protection and Enhancement Act***. The University of Alberta Hazardous Waste Management System provides hazardous waste disposal service to University labs at no charge, so take advantage of this system to safely and legally dispose of laboratory waste.

At the University, all hazardous waste is collected, transported to the University's Waste Management Facility and disposed of centrally as part of the University's Hazardous Waste Management System. The procedures detailed in this section are for chemical waste only; for information on biohazardous and radioactive waste disposal, please contact the appropriate unit of the ***Office of Environmental Heath & Safety***.

There are some hazardous materials that are not collected as part of the University of Alberta Hazardous Waste Management System. These include:

- Non-returnable gas cylinders (i.e. lecture bottles). Dispose of these through the original supplier, or through a commercial hazardous waste contractor.
- Hazardous materials restricted for transportation under the ***Transportation of Dangerous Goods Regulation***. These must be treated on site by a hazardous waste contractor.

6.2. Handling and Storage

As a general rule, all the precautions followed 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 ***Occupational Health and Safety Code, Section 396***, 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 it is not necessary to separate halogenated from non-halogenated waste.

6.3. Labelling Hazardous Waste

The individual generating the waste is responsible for proper labelling of waste. All waste containers must be properly labelled to accurately identify the contents of the container. Containers should have the following information:

- Building name and room number
- Name of principal investigator and a contact phone number.
- Three main contents, broken down by approximate percentage.
- The proper TDG shipping name, classification, PIN and packing group of the waste (Contact the ***Office of Environmental Health & Safety*** if you require assistance with TDG labelling information).

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 relabelled to indicate the contents if the original is missing or illegible.

UNIDENTIFED WASTE WILL NOT BE COLLECTED. It is the responsibility of the waste generator to identify and then dispose of through the usual route, or arrange for disposal as an unidentified waste through a commercial hazardous waste contractor.

6.4. Packaging Hazardous Waste

The waste generator is responsible for proper packaging of waste. Whenever possible, use the original container of the chemical for disposal. Otherwise, choose a container based on the following:

- Use a sealable container with a screw lid that does not leak when inverted. Foil, Parafilm™, corks or other plugs are not acceptable.
- Use a container that is compatible with the waste it contains (eg: no HF in glass containers).
- Visually inspect the container for damage or defects. Do not use a damaged container.
- Package old and unused chemicals in bags, and box according to compatibility.

For labs that generate a large amount of liquid waste, 19L (5gal) polyethylene ULC safety cans are a good choice. These can be reused and returned by the Environmental Health & Safety Waste Management Technician, provided they are properly labelled with a return address or location.

6.5. 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.

6.5.1. 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 clean and the labels defaced, they may be disposed of through the Waste Management System.

6.5.2. Sharps

All needles and similar sharps are treated as biohazardous waste. Do not re-cap needles, and do not use a guillotine type cutter to clip the needle, which may result in spreading the contents of the needle. These along with all other sharp objects (excluding clean glass which can be disposed in glass waste containers) should be dropped into a specifically designed sharps disposal unit or another appropriate puncture proof container.

6.6. Hazardous Waste Pickup

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

If disposal of hazardous waste is the responsibility of the individual lab, then the procedure is as follows. Waste collection is initiated by the waste generator who completes a "Request for Disposal of Radioactive and Chemical Waste" form. This can be done either in hardcopy and sent to the ***Office of Environmental Health & Safety*** by campus mail, or preferably, by a request form submitted by email through the ***Office of Environmental Health & Safety*** web page. The Waste Management Technician reviews the form for completeness and to determine if any items listed are prohibited from transport, and then arranges a time for pickup.

If hazardous waste is collected from a central storage area, contact your department for details on the waste disposal process.

7. Hazard Control Measures

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.

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. Contact the ***Office of Environmental Health & Safety*** for assistance.

7.1. Fume Hoods

Fume hoods are designed to control workers' 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. Apparatus used in the hood should be equipped with appropriate condensers, traps and scrubbers to collect or contain wastes and vapours.

Before beginning any work in the fume hood, confirm that the hood is operational. Check that the local on/off switch is in the "on" position and check the airflow. 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 your ***Facility Liaison OfficerService Manager*** (the ***Facility Liaison OfficersServices Manager*** coordinate all University building and grounds repair and maintenance). 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 the ***Facility Liaison OfficerService Manager***.

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:

- Sash openings should be kept at 30cm (12 inches) or less while working in the hood. When the hood is not in use, the sash should be completely closed.

- 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. Fume hoods should not be used for long term storage of chemicals or apparatus.
- Do not modify the interior of the hood (for example, by installing shelves).
- 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.

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 should 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 odoriferous or toxic substances. Labs are also designed so that they are at negative pressure to the rest of the building, to prevent movement of odoriferous or toxic substances to other parts of the building.

7.3. Safe Work Procedures

Safe work procedures 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. Safe work procedures are then developed based on the identified hazards. These should be written, readily accessible to everyone in the lab, and personnel should be made aware that procedures exist. Procedures 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 safe work procedures include:

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

7.4. Personal Protective Equipment

7.4.1. Eye and Face Protection

Eye protection should be worn in all labs when working with or around chemicals. It must meet the guidelines in the Canadian Standards Association standard CSA Z94.3-99 “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. The lab supervisor must determine the level of eye 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. It is recommended that appropriate gloves be used when handling hazardous chemicals, toxins and materials of unknown toxicity, corrosives, and hot / cold objects. Particular attention should be given to chemicals which have a “Skin” notation on the MSDS sheet or in Schedule 1, Table 2 of the ***Chemical Hazards RegulationOH&S 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.

For routine lab work with small amounts of chemicals, disposable gloves of a suitable material are generally acceptable, as they offer the best combination of dexterity and tactile sensitivity, barrier protection and cost. Remove and replace when they become contaminated. 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 heavier 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.

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. See **12. References** for web links to manufacturer glove selection guides.

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 through the ***University of Alberta – Hazardous Waste Management System***.

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, use a chemical or flame resistant synthetic material such as Tyvek© or Nomex©. Plastic or rubber aprons should be used 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 as a result of the hazard assessment it is determined that respiratory protection is required, then those lab personnel requiring the protection must:

- Complete a health screening questionnaire provided byRespirator Wearer's Questionaire and submit it to the ***Occupational Health Nurse*** to determine personal fitness for respiratory use. The questionnaire is available on the ***Office of Environmental Health & Safety*** website.
- Be fit tested by ***Office of Environmental Health & Safety – Occupational Hygiene & Chemical Safety Unit*** 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.

Additional information on respiratory protection is available through the ***Office of Environmental Health & Safety***.

7.5. Emergency Showers and Eyewash Stations

In accordance with the ***Occupational Health and SafetyOH&S Code, Section 24***, all laboratories where corrosive or other chemicals hazardous to the eyes or skin are used must have an access to an eyewash station and/or a safety shower in close proximity and accessible at all times. The need for an emergency shower /eye wash is identified based on a hazard assessment of the area that takes into account the concentration, quantities and frequency of use of corrosive chemicals. Lab personnel should 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.

Most of the emergency showers and eyewash stations at the University of Alberta use cold running water. To a person standing under a shower that uses cold water, 15 minutes may seem like an eternity. It is therefore important that another person assist the victim, to make sure 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 in 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. 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.

Eyewashes and showers should be tested regularly. Flush eyewash stations for 3 minutes, once a 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. Lab personnel should not carry out testing of safety showers. To have your shower tested, contact your ***Facility Liaison OfficerServices Manager***.

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 which 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, please contact the ***Facility Liaison OfficerServices Manager***. For more information on fire extinguishers, to attend a fire extinguisher training course, or for further information on Fire & Life Safety in general, contact the ***Office of Environmental Health & Safety***.

Office of Environmental Health & Safety
Phone: 492-6888 Fax: 492-7790
www.ehs.ualberta.ca

8. Laboratory Equipment

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.
- Soft glass may be used for applications in which the glassware is not exposed to these conditions, such as for reagent bottles, glass tubing, and measuring equipment.
- 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 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 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.
- On-off switches, rheostat type speed controllers, and similar devices can produce sparks every time they are adjusted. If electrical equipment is to be used in the fume hood, all controls should be outside the hood. Place a switch in the power cord if necessary.
- 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 the ***Safety Codes Officer (Electrical)***.

Electrical devices such as stirrers and mixers are often operated over extended periods of time with the possibility of mechanical failure, electrical overload or blockage of stirrer. If they are to be left unattended, the associated equipment should be fitted with a suitable fuse or thermal protection device that will shut down the apparatus in the event of such problems.

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. Any apparatus under reduced pressure should be shielded 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^{o}C, since they present neither shock nor spark risks and the temperature is guaranteed not to rise above 100^{o}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^{o}C, and silicone oil should be used for temperatures up to 300^{o}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 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.

8.5. 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 or modified commercial units 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.

Lab refrigerators should be clearly labelled as being for chemical storage only. **No food or drink may be stored in a lab refrigerator along with chemicals**.

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 aluminium foil or plastic wrap are unacceptable for storage of volatile chemicals in the refrigerator. Likewise, corks and glass stoppers are also inadequate. 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. 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 items such as 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 can be obtained from the ***Office of Environmental Health & Safety***. In addition, if equipment has been used for radioisotope or biohazards work, additional decontamination may be necessary. Contact the ***Office of Environmental Health & Safety*** for details.

9. Laboratory Closeout & Clearance to Work 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 the ***Office of Environmental Health & Safety*** to ensure these steps have been taken.

A lab closeout is also required when there are renovations or construction taking place in the lab. The procedure is the same as described above. This is intended to ensure the safety of trades' people who will be working in the area.

For minor renovations and for maintenance work, it is not necessary to perform a full lab closeout. Instead, a ***Clearance to Work in Hazardous Areas*** is required. For a clearance to work, the principal investigator in charge of the lab must ensure the area is free of laboratory hazards, and then receive ***Office of Environmental Health & Safety*** approval. In most cases, an inspection by ***Office of Environmental Health & Safety*** is not required. Since ***Clearance to Work in Hazardous Areas*** are Unit specific, please contact Biosafety, Occupational Hygiene & Chemical Safety, or Radiation Safety for further details.

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 the Chair in each department. If improper management of hazardous materials at closeout requires additional services from the ***Office of Environmental Health & 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 been disposed.

A final inspection by representatives from the ***Office of Environmental Health & Safety*** is <u>not</u> required for this type of closeout. The principal investigator or his / her delegate should inspect the area to ensure the cleanup has been satisfactorily performed. Any hazardous materials left in the workspace become responsibility of the principal investigator.

Detailed close out and clearance to work procedures can be obtained from the ***Office of Environmental Health & Safety***.

10. Inspections & Incidents

10.1. 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. The ***Office of Environmental Health and Safety*** performs regular audits of University laboratories to assess regulatory compliance and occupational health & safety issues. However, it is recommended that laboratory supervisors conduct inspections of their work areas on a monthly basis. A generic inspection form is included in **Appendix C**. Customize this form to meet the specific circumstances of your own laboratory.

10.2 Accident and Incident Reporting

All incidents involving chemicals spills, chemical exposure and any chemical related injuries must be recorded, investigated and reported. This exercise helps determine the causes of the incident, implement corrective measures to prevent re-occurrences and document the incident.. An Injury/ Incident Report Form is included in **Appendix D**. Complete this form, keep a copy on file and forward a copy to the ***Office of Environmental Health & Safety***.

In some cases, ***Workers Compensation Board (WCB)*** forms are required to be completed. The ***WCB Act*** requires that all injuries that disable or may disable a worker for more then the day of the incident be reported by the employer within 72 hours; failure to do so could result in fines.

10.3 Health and Safety Concerns

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 the building ***Facility Liaison OfficerServices Manager***. If the problem still cannot be addressed, contact the ***Office of Environmental Health & Safety*** for assistance.

11. Emergency Procedures

An emergency situation exists when an incident occurs in which there is a high risk of injury/exposure to persons, or damage to property or the environment. Emergencies on the University of Alberta main campus, and at all other University properties in Edmonton, should be reported to the Communications Control Centre (CCC) at **492-5555**. Remote stations should contact their local emergency services by calling 911. For leased properties, please refer to the lease agreement to determine the proper reporting procedure. For remote and leased sites, the CCC should also be informed of the situation after the appropriate emergency services have been contacted.

When informed of an emergency situation, the CCC will contact the appropriate emergency response persons or team. For this purpose, the CCC needs specific information from the person reporting the incident. This information must include:

- Identity of the person making the report.
- Nature of the incident (fire, explosion, chemical spill, gas leak).
- Location of the incident (building and room number).
- Presence of any injuries.
- When and how the incident occurred.

The basic steps to be taken for all emergencies are the same: **warn others, evacuate the area, and contact the Communication Control Centre (492-5555).**

11.1. Chemical Spills

A chemical spill is defined as an uncontrolled release of a hazardous chemical, either in the form of a gas, liquid or solid. In the event of a spill in the laboratory:

- 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) even though it is not an emergency, whether assistance is required to clean up the spill. If so, contact the Communication Control Centre (**492-5555**) and provide the information listed above. Contact your departmental spill designate.
- 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 ***Environmental Health and Safety Guideline: Chemical Spill Response***.

All chemical spills and gas releases should be reported in writing to the ***Office of Environmental Health & Safety***. Use the Injury / Incident Report Form given in **Appendix D**. 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 clean up of the spill. The report should be submitted to ***Office of Environmental Health & Safety*** within 48 hours of the spill occurring, regardless of whether the Communications Control Centre was notified or not.

11.2. 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 areas of refuge are located. These are temporary places of shelter from fire. Exit stairwells provide suitable refuge since solid walls enclose them. Certain floors or parts of floors may be designated as refuge areas. Know the location of the Evacuation Assembly Points for your building in the event that the building must be evacuated. Check with your building Chief Emergency Warden to find such areas for your building.

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 the Communication Control Centre (**492-5555**) and provide the information listed above about the fire or explosion.
- Meet emergency response personnel at the main building entrance and provide all necessary information about the fire or explosion.

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.

11.3. 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 the Communication Control Centre (**492-5555**) and provide the information listed above about the gas release.
- Meet emergency response personnel at the main building entrance and provide all necessary information about the gas release.

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.

12. References

12.1. General 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.

Canadian Standards Association. *CAN/CSA Z94.3-92 Industrial Eye and Face Protectors*. Toronto: CSA, 1992.

Compressed Gas Association. *CGA P-1-2000: Safe Handling of Compressed Gases in Containers*," 9th Ed. Arlington, VA: Compressed Gas Association Inc., 2000.

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 Environmental Health and Safety Website, www.ehs.ualberta.ca

12.2. Material Safety Data Sheet WWW Sites

12.2.1. Lab Chemicals, Compressed Gas, and Photographic Chemicals

Fisher Scientific Canada
http://www.fishersci.ca/homepage4.nsf/(waSearch)?openagent&lang=E&DB=msds2.nsf

EM Science
http://www.emdchemicals.com/corporate/Help.asp#msds

Sigma-Aldrich [1]
http://www.sigmaaldrich.com/catalog/search/AdvancedSearchPage

JT Baker
http://www.jtbaker.com/asp/Catalog.asp

Praxair
http://www.praxair.com/praxair.nsf/HTMLMSDSsByTitle?OpenView

Kodak
http://www.kodak.com/US/en/corp/hse/prodSearchMSDS.jhtml

12.2.2. Consumer and Proprietary Products

MSDS Search
http://www.msdssearch.com/MSDSSEARCHhome.htm

MSDS Solutions[1]
http://www.msds.com/

MSDSonline[1]
http://www.msdsonline.com/

[1] A user account must be set up to access these MSDS sites.

12.3. Manufacturer Glove Selection Guides

MAPA
http://www.mapaglove.com/ChemicalSearch.cfm?id=1

Best Manufacturing
http://www.chemrest.com/

Ansell
http://www.ansell-edmont.com/

Marigold Industrial
http://www.marigoldindustrial.com/GB/index.html

Safeskin
http://www.des.umd.edu/os/ppe/glove/

Appendix A: Some 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 MSDS 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 MSDS.

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

In addition, the halogens (fluorine, chlorine, bromine) also react as ozidizers 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, LiAlH4)

Office of Environmental Health & Safety
Phone: 492-6888 Fax: 492-7790
www.ehs.ualberta.ca

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 MSDS, and follow the segregation guidelines in **5. Storage of Chemicals**.

Chemical	Incompatibilities for Chemical Storage
Acetic Acid	Aldehydes, bases, carbonates, chromic acid, ethylene glycol, hydroxides, metals, oxidizers, perchloric acid, peroxides, permanganates, phosphates, xylene
Acetic Anhydride	Acids, alcohols, bases, finely divided metals, oxidizers, reducing agents
Acetone	Inorganic acids, amines, hydrogen peroxide, oxidizers, plastics
Acetylene	Copper metal, halogens, mercury, potassium, silver, oxidizers
Alkalis	Acids, carbon dioxide, chlorinated hydrocarbons, chromium, flammable liquids, mercury, oxidizers, salt, sulphur, water
Ammonium Nitrate	Acids, alkalis, chlorates, fine organic powders, metals, nitrates, oxidizers, sulfur
Aniline	Inorganic acids, dibenzoyl peroxide, hydrogen peroxide, oxidizers
Azides	Acids, heavy metals, oxidizers
Bromine	Acetaldehyde, acetylene, alcohols, alkalis, amines, benzene, butadiene, butane and other petroleum gases, ethylene, fluorine, hydrogen, ketones, finely divided metals, sodium carbide, sulfur, turpentine
Calcium Oxide	Acids, ethanol, fluorine
Carbon (activated)	Alkalis, oxidizers, calcium hypochlorite, halogens
Carbon Tetrachloride	Benzoyl peroxides, ethylene, fluorine, oxygen, silanes
Chlorates	Acids, ammonium salts, carbon, metal powders, sulfur, finely divided combustibles and organics
Chromic Acid	Acetic acid, acetone, alcohols, alkalis, ammonia, bases, camphor, flammable liquids, glycerine, turpentine
Chlorine	Acetylene, ammonia, benzene, butadiene, ethylene and other petroleum gases, hydrazine, hydrogen, hydrogen peroxide, iodine, sodium hydroxide, turpentine, other petroleum components, finely divided metals
Chlorine Dioxide	Ammonia, hydrogen, hydrogen sulfide, mercury, methane, phosphine, phosphorous, potassium hydroxide
Copper	Acetylene, calcium, hydrogen peroxide, oxidizers
Cyanides	Acids, alkalis, strong bases
Flammable Liquids	Ammonium nitrate, chromic acid, hydrogen peroxide, nitric acid, sodium peroxide, halogens
Fluorine	Ammonia, halocarbons, halogens, ketones, metals, organic acids, hydrocarbons, other combustible material
Hydrazine	Inorganic acids, hydrogen peroxides, oxidizers
Hydrocarbons	Acids, bases, oxidizers
Hydrochloric Acid	Alkali metals, amines, bases, copper, copper alloys, aluminium, moisture
Hydrofluoric Acid	Ammonia, glass, organics, sodium
Hydrogen Peroxide	Acetylaldehyde, acetic acid, acetone, alcohols, aniline, carboxylic acids, flammable liquids and combustible material, metals and their salts, nitric

	acid, nitromethane, organics, phosphorous, sodium, sulfuric acid
Hydrogen Sulfide	Acetylaldehyde, oxidizers, sodium
Hypochlorites	Acids, activated carbon
Iodine	Acetylaldehyde, acetylene, ammonia, hydrogen, sodium
Mercury	Acetylene, aluminium, amines, ammonia, calcium, fulminic acid, lithium, oxidizers
Nitrates	Sulfuric acid, other acids, nitrites
Nitric Acid (Conc.)	Acetic acid, acetonitrile, amines, ammonia, aniline, bases, benzene, brass, chromic acid, copper, cumene, flammable liquids and gases, formic acid, heavy metals, hydrogen sulfide, ketones, organic substances, sodium, toluene
Nitrites	Acids, nitrates
Nitroparaffins	Amines, inorganic bases
Oxalic Acid	Mercury, oxidizers, silver, sodium chlorite
Oxygen	Acetylaldehyde, alkalis, ammonia, carbon monoxide, ethers, flammable gases, liquids & solids, hydrocarbons, phosphorous
Perchloric Acid	Acetic acid, acetic anhydride, alcohols, aniline, bismuth and bismuth alloys, combustible materials, dehydrating agents, ethyl benzene, hydroiodic acid, hydrochloic acid, grease, iodides, ketones, other organic materials, oxidizers, pyridine
Peroxides, Organic	Acids (inorganic, organic)
Phosphorous	Air, alkalis, oxygen, reducing agents
Potassium	Acetylene, acids, alcohols, carbon dioxide, carbon tetrachloride, halogens, hydrazine, mercury, oxidizers, selenium, sulfur
Potassium Chlorate	Acids, ammonia, combustible materials, fluorine, hydrocarbons, metals, organic substances, sugars
Potassium Perchlorate	Acids, alcohols, combustible material, fluorine, hydrazine, metals, organic materials, reducing agents
Potassium Permanganate	Benzaldehyde, ethylene glycol, glycerol, sulfuric acid
Selenides	Reducing agents
Silver	Acetylene, ammonia, ammonium compounds, fulminic acid, oxalic acid, oxidizers, ozonides, peroxyformic acid
Sodium	Acids, carbon tetrachloride, carbon monoxide, hydrazines, metals, oxidizers, water
Sodium Nitrate	Acetc anhydride, acids, metals, organic matter, peroxyformic acid, reducing agents
Sodium Nitrite	Ammonium nitrate and ammonium salts
Sodium peroxide	Acetic acid, acetic anhydride, benzene, benzaldehyde, carbon disulfide, ethyl acetate, furfural, gylcerin, hydrogen sulfide, metals, methyl acetate, peroxyformic acid, phosphorous
Sulfides	Acids
Sulfuric Acid	Flammable and combustible liquids, potassium chlorate, potassium perchlorate, potassium permanganate, like compounds of sodium and lithium
Tellurides	Reducing agents

Appendix C: Chemical Laboratory Safety Inspection Checklist

Principal Investigator: **Date:**
Room & Building: **Inspected By:**

A. Documentation	Yes	No	NA	Comments
Emergency procedures posted?				
Chemical Spill Response Guideline available?				
Laboratory Chemical Safety Manual available?				
Chemical inventory available and up to date?				
MSDSs available for all controlled products?				
WHMIS and Chemical Safety training records available?				
B. Housekeeping				
Benches and sinks clean and tidy?				
Exit doors unobstructed?				
Aisles unobstructed?				
No tripping hazards (e.g. cords, hoses, equipment)				
No food or drink in lab				
C. Emergency & Safety Equipment				
Appropriate fire extinguisher available?				
First Aid Kit available and fully stocked?				
Safety glasses available and in use?				
Lab coats and gloves worn?				
Eyewash available and accessible?				
Emergency Shower available and accessible?				
Spill Kit available and fully stocked?				
Fumehood sash at < 12 inches (30 cm)?				
D. Chemical Storage				
All chemicals have WHMIS compliant labels?				
Chemicals segregated by compatibility class?				

Chemicals dated upon receipt?				
Peroxide forming chemicals labelled with opening date?				
Volume of flammable liquids in open lab < 25L?				
Flammables stored in intrinsically safe refrigerator only?				
All gas cylinders upright and secured?				
Chemicals waste properly stored and labelled?				

Appendix D: Injury / Incident Report Form

UNIVERSITY OF ALBERTA

Office of Environmental Health & Safety 11390 – 87 Avenue, Rm 107 ECP Edmonton, Alberta T6G 2R5	**Department/Faculty Injury/Incident Report Form**

PART A – to be completed by individual(s) directly involved or injured in the incident.

☐ Medical Aid ☐ Lost Time ☐ Spill / Contamination / Environmental Release ☐ Near Miss ☐ Property Damage

IDENTIFY – Person(s) involved

Date and time of Incident

______________________________ | ____ | ____ | ____ ____________ AM / PM
First Name Last Name YR MO DD HH: min

Department/Faculty: ______________________ Address: _ Phone #: ______________________

Occupation: ______________________________________

Date & Time of **Medical Evaluation**: ____ | ____ | ____ | __________ ☐ University Health Centre ☐ Hospital
YR MO DD HH: min ☐ Clinic or Family Physician

Exact details of injury / illness & treatment (eg. body part involved, cut, strain, bruise, illness symptoms and date of onset, etc.)

____

____

W.C.B. Form: (Please check one) ☐ Has been sent to Human Resources ☐ Not required

Description of Incident (Add additional pages if necessary)
State exactly the sequence of events leading to the incident, where it occurred, what the person was doing, the size, weight and type of equipment or materials involved, etc.

____

____

____

____

WITNESSES (If any)

NAME	DEPARTMENT	Phone #

PROPERTY DAMAGE

Identify property involved. Give machine name, tool name, etc.	Description of damage or loss	Estimated value of Loss

Completed by: ______________________________________ Date: ____________
Print Name

______________________________ **Forward to Supervisor Immediately**
Signature

The information on the attached is being collected under the general authority of the Universities Act, and the Freedom of Information and Protection of Privacy Act (Section 32c.) By completing and submitting this information, you are consenting to the collection and use of this information for the purpose of early illness intervention through medical surveillance. Should you have any questions about this collection of personal information, contact the Office of Environmental Health & Safety, Occupational Health Nurse, JoAnne Seglie 11390 – 87 Avenue, 107 ECP, University of Alberta, telephone 492-5378, fax 492-7790.

PART B - to be completed by Supervisor within 24 hours

Why did it happen? (conditions and/or actions contributing to injury / incident).

____
____
____
____
____
____
____
____
____
____

Corrective Actions to Prevent Re-occurrence	Action by whom & Date to be completed

Investigated by: ______________________________ Title: ____________
Print Supervisor's Name

______________________________ Phone #: ____________ Date: ____________
Signature

Send copy of completed form to Office of Environmental Health & Safety within 48hrs of incident.

for EH&S Use Only

☐ **Chemical** ☐ **Radioactive** ☐ **Physical** ☐ **Biohazard** ☐ **Fire / Explosion** ☐ **Vehicle** ☐ **IAQ**

Further follow-up required? ☐ Yes ☐ No
If yes, indicate action required below and attach details if required.

Reviewed by
EH&S Officer ____
Name Signature Date