

LABORATORY PROCEDURES AND SAFETY MANUAL

Applicable to all Faculties with Laboratories

July 2003

KEY CONTACTS

EMERGENCY.....562-5411

ADDITIONAL TELEPHONE NUMBERS

Protection Services.....5499
Occupational Health, Disability and Leave Office (OHDLO).....1472
Occupational Health and Safety Officer.....3052
Physical Resources Service (Maintenance)2222
Environmental Health and Safety Service (EHSS).....5892
Radiation/Biosafety Office5892
University Hazardous Waste Management.....5892
Fire Prevention Coordinator5747
University Info-Campus.....5700

DEPARTMENT TELEPHONE NUMBERS

(To be completed by manual owner)

Manual Owner.....

Supervisor (if applicable).....

Building Administrator.....

Senior Technician.....

Hazardous Waste Coordinator.....

OTHERS

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EMERGENCY PROCEDURES

Immediately report all emergencies requiring assistance to Emergency EXT. 5411.

You must immediately advise Emergency EXT.5411 in the event of a critical injury or a fatality.

Should you require first aid treatment, report to the first aid station nearest you, or call Emergency EXT.5411.

"Critically injured" means an injury of a serious nature that: a) places life in jeopardy; b) produces unconsciousness; c) results in substantial loss of blood; d) involves the fracture of a leg or arm but not a finger or toe; e) involves the amputation of a leg, arm, hand or foot but not a finger or toe; f) consists of burns to a major portion of the body; or, g) causes the loss of sight in an eye.

Accident/Incident Reporting Procedure

Accidents/incidents MUST BE REPORTED using the University of Ottawa *Accident, Incident or Occupational Disease Report*. These include:

- All accidents, incidents or suspected occupational diseases requiring medical attention and/or implying loss in working days; and,
- Other incidents, including those involving only minor injuries, "close calls" without injury, direct exposure to chemicals, damage to equipment, chemical odours or spills and leaks of hazardous materials

The forms are available from your departmental office and the Human Resources Service (HRS), Occupational Health, Disability and Leave Office. **The report MUST be forwarded WITHIN 24 HOURS of the event to the Occupational Health, Disability and Leave Office, Tabaret Hall, Room 019. The fax number is 562-5206.**

Major Fire Emergencies

1. In the event of a **major fire** beyond your control, **SHOUT "FIRE, FIRE, FIRE"** and **pull the nearest fire alarm.**
2. Attempt to rescue persons in immediate danger. **Do not endanger yourself.**
3. **Evacuate personnel from the area. Leave fume hoods on. Close, but DO NOT lock the door.**
4. **Do not attempt to fight a major fire on your own.**
5. Fire extinguishers are to be used to assist you in **getting out safely.**
6. **CALL EMERGENCY EXT.5411. Give location and details.**
Remain available in case further information is required.

Small Fire Emergencies

1. **Small fires** may be fought with **appropriate fire extinguishers** or suffocated with **sand, water or cover.**
2. Ensure fire is properly extinguished by trained personnel. Call your Building Administrator or Fire Warden.
3. Remain available in case further information is required.
4. Complete an *Accident, Incident or Occupational Disease Report*. Forward the report **within 24 hours** to the Occupational Health, Disability and Leave Office, if there is a possibility of exposure or injury.

Chemical Spills

DECIDE if you can safely control the spill.

If unsafe or unsure, call Emergency EXT. 5411. Fire alarm should only be pulled if situation is out of control and building must be evacuated.

If chemical enters a floor drain or sink, immediately block the drain if safe to do so and contact Emergency EXT.5411.

If hazardous vapours are being generated which may migrate outside of the localized area, alert people in the area and contact Emergency EXT.5411.

When reporting a spill to Emergency, give the exact location and details (type and quantity of material, associated risks, injuries, etc.). Remain available in a safe location in case further information is required.

If safe to do:

1. **Eliminate all ignition sources** (burners, hotplates and other sources of ignition) if flammable material is involved. **If vapours are potentially flammable or explosive, DO NOT attempt to switch any electrical equipment on or off.**
2. Ensure that appropriate personal protective equipment is worn (mask, gloves, etc.) when cleaning spill.
3. **Quickly block or contain size and spread of spill** by using appropriate absorbing material (sand, vermiculite, inert absorbent, spill pillows, etc.).
4. **Evacuate personnel from the area.** Prevent others from entering area by closing doors, posting warnings, etc.
5. **Make sure fume hood is on** if one is available to capture or direct flow of gases and vapours.
6. Once spill has been absorbed, place **all** cleanup material in a sealable container. Seal container; **label and dispose as hazardous waste.**
7. Complete an *Accident, Incident or Occupational Disease Report*. Forward the report **within 24 hours** to HRS, Occupational Health, Disability and Leave Office, if there is a possibility of exposure or injury.

Biohazard Spills

DECIDE if you can safely control the spill.

If unsafe or unsure, call Emergency EXT. 5411. Fire alarm should only be pulled if situation is out of control and building must be evacuated.

1. **Alert all present and evacuate the room. Minimize spread of spill. DO NOT** take contaminated material out of area of spill. Close door and post a warning sign including your name, telephone number, date and time you will return, and the following message "NO ENTRY - Biohazardous Spill".
2. Remove contaminated clothing turning the exposed area inward, and **autoclave.**
3. **Wash all exposed skin with disinfectant soap.**
4. Inform principal investigator in charge of the research project and follow his/her instructions.
5. If principal investigator is unavailable, **call Emergency EXT. 5411.**
6. Remain available in case further information is required.
7. Complete an *Accident, Incident or Occupational Disease Report*. Forward the report **within 24 hours** to HRS, Occupational Health, Disability and Leave Office, if there is a possibility of exposure or injury.

If safe to do: (for Level 1 or 2 agents)

Ensure all appropriate personal protective equipment is worn.

Spill occurs in or out of biological safety hood:

If spill occurs in biological safety hood: i) Leave hood running.
 ii) Run the hood for 10-15 minutes after clean-up.

1. Flood the spill with 10% bleach and leave for 20 minutes.
2. If threat of aerosolization exists cover area with absorbent material.

3. Wipe absorbent material saturated with 10% bleach and place all waste in a biohazard waste bag.
4. Contaminated items should be wiped with disinfectant or wrapped and autoclaved.

Spill in centrifuge:

1. Leave lid shut for at least 1 hour for aerosols to settle.
2. After opening wipe inside of centrifuge (including lid) and rotor with paper soaked in 10% bleach. Pay special attention to the bucket holding the broken tube.
3. Remove rotor and repeat disinfection thoroughly.
4. Rinse both rotor and inside of centrifuge with water after using bleach.

Leaving the scene:

If you must leave the scene, place a sign warning others of the nature of the spill and provide your name, telephone number and when you will return.

Level 3 agents:

For specific spill response information refer to the Biohazard Containment Suite Manual.

Radioactive Spills

DECIDE if you can safely control the spill.

1. **Notify all individuals in the immediate area** that a spill has occurred.
2. **Prior to vacating** the area, remove any contaminated clothing and shoes. If spill is on skin, wash thoroughly with soap and tepid water. Multiple washings are superior to one rigorous washing. **Monitor area after each washing.**
3. **Lock and sign door.** The warning sign should include name, telephone number where to be contacted, date/time you will return, and the following message: "Warning - Radioactive spill". Specify radioisotope and activity involved.
4. **Limit access** only to those responding to the spill.
5. **Call Emergency EXT.5411.**
6. Remain available in case further information is required.
7. Complete an *Accident, Incident or Occupational Disease Report*. Forward the report **within 24 hours** to HRS, Occupational Health, Disability and Leave Office, if there is a possibility of exposure or injury.

If safe to do:

1. Contain spill by using absorbent material (paper towels).
2. Obtain any additional supplies and/or personal protective equipment (overalls, shoe coverings) required for clean-up. **DO NOT TRACK CONTAMINATION IN DOING SO.**
3. Push spill toward its centre. Collect all contaminated material in one bag, appropriately labelled.
4. Decontaminate area in convenient sectors with appropriate solutions. Check for contamination using a monitor with appropriate detector or swipe test.
5. Reclean if contamination is found. Three cleans should remove all contamination.
6. If fixed contamination remains, contact the Radiation/Biosafety Office.

Leaving the scene:

1. Monitor self (especially feet, hands including gloves, lab coat) for contamination.
2. Leave lab coat behind if contaminated. Remove dosimetry badge to avoid erroneous reading being obtained.
3. Lock and sign door (name, contact telephone number, nature of incident and time you will return).

DECIDE if you can safely control the spill.

If unsafe or unsure, or the spill is in the vicinity of a floor drain or sink, immediately block the spread of the spill to prevent the mercury from entering the sewer system and contact Emergency EXT. 5411.

If a large spill of mercury is involved or if vapours are being released (eg. mercury on a heated surface), close off the area and contact Emergency EXT. 5411.

When reporting a spill to Emergency, give the exact location and details (quantity of material, associated risks, etc.). Remain available in a safe location in case further information is required.

If safe to do:

1. If a small amount of mercury is spilled (eg. a broken thermometer), use an aspirator bulb, medicine dropper or mercury sponge to pick up droplets. If available, use a mercury spill kit. **When cleaning the spill, appropriate respirator and protective clothing must be worn.** Place the mercury in a container, cover with water and/or oil and seal the container. **Label the container for disposal as hazardous waste.**
2. If the mercury has broken into many droplets, or if droplets have worked into cracks or other hard to clean areas, sprinkle with sulphur powder or commercial products that will form amalgam with mercury. Leave for several hours, then collect and place solid into a container, seal it and **label it for disposal as hazardous waste.**
3. Complete an *Accident, Incident or Occupational Disease Report*. Forward the report **within 24 hours** to HRS, Occupational Health, Disability and Leave Office, if there is a possibility of exposure or injury.

Formalin Spills

DECIDE if you can safely control the spill.

If unsafe or unsure, call Emergency EXT.5411. Fire alarm should only be pulled if situation is out of control and building must be evacuated.

If formalin enters a floor drain or sink, immediately block the drain if safe to do so and contact Emergency EXT.5411.

If hazardous vapours are being generated which may migrate outside of the localized area, alert people in the area and contact Emergency EXT.5411.

When reporting a spill to Emergency, give the exact location and details (quantity of material, associated risks, etc.). Remain available in a safe location in case further information is required.

If safe to do:

1. **Quickly block or contain size and spread of spill** by using appropriate absorbing material (sand, vermiculite, paper towels, etc.). **Protect areas around drains and sinks.**
2. **Evacuate personnel from the area.** Prevent others from entering area by closing doors, posting warning signs
3. **Make sure fumehood is on** if one is available to capture or direct flow of gases and vapours.
4. Ensure that appropriate personal protective equipment is worn by those cleaning the spill. Gloves made of nitrile or PVC are preferred; rubber or neoprene gloves may also be used. Safety goggles should be worn. Respirators with appropriate cartridges are recommended.
5. Once spill has been absorbed, place **all** cleanup material in a sealable container. Seal container; **label and dispose as hazardous waste.**
6. Complete an *Accident, Incident or Occupational Disease Report*. Forward the report **within 24 hours** to HRS, Occupational Health, Disability and Leave Office, if there is a possibility of exposure or injury.

FIRST AID

In the event of any medical emergency, CALL EMERGENCY EXT. 5411 FOR ASSISTANCE IF NECESSARY.

A basic knowledge of first aid procedures is essential for working anywhere where there is a significant risk of accidents, such as in laboratories. This manual is a guideline intended to minimize the extent of injury following an accident. It is recommended that you enrol in courses in First Aid and Cardio-Pulmonary Resuscitation (CPR). For more information on these courses, contact your supervisor or the Occupational Health and Safety Officer, EXT.3052.

There are designated individuals in your department or work area with First Aid and/or CPR training. Contact your departmental office for more information or consult the Occupational Health and Safety bulletin board.

It is recommended that first aid kits be present in each laboratory and work area. Information on obtaining additional kits, or supplies for replenishment of kits, are available through your department.

Initial Assessment in Case of an Accident or Sudden Illness

- Assess safety of scene for yourself and the casualty. If required, remove danger or remove casualty from danger.
- Assess cause of accident. **QUICKLY** determine how accident occurred, if possible. Is a neck or spinal injury suspected? If so, do not move casualty if the area is secure.
- Instruct casualty to lie still (if conscious). Offer reassurance.
- Assess the casualty. Check consciousness. Is the airway open? Is the casualty breathing? Is there a pulse? Is there severe bleeding?
- **Send for help. DESIGNATE someone to go for help, have them return to the scene and report to you. Provide the following information: 1) your identity, 2) description of accident circumstances, 3) location of emergency (BE EXACT), 4) number of casualties/type of injuries/condition of casualty, 5) phone number where you can be reached when applicable.**

Chemical Contact with Skin and Burns on Skin

Remove contaminated clothing. If the contaminant is in a powdered form, brush it off your clothes and skin as much as possible. **Rinse** the affected area **thoroughly** with copious amounts of cool running water. Use emergency shower if necessary. **Make sure the rinsing with running water is continued for a minimum of 15 minutes. DO NOT apply ointment UNLESS it is specifically designed for the chemical involved. DO NOT USE WATER on chemical burns from any metals (sodium, potassium, magnesium, and aluminium). Seek medical attention.**

Chemical Contact with Eyes

Proceed to the eye wash immediately and activate it by pushing the lever forward. Hold lids apart and flush the eye(s) with plenty of running water **for a minimum of 15 minutes**. If a tap or hose is used, direct water on the bridge of the nose, water will run into the eyes automatically. If necessary, use a portable eyewash unit as an **interim wash** until the injured party can reach proper facilities. Seek medical attention.

Clothing Fires

STOP (where you are), **DROP** (to the floor) and **ROLL** (to smother the flames). Shout for help. Avoid using fire extinguishers on people except in extreme emergencies. If you must use a fire extinguisher on a person, **DO NOT** aim at the face. **To avoid spreading the fire to the entire area, DO NOT proceed to the shower until the flames have been extinguished (unless very close to the shower).** After the fire has been extinguished, go to the nearest shower or hose and cool the burned

areas with water. Seek medical attention.

Asphyxiation

If safe, remove victim from the area immediately and loosen tight clothing. A person trained in CPR should monitor the victim's airway and vital signs. Seek medical attention.

Cuts and Animal Bites

Allow the wound to bleed uninhibited for a few seconds to purge the wound. **Apply pressure** to the cut or bite with a sterile pressure dressing except when there is an object protruding from the wound, in which case apply pressure **around the wound**. Wash wound if bleeding stops. Seek medical attention for even small cuts and all bites. Advise medical staff if the animal is contaminated with a virus.

Critical Injuries and Fatality

CALL EMERGENCY EXT.5411. DESCRIBE EMERGENCY AND LOCATION. Provide any necessary first aid within your capabilities. Keep victim warm. **DO NOT** move victim unless in danger. Remain with injured person until help arrives. Remain available in case further information is required.

GENERAL LABORATORY SAFETY GUIDELINES

Awareness - Communication

- **BE FAMILIAR** with the locations and operation of safety and emergency facilities such as fire extinguishers, first aid kits, spill kits, emergency wash facilities, fire alarm pull stations, telephones, and emergency exits.
- **BE ALERT** to unsafe conditions.
- **PROMPTLY REPORT** unsafe conditions and accidents to your supervisor.

Personal Protective Equipment - Proper Attire

- Wear clothing appropriate for the level of hazard. Lab coats (knee-length) and proper footwear are required for work involving chemicals, biohazards or radioisotopes. Gloves and safety glasses or safety goggles must be worn as required by the work being performed.
- **NEVER WEAR CONTACT LENSES** when working with hazardous chemicals, unless wearing safety goggles.
- Open and/or high-heeled shoes must **NEVER** be worn in laboratories.
- Long hair must be tied back or otherwise restrained when working with chemicals, biohazards, radioisotopes, open flames or moving machinery.
- Leave behind protective equipment (lab coats, gloves, etc.) when leaving the work area, except when going directly from one laboratory to another.
- Wash hands and arms with soap and water before leaving the work area.

Proper Usage of Laboratories

- Work spaces must be kept clean and free of clutter (chemicals, biological specimens, etc.).
- Smoking, eating, and drinking are **NOT** permitted in laboratories.
- **DO NOT** store food and drinks in laboratory refrigerators.
- **DO NOT** run in laboratories. Walk.
- All laboratory doors are fire doors. **THEY MUST BE KEPT CLOSED AT ALL TIMES.**
- **NEVER BLOCK** exits and passageways, or access to emergency equipment (i.e. eye wash stations, emergency showers, fire extinguishers, first aid kits and electrical panels).

Conducting Experiments

- **NEVER** perform unauthorized work, preparations or experiments.
- Consider safety issues **BEFORE** beginning work. Refer to Material Safety Data Sheets (MSDS) prior to using a product. Check all equipment for damage prior to setting up experimental apparatus.
- Select a suitable location. Experiments involving hazardous materials should be done in a vented fume hood.
- **ADVISE** fellow researchers and/or supervisors of experiments in progress.
- **DO NOT** leave an experiment unattended if it represents a potentially hazardous situation.
- If necessary, **POST SUITABLE WARNING SIGNS** if hazardous situation is present and left unattended. Include your name and the extension where you can be reached.
- Perform a safety check at the end of each experiment. Make sure that gas, water, electricity, vacuum lines, air and heaters have been turned off unless required.

Proper Handling of Hazardous Materials

- Work with materials only when you know their flammability, reactivity, toxicity, and the emergency procedures associated with these materials. Refer to MSDS.
- Label reagents and samples according to WHMIS legislation.
- Keep an updated inventory of all chemicals stored in your laboratory.
- **DO NOT** remove chemicals from the laboratory without updating your chemical inventory.
- Store chemicals according to chemical compatibilities rather than alphabetical order.
- Store chemicals in appropriate locations (eg. flammable storage and acid storage cabinets).
- **DO NOT** leave reagent bottles, empty or full, on the floor or in the sink.
- Transport hazardous chemicals (eg. solvents) and chemical waste in approved bottle carriers or on special waste cart, if available.
- **NEVER** pipette by mouth.
- Clean up spills immediately if trained and able to do so. If the spill is too large to handle or if unsure

EHSS,
what to do, **CALL EMERGENCY EXT.5411.**

University of Ottawa

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1. INTRODUCTION

Purpose of Manual

Safety standards are designed to reduce to an acceptable level the risks inherent in the use of dangerous materials and potentially dangerous procedures or practices. All laboratories can be inherently dangerous places, and the attitudes and actions of those who work in the laboratory determine their own safety and that of their colleagues and ultimately, that of the community.

Different standards are set for different levels of risk. High levels of risk require more stringent standards than lower levels of risk. Compromises are, therefore, made in setting safety standards so as not to impede much needed research while keeping the risks of those involved to a minimum. Laboratory equipment and design has become more sophisticated and safer, but safe and proper utilization still depends on properly trained and genuinely concerned personnel, who are safety conscious at all times.

This manual is intended to provide **basic** rules for safe practices in a laboratory. Individual supervisors must identify and supplement this manual with safe procedures and training specific to the needs of their laboratory safety programs when the safety subject is not adequately covered by this manual.

In all cases, the individual supervisor is ultimately responsible for teaching safe work practices and must insist upon the use of such proper procedures to eliminate unnecessary hazards.

Since this manual will be periodically revised, readers are asked to convey to their faculty's Chief Administrative Officer comments on its contents, suggestions of items to be included, or omissions or errors.

Acknowledgements

The following individuals and services of the University of Ottawa made important contributions to the writing of this manual: the senior technical support staff of the Faculties of Engineering, Medicine and Science; Environmental Health and Safety Service; Occupational Health and Safety Office; Occupational Health Service; Protection Services; and Physical Resources Service.

The *Laboratory Procedures and Safety Manual*'s general form and content were shaped by similar manuals from McMaster University and McGill University. The manual's content was further developed and adapted by the Environmental Planning Team for the Faculties of Engineering, Medicine and Science to meet the specific needs of the University of Ottawa.

2. RESPONSIBILITIES

The responsibilities presented here summarize and elaborate on those described in two University of Ottawa policy statements:

- Policy 77: Health and Safety Policy; and,
- Policy 91: Environmental Management Policy.

The information presented here **is not** a substitute for these University policies. These policies should be consulted by those wishing further clarification of their responsibilities.

A listing of the University of Ottawa's safety services and their functions is provided in **Appendix A**.

2.1 Individuals

Each **individual** is responsible for complying with **all directives, procedures and standards established by the University, their faculty or by government agencies**. In particular, each individual is responsible for conducting activities in a manner that will not endanger him/herself nor others and for exercising all reasonable care in activities that may pose a risk to the environment. When directed to do so, all University employees shall participate in training and information sessions that may be offered. **Each individual is responsible to ensure that he/she has received WHMIS training**. All individuals shall provide assistance and cooperate with University and government authorities (including Occupational Health and Safety Committee representatives) conducting inspections, audits or investigations in accordance with specified policies and procedures. All individuals are required to report all known occupational health and safety or environmental hazards to their immediate supervisors. Contact your immediate supervisor for further details.

2.2 Supervisors

Supervisors are responsible for ensuring **compliance with all directives, procedures, standards and guidelines established by the University, their faculty or by government agencies**. They shall provide opportunities for personnel under their authority to attend any training or information sessions required by the University or faculty. Supervisors must also initiate necessary preventive measures to control health and safety or environmental hazards associated with activities under their authority. Supervisors are required to take corrective action, within the scope of their authority, as soon as they are made aware of a situation involving non adherence to policy and procedures, or laws and bylaws. Situations requiring further assistance or intervention should be reported to their immediate supervisor.

2.3 Principal Investigators

Principal investigators are responsible for ensuring that **all those under their authority are diligent in the application of their responsibilities**. They are responsible for communicating procedures, standards and guidelines in teaching and research activities that they supervise and for ensuring compliance with them. They shall provide opportunities for personnel under their authority to attend any training or information sessions required by the University or faculty. Where necessary, they are responsible for developing and establishing specific procedures for activities under their authority, in support of University or faculty directives, and in conformance with external agency requirements. Principal investigators must also initiate necessary preventive measures to manage occupational health, safety or environmental hazards associated with activities under their authority. Principal investigators are required to take corrective action, within the scope of their authority, as soon as they are made aware of a situation involving non adherence to policy and procedures, or laws and bylaws. Situations requiring further assistance or intervention should be reported to their department chairperson.

2.4 Department Chairs

Department chairs are responsible for **monitoring compliance with all directives, procedures and standards established by the University, their faculty or by government agencies at the faculty level**. This includes supporting the implementation and maintenance of faculty directives and monitoring adherence to them at the department level. Department chairs must also initiate necessary preventive measures to control health and safety or environmental hazards associated with activities under their authority. Department chairs are required to take corrective action, within the scope of their authority, as soon as they are made aware of a situation involving non adherence to policy and procedures, or laws and bylaws. Situations requiring further assistance or intervention should be reported to their dean.

2.5 Deans

Deans are responsible for **overseeing compliance with all directives, procedures and standards established by the University, their faculty or by government agencies at the departmental level. The Dean must also ensure that appropriate occupational health, safety and environmental programs are in place at the faculty level**. This includes developing, establishing and maintaining objectives, plans, directives, guidelines and procedures necessary to manage occupational health and safety hazards and to ensure sound management of environmental issues applicable to his/her faculty. Deans shall allocate or, if necessary, request sufficient resources to ensure the effective operation of these programs. They are also responsible for monitoring adherence with directives, guidelines, procedures and standards established for their faculty. Deans are required to take corrective action, within the scope of their authority, as soon as they are made aware of a situation involving non adherence to policy and procedures, or laws and bylaws. Situations requiring further assistance or intervention should be reported to the appropriate University authority.

3. OPERATING AND MAINTENANCE PROCEDURES

3.1 Hazardous Materials Procurement

To best ensure compliance with legislative requirements concerning labelling and MSDS and to rationalize inventories, staff are asked to channel purchases of hazardous materials through the Faculty of Science (on the main campus) or Faculty of Medicine Stores.

If you procure hazardous materials directly, note that the following requirements must be met:

- Hazardous products must be properly labelled according to WHMIS standards.
- Those working with the hazardous materials must have access to a current MSDS.

Additional information on WHMIS labelling and MSDS may be found in Appendix B.

Waste Minimization

The cost of hazardous waste disposal is of growing concern to the University. Before ordering a new material, please consider its final disposal. Proper management of hazardous materials will help minimize disposal costs and may be achieved by observing the following:

- Do not overstock. One of the main sources of laboratory waste is surplus stock - the result of overbuying. It may be tempting to take advantage of lower unit prices by buying in quantity, but the costs of disposal of the surplus may ultimately override any savings realized at the time of purchase. Central purchasing through the Faculty of Science or the Faculty of Medicine Stores can definitely help solve these issues. Users can buy the quantity they need from Stores at a competitive price.
- Whenever possible, return test materials and containers to their sources. You must conform to the Transportation of Dangerous Goods Act requirements for label packaging. Call the Environmental Health and Safety Service for additional information.

- Do not accept donations of materials you do not plan to use. Traditionally, many companies have unloaded unwanted reagents by donating them to universities, which eventually absorb the costs of disposal.
- Whenever possible, recycle materials rather than dispose of them. The University of Ottawa has established recycling programs for the following hazardous materials: photographic wastes, fuels and oils, batteries, and lead. For procedures and schedules, contact your hazardous waste coordinator, faculty representative, or the Environmental Health and Safety Service. For information concerning recycling of non-hazardous materials, contact Physical Resources Service.
- Conserve energy and water as much as possible. Turn off lights and equipment if not in use. Do not leave water running unnecessarily.
- Label all waste materials. If the identity of a hazardous waste is not known, it must be analyzed before disposal, the costs of which are prohibitive.

3.2 Hazardous Waste Disposal

These are general procedures only. Detailed information on specific classes of waste may be found in Section 5, or by contacting the Environmental Health and Safety Service.

Waste Containment

- **Generators are responsible** for the waste they generate until it is **accepted for disposal** by the hazardous waste coordinator.
- **Do not dispose of any hazardous materials down the drain.** Refer to the Sewer Use Guidelines for exceptions.
- **Do not mix incompatible chemical wastes.** Refer to Appendix C.
- Metallic waste containers used for flammable liquids **MUST** be grounded during filling procedures.
- **Inappropriate containers will not be accepted.** All waste materials must be **safely contained.** Use appropriate containers and ensure that they are clean and not leaking.
- **Improperly labelled containers will not be accepted.** All hazardous waste containers must be labelled with the appropriate hazardous waste label. Materials still in their original containers must have a label identifying their contents. If they are waste, they require the hazardous waste label.
Chemicals: All chemical waste containers must be labelled with the University of Ottawa or Faculty of Medicine hazardous waste label (available free of charge from Faculty of Science or Faculty of Medicine Stores, or EHSS). If wastes are combined in a single container, the label must list **all** chemicals contained.
Biohazards: Biomedical waste containers are colour coded according to the types of wastes they contain. Refer to Section 5.5 or contact the Radiation/Biosafety Office.
Radioactives: Labelling requirements vary depending on the type of waste. For more information, contact the Radiation/Biosafety Office.
Sharps: All sharps containers must have a hazardous waste label showing department, room, name and telephone number of the generator.
- Fill containers only about 75% full. **Overfilled and/or leaking containers will not be accepted.**
- Wear the appropriate personal protective equipment (lab coat, gloves, eye protection, apron, etc.) depending on the level of hazard.
- Chemical waste containers should be **vented.**
- **Do not store your full hazardous waste containers. Call your hazardous waste coordinator, faculty representative or EHSS to have them removed.**

Waste Removal

Hazardous waste removal procedures are specific to each faculty or department. For your department's procedures, refer to the schedules periodically issued by the faculty or department.

3.3 Safety Check

Once per month, check the condition of the following. Report any problems to your supervisor or Building Administrator.

- Fire extinguishers. Verify that the fire extinguisher is in its proper location and that the gauge indicates that it is fully charged. If the fire extinguisher is not up to standards, call Protection Services at EXT.5499 for immediate replacement.
- Emergency wash devices. To prevent possible amoeba infections, each eye wash station should be tested by letting the water run for several minutes. This does not apply to portable eyewash units which instead must be checked for the presence of microorganisms (check the expiry date). Do not test emergency showers.
- Fume hoods and biological safety cabinets. Verify that proper air flow is being maintained using a piece of paper or tissue attached to the bottom of the sash. Ensure biological safety cabinets have been certified.
- Chemical storage compartments. Verify that the contents are organized in accordance with their chemical compatibilities. If compartment is vented, verify that proper air flow is being maintained.
- Tubing for circulating water, vacuum or gases. Verify that connections are appropriately secured and that there are no leaks. Rubber tubing should be checked for cracking.

3.4 Procedures for Permanently Vacating Laboratories

Objective

The laboratory area, when vacated, must be left in a safe and tidy condition.

Responsibilities

- 48 hours prior to vacating a work space, advise the Building Administrator or a designated Occupational Health and Safety Committee representative to physically inspect the area.
- It is the responsibility of the principal investigator to ensure that the objective is met.

Work Spaces and Equipment

- All work spaces, including fumehoods, must be clear and clean.
- All equipment must be cleaned. Any hazardous chemicals left within equipment must be removed by trained personnel. Examples of hazardous materials left within equipment are heavy metal particulates, polychlorinated biphenyls (PCBs), chlorofluorocarbons (CFCs), mercury, oils and compressed gases. For removal of suspected PCBs, contact EHSS.
- Equipment cavities sufficiently large to entrap children must be left open by complete removal of hinged or fastened doors, or coverings.

Hazardous Waste Disposal

- All chemicals must be either properly disposed of as hazardous waste or distributed among researchers who want them.
- All chemical containers must be labelled with the exact chemical names of all contents using the proper hazardous waste label including hazard identification and precautions.
- All other containers must be properly labelled according to their contents.

Biohazardous Materials

- Contact the Radiation/Biosafety Office for disposal and decontamination.

Radioactive Materials

- Contact the Radiation/Biosafety Office for disposal and decontamination.

3.5 After-Hours Work

Working alone is considered an unsafe practice at any time. If, however, the nature of your work makes it unavoidable, measures should be taken to ensure that others are aware that you are doing so and to have someone check in with you from time to time, either in person or by telephone.

- Ensure that you carry a University of Ottawa ID card at all times.
- Always check with your supervisor if specific procedures require a buddy system.
- **CALL** Protection Services EXT.5499 to advise them where you will work and for how long.
- **CALL** Protection Services again when leaving the area.

4. SAFETY PROTOCOLS AND EQUIPMENT

4.1 Personal Protective Equipment

- For any laboratory work, you must wear a lab coat and proper footwear. Eye protection and gloves must be worn as required.
- Additional equipment may be required depending on the hazardous exposure levels.
- It is the user's responsibility to maintain their personal protective equipment in good condition.
- Supervisors are responsible for ensuring access to and the use of the required personal protective equipment and for ensuring that users are properly trained in its use.

Gloves

A wide variety of gloves are available to protect against chemical exposure. Because the permeability of gloves of the same or similar material varies from manufacturer to manufacturer, no specific recommendations are given here. Appendix D lists the chemical resistances of some common glove materials. Be aware that as a chemical diffuses through a glove, that chemical is held against the worker's hand longer and the individual may then be more exposed to the chemical than if the glove had not been worn.

- Always check to ensure the absence of cracks or small holes in gloves before each use.
- **Do not wear gloves in public areas.** Remove gloves before leaving the work area and before handling such things as telephones, doorknobs, writing instruments, and laboratory notebooks.
- Gloves may be reused, cleaned, or discarded, consistent with their use and contamination.

Eye Protection

- **Eye protection is mandatory** in most laboratories where corrosive or toxic chemicals are used or stored, and anywhere near high-pressure, high vacuum equipment or when carrying out work that can generate dusts, sprays or other projectiles.
- **Use of contact lenses in the laboratory is prohibited unless wearing safety goggles.** Vapours readily enter the space between the lenses and the eyes via capillary action. This makes the lenses difficult to remove. If irrigation of the eye is not performed within 15 seconds of coming into contact with certain corrosive materials, permanent eye damage is likely to occur.
- Depending on the protection required during a specific procedure, regular safety glasses, chemical safety goggles or a full face shield may be necessary. Consult with your supervisor.

Clothing

- Be aware that there are hazards associated with materials commonly used in personal clothing. Cotton is highly permeable. Nylon, polyester and spandex are easily melted. Body-hugging materials such as spandex will hold spilled chemicals close to the skin. Evaluate the potential hazards of your activities and wear appropriate clothing. Lab coats (knee-length) must be worn at all times in laboratories when work involves chemicals, biohazards, or radioisotopes.

- Lab coats should have snap fasteners rather than buttons so that they can be quickly removed.
- Contaminated lab coats or clothing should not be washed with other laundry at home.

Hearing Protection

It is recommended that hearing protection be worn if average noise levels exceed 85 dBA (decibels) over an 8-hour period. It is permissible to be at noise levels greater than 85 dBA for short periods of time without hearing protection.

Contact the Occupational Health and Safety Office for more information. Hearing evaluations are recommended for all employees working in a noisy environment.

4.2 Laboratory Safety Equipment

Fumehoods

Fumehoods serve to control exposure to toxic, offensive or flammable vapours. Apparatus used in hoods should be fitted with condensers, traps or scrubbers to contain or collect waste solvents or toxic vapours. The fumehood is **NOT** an appropriate means for disposing of chemicals. **The fumehood is NOT a storage cabinet.** Stored chemicals can interfere with efficient hood operation, and in the event of an accident or fire, every item in the hood may become involved.

- **Minimize storage** of hazardous materials in hoods and dispose of collected waste promptly.
- **Be sure the hood is working properly.** A continuous monitoring device such as a narrow strip of tissue paper can be a good indicator of air flow.
- **Only materials being used** in an ongoing experiment should be kept in the fumehood. Cluttering of the hood will create air flow disturbances.
- Large apparatus inside a hood should be placed upon blocks or legs to allow air to flow **underneath**.
- Equipment should be placed as far back in the hood as practical and activities carried out **at least 15 cm (6 in.) from the front edge of the hood.**
- **Keep your head outside of the hood whenever possible.** Avoid cross drafts at the face of the hood. A hood's air flow can be disrupted by drafts from windows, doors, and even by the positions of the workers at the hood.
- Keep the sash clean and clear.
- Operate the hood with the sash **as low as practical.**
- Keep hood sash closed when not attended.
- **Clean all chemical residues** from the hood chamber after each use.
- **Electrical devices (unless certified explosion-proof) should be connected outside of the hood** to avoid sparks which may ignite a flammable or explosive chemical.
- **In emergency situations** (i.e. fires, gaseous emissions, spills), **pull the sash down completely** and make sure hood fans are turned on. **Call EMERGENCY EXT.5411.**
- **For maintenance or repairs, call your supervisor or the Building Administrator.**

Biological Safety Cabinets

- **Biological safety cabinets should be certified at the time of installation, annually and whenever they are relocated.** To arrange for certification, contact the Radiation/Biosafety Office.
- Do not block the front intake or rear exhaust grille. **Keep equipment at least 10 cm inside the cabinet window.**
- **Perform transfers of viable materials as deeply into the cabinet as possible.**
- Disinfect interior surfaces of work area regularly with an appropriate disinfectant. Disinfect equipment before removal.
- After activating cabinet's fan, **wait 23 minutes before beginning work** to allow sufficient time to purge airborne contaminants. Allow it to run an additional 2-3 minutes after completion of work.
- **Minimize air turbulence** both outside the cabinet (eg. pedestrian movement nearby) and inside (eg. use of flames). If flame must be employed, a burner with a pilot light should be used.
- **Do not work in cabinet when germicidal lamp is on.**

Emergency Showers

- **Be familiar** with the location and operation of the emergency shower nearest to your laboratory.
- The shower area must be readily accessible, and be kept clear of obstructions.
- Rinse the affected area for a minimum of 15 minutes with copious amounts of cool water.
- The use of emergency showers must be reported on an accident/incident reporting form.

Eye Wash Stations

- **Be familiar** with the location and operation of the eye wash station nearest to your laboratory.
- The eye wash station area must be readily accessible, and be kept clear of obstructions.
- Spray eyes for a minimum of 15 minutes with a copious and gentle flow of potable water.
- If necessary, use a portable eyewash unit as an **interim wash** until the injured party can reach a plumbed fixture. Portable eyewash units require strict attention to maintenance, and may provide an environment for the growth of microorganisms.
- The use of eyewash stations must be reported on an accident/incident reporting form.

Back-Flow Preventers

Back-flow preventers are designed to prevent the back-flow of contaminated water into potable supply lines. This condition could arise when hoses or pipes are connected to existing water supplies and a reversal or drop of water pipe pressure occurs, causing a reverse flow of contaminated water. To prevent this reverse flow, back-flow preventers must be installed on these additional systems. For more information, contact your Building Administrator.

4.3 Fire Safety

- Familiarize yourself with the location and operation of the fire extinguishers, emergency exits, evacuation routes, fire alarm systems and fire suppression systems in your area.
- If the fire alarm is sounded, follow the evacuation routes established for your area. Use stairs that are clear of smoke; **never use elevators**. Be observant. Report anomalies (fire, smoke, odours) to Fire Wardens. Once outside of the building, move away from the doors to enable others to exit. Never re-enter the building before authorized to do so by the officer responsible.

Fire Prevention

- **Quantities of flammable liquids** kept on hand in the laboratory **should be minimized**.
- **Use CSA-approved flammable liquid storage cabinets**. Keep doors of these cabinets closed and latched at all times. **No other materials** should be stored in these cabinets.
- Unless necessary for your work, **keep flammable liquids away from heat, flame and direct sunlight**. No welding or soldering should be performed in their vicinity.
- Static charges can build up in pipes or other apparatus through which organic liquids are flowing. **Such equipment should be electrically grounded**.
- **In case flammable or explosive chemicals are spilled and/or being evaporated into the atmosphere, DO NOT switch any electrical equipment on or off.**
- **Smoking is NOT permitted in any building.**

Fire Extinguishers

- Fire extinguishers are to be used to assist you in getting out safely or for fighting small fires. **Do not attempt to fight a major fire on your own.**
- All laboratories where flammable solvents are used must be equipped with an appropriate fire extinguisher. In case of problems with fire extinguishers, or if used, immediately notify the Fire Prevention Coordinator, EXT.5747, for **urgent replacement**.
- In selecting the appropriate extinguishers for the laboratory, the type of combustible material must be considered:

CLASS A (H₂O) fires involve ordinary combustible materials such as wood, **cloth**, paper, **rubber** and **many plastics**.

CLASS B (CO₂) fires involve flammable liquids and gases, oils, greases, tars, **oil-base paints**, **lacquers** and **some plastics**.

CLASS C (Dry chemicals) fires involve Class A and/or B materials in the presence of live electrical

equipment, motors, switches and wires.

CLASS D (Metalex) fires involve combustible metals such as magnesium, titanium, sodium, potassium, zirconium, lithium and any other finely-divided metals which are oxidizable.

4.4 Radiation Safety

- **All users must receive training prior to using radioactive materials and must be operating under an active radioisotope permit.**
- Detailed information on radiation safety is provided by the Canadian Nuclear Safety Commission posters which are required in all radiation work areas.
- For further information, contact the Radiation/Biosafety Office.

X-Ray Generators

- Study and follow all precautions specified by supplier of the instrument before using it.
- Warning signs must be displayed on or near the main power switch of the instrument and on the entry door to the location.
- X-ray safety is regulated by the Ontario Ministry of Labour and all activities must comply with the directives of the Ministry and Regulation 861 of the Occupational Health and Safety Act.
- Contact the Radiation/Biosafety Office for more detailed information.

Lasers

- Study and follow all precautions specified by the supplier of the instrument before using it.
- Home-made lasers must conform to all safety rules applied to similar commercial lasers.
- Post warning signs in laser areas and on doors leading to those areas.
- **Always wear eye protection that is specified for the particular wavelength and power level used.**
- If possible, keep laser beams at or below waist level.
- Never look directly at the beam or pump source.
- Use the image converter to look at the beam pattern directly.
- Ensure that there are no unwanted reflective objects in or along the beam (even buttons or screw heads could be dangerous). Remove rings and watches.
- If possible, keep the room illumination level high to avoid pupil dilation.

UV Radiation

- Study and follow all precautions specified by supplier of the instrument before using it.
- Post warning signs in areas where UV lamps are used.
- **Always wear protective safety glasses with applicable UV filtering lenses.**
- Protect all skin from UV radiation.
- **DO NOT** touch mercury lamp with oily fingers - this may cause spot heating and cracking.
- UV sources should be operated within an enclosure and adequately cooled to prevent the mercury lamp from exploding and leaking hot mercury vapour.

Microwaves

- **DO NOT** attempt to operate microwave ovens with the door open.
- **DO NOT** tamper with or defeat safety interlocks.
- Ensure that seals around door are clean and undamaged.
- Loosen lids on containers to relieve pressure build up during heating process.
- **DO NOT** use metal containers in microwave ovens.
- Only qualified and trained people should alter or modify microwave ovens.

High Magnetic Fields

The high magnetic fields present in magnetic resonance laboratories may pose serious health risks to those with certain cardiac pacemakers, prosthetic implants, or artificial limbs. Those having such implants or prosthesis should consult their physician before entering the vicinity of a high field magnet. Since the

attraction of ferromagnetic objects, such as gas cylinders or metal tools, towards high field magnets can be enormous, there is also a risk associated with handling metallic objects near high field magnets. Persons are at risk when they are between the magnet and a nearby heavy ferromagnetic object. The law dictates that areas surrounding NMR magnets (above and below as well as radially) be well indicated with warning signs.

The presence of strong magnetic fields will lead to the loss of magnetically stored data (eg. bank cards, computer disks, audio and video cassettes, etc.). As a result, such objects must be kept well away from high field magnets. Other devices such as analogue watches, oscilloscopes, video monitors or motorized devices may not operate properly near a high field magnet.

4.5 Electrical Safety

- Report defects/faults to your supervisor.
- **All electrical apparatus must be properly grounded.**
- **Never remove the ground pin of a 3-pronged plug.**
- **DO NOT** use portable space heaters in proximity with combustible and flammable material.
- Frayed wires and cords must not be used.
- **DO NOT** use electric wires as supports and never pull on live wires.
- Ensure that all wires are dry before plugging into circuits.
- **Electrical devices (unless certified explosion-proof) should be connected outside of the hood** to avoid sparks which may ignite a flammable or explosive chemical.
- All electrical equipment immersed in liquids must have ground fault circuit interrupters.
- Circuit breaker panels within laboratories must be easily accessible and clearly marked. Familiarize yourself with their location.
- Minimize the permanent use of extension cords. Ask your supervisor or the Building Administrator to install additional outlets.
- Only qualified and trained people should repair or modify electrical or electronic equipment.
- All electrical equipment must be CSA or Ontario Hydro approved or inspected by electrical authority.

Static Electricity and Sparks

- **Static electricity and sparks may cause a fire under the right circumstances. Always be conscious of the potential for generating sparks.**
- Electrical equipment must have spark protection in areas where there is a danger of fire or explosion.
- Some protection from static electricity and sparks is obtained by proper grounding and bonding of containers and equipment.
- A dry atmosphere promotes the formation of electrical charges.
- **Common sources of sparks and static electricity are:**
 - i) decanting of organic liquids from one metal container to another.
 - ii) plastic aprons.
 - iii) metal clamps, nipples or wires used with non-conducting hoses.
 - iv) gases released quickly from cylinders under high pressure.
 - v) switches and thermostats.
 - vi) electrical contacts (eg. light switches and thermocouples, refrigerators) may produce sparks.

4.6 Glassware Safety

- When handling glass rods or tubes:
 1. Fire polish the ends.
 2. **Lubricate** with water or glycerine when inserting through stopper.
 3. Ensure stopper holes are properly sized; not too small.
 4. Insert carefully, with a slight twisting motion, keeping hands close together.
 5. **Use gloves or a cloth towel to protect your hands.**
- Use a dust pan and brush, not your hands, to pick up broken glass.

- **Discard broken glass and Pasteur pipettes in a broken glass container or other rigid container separate from regular garbage and label it appropriately.**
- Protect glass that is subject to high pressure or vacuum. Wrapping glass vessels with cloth tape or plastic wrapping will minimize the possibility of projectiles.
- **Eye protection MUST always be worn when working with glass apparatus under either high pressure or vacuum.**
- Glass is weakened by all types of stresses (eg. heating, bumping, etc.). **Handle used glassware with extra care.**
- **Discard or repair all damaged glassware**, as scratched, chipped, cracked or star-cracked vessels cannot handle the normal stresses.

5. GUIDELINES FOR SPECIFIC CLASSES OF HAZARDOUS MATERIALS

5.1 Flammable, Combustible and Ignitable Materials

Definition

- **Flammable liquids:** Liquids having a flash point below 37.8°C (eg. ethanol, varsol, gasoline, paint thinners, etc.).
- **Combustible liquids:** Liquids having a flash point between 37.8°C and 93.3°C (eg. toluene, kerosene, etc.).
- **Ignitable solids:** Solids capable, under standard temperature and pressure, of causing fire through friction, absorption of moisture or spontaneous chemical changes and which, when ignited, burn so vigorously and persistently that they cause a danger (eg. charcoal, white phosphorous, magnesium alloys, hexamine, beryllium, hafnium powder, zirconium, sodium, potassium). Those ignitable solids that ignite upon contact with water or air are treated as reactive materials (Section 5.3).
- **Flammable gases:** A flammable gas is a compressed gas and at normal atmospheric pressure forms a flammable mixture with air: 1) when in concentration of 13% v/v or less; or, 2) over a concentration range of at least 12% v/v (eg. hydrogen, butane, propane). Flammable gases are addressed in Section 5.8.

Personal Protective Equipment

- Lab coat, safety glasses, appropriate gloves and footwear.

Storage

Flammable and Combustible Liquids:

- Flammable and combustible liquids in laboratories may only be stored in either glass containers of 4L capacity or less, or metal or plastic containers of 20L (5 gallons) or less.
- These liquids **MUST** be stored in CSA approved flammable storage cabinets. Keep cabinet doors closed at all times.
- Heat-sensitive flammable liquids must be stored in **explosion-proof refrigerators**. Non-vented refrigerators or cold rooms are not to be used for the storage of flammable liquids.
- **DO NOT store other materials, such as reactive chemicals, in the same storage cabinet with flammable liquids.**
- Store only quantities actually needed.

Ignitable Solids:

- Store in an airtight container or bottle to prevent dispersal of dust. Store under an inert material if necessary.
- Ignitable solids **MUST** be stored in CSA approved flammable storage cabinets. Keep cabinet doors closed at all times.

Handling

Flammable and Combustible Liquids:

- **Refer to Material Safety Data Sheets (MSDS) prior to using product.**
- Flammable and combustible liquids **MUST** be used in well-ventilated areas.
- **Keep away from sources of ignition.**

- **Flammable liquids should be transferred inside a working fume hood.**
- If transferring between metal containers, both containers **MUST** be grounded.
- Some flammable liquids (eg. ethers) are also peroxide formers. Refer to Section 5.3 for additional safety precautions.
- **In case flammable chemicals are spilled and/or being evaporated into the atmosphere, DO NOT switch any electrical equipment on or off.**

Ignitable Solids:

- **Refer to Material Safety Data Sheets (MSDS) prior to using product.**
- Ignitable solids **MUST** be used in well-ventilated areas.
- Keep away from sources of ignition.
- Clean the work area frequently to prevent the accumulation of ignitable dusts.

Disposal

Flammable and Combustible Liquids:

Containers: If applicable, a 5 gallon polypropylene drum. Otherwise, a 4L or smaller glass bottle.

- Before combining different wastes, test a small amount for reactivity. Pour wastes into waste containers slowly in a well vented area, either a fume hood or vented to a fume hood. If waste container becomes warm, wait until cool before recapping. Seal waste container after each addition.
- **Keep halogenated wastes separate from non-halogenated if possible** to reduce the cost of disposal.
- Chemicals which have contained sodium or similar material must be placed in separate containers from solvents which contain water.
- Store waste containers **AWAY** from any sources of ignition. Any fumehood used for storing flammable liquid waste **MUST NOT** be used for any other purpose.
- In the case of **oil** being collected for **recycling**, contact your hazardous waste coordinator for collection of full drums.
- Make sure waste bottles are **properly sealed and clean**. **Label all containers** with a hazardous waste label indicating all chemicals contained, their concentrations and quantities, and the generator's name and phone number.

Ignitable Solids:

Containers: Airtight container or bottle, stored under an inert material (eg. nitrogen or argon) if necessary.

- Fill waste containers in a well vented area, i.e. fume hood or vented to fume hood, to prevent any potentially ignitable dusts from collecting in the room.
- Store waste containers **AWAY** from any ignition sources.
- Make sure waste bottles are **properly sealed and clean**. Label all containers with a hazardous waste label indicating all chemicals contained, their quantities, and the generator's name and phone number.

Solvents

Many solvents are flammable or combustible liquids and should be handled as such. However, some have additional hazardous characteristics. Benzene and many halogenated hydrocarbons are known or suspected carcinogens and should be considered **chronically toxic**. Ethers are peroxide formers and should be considered **potentially explosive** (Section 5.3). General guidelines for solvents are provided here but other sections should also be consulted when appropriate.

Storage: Solvents should be stored as flammable or combustible liquids. Additional precautions may be required in some cases (eg. ethers).

Handling: In general, solvents should be handled as flammable or combustible liquids. Avoid exposure to the liquids and their vapours. Avoid skin contact (absorption may cause dryness and cracking of the skin, opening the way to infection and allergic responses). Additional precautions may be required in some cases (eg. ethers).

Disposal: Solvents should be disposed of as flammable or combustible liquids (Section 5.1).

Fuels and Oils

Storage and Handling: Fuels are considered flammable liquids and should be stored and handled as flammable liquids. Oils are typically less volatile and are considered combustible liquids.

Disposal: Waste fuels and oils should be stored in either 5-gallon polypropylene drums or 45-gallon drums, depending on volumes generated. Waste fuels should be transferred to the waste container in a well vented area or a fume hood. **Do not overfill the drum** (approximately 80% full). Once transfer is complete, reseal the drum/container. In the case of oil being collected for **recycling**, contact your hazardous waste coordinator for collection of full drums. **Keep a record of all fuels in the waste drum.** Label the waste containers with the University of Ottawa hazardous waste label.

5.2 Corrosive Chemicals

Definition

Substances that, by direct chemical action, are injurious to body tissue or corrosive to metal. Corrosive injury may range from minor (irritation) to actual physical disruption of body tissues.

Examples

Acids, bases, bromine, peroxides, acetic anhydride, etc.

Personal Protective Equipment

- Lab coat, safety glasses, appropriate gloves and footwear, appropriate respirator if required.

Storage

- **Acids and bases MUST NOT be stored together** in the same cabinet or on the same shelf.
- Store in acid resistant cabinets or on polyethylene trays if possible.
- Use vented storage areas if possible.
- **NEVER store on shelves higher than waist level. Store away from high traffic areas.**
- Corrosive compressed gases must be stored in a well vented area.

Handling

- **Refer to Material Safety Data Sheets (MSDS) prior to using product.**
- **DO NOT attempt to add water to a highly concentrated acid, since this will result in a violent exothermic reaction and may cause serious injury.**
- Keep corrosives away from heat sources as much as possible to avoid production of fumes. Avoid direct contact with fumes.

Disposal

Containers: **Acid solutions** must be stored in glass bottles (except **hydrofluoric acid**, which must be stored in PVC bottles). **Solid acids** may be stored in appropriate plastic containers.

Base solutions must be stored in glass bottles. **Solid bases** may be combined with other chemically compatible bases or inorganic alkaline chemicals.

- Corrosive solutions and solids waste containers must be stored in an acid storage cabinet.
- **NEVER combine waste bases with waste acids.** Use separate waste containers.
- Before combining different waste acids or bases, test a small amount for reactivity. Pour wastes into waste containers slowly in a well vented area, either a fume hood or vented to a fume hood. If waste container becomes warm, wait until cool before recapping. Seal waste container after each addition.
- Make sure waste bottles are **properly sealed and clean. Label all containers** with a hazardous waste label indicating all chemicals contained, their concentrations and quantities, and the generator's name and phone number.

5.3 Reactive Chemicals

Definition

Reactive chemicals are substances which enter into **violent reactions** during which the spontaneous liberation of heat and/or gases is too rapid to be safely dissipated by the surroundings. Thus, the reaction is

out of control and either the vessel bursts, an explosion occurs, toxic vapours are uncontrollably liberated, flammable gas is evolved or spontaneous ignition occurs.

Reactive chemicals may be grouped in five broad categories:

- Explosives (generally shock sensitive and/or heat sensitive materials)
- Water reactives
- Air reactives
- Oxidizers and reducers
- Peroxide formers

Personal Protective Equipment

- Lab coat, safety glasses, appropriate gloves and footwear.

Storage - General

- **DO NOT** store large quantities of these chemicals in your work area.
- Completely **isolate** these chemicals from any sources of heat or moisture.
- Clearly label the area where reactive chemicals are stored.

Handling - General

- **EXERCISE EXTREME CAUTION WHEN HANDLING THESE MATERIALS.**
- **In case reactive or explosive chemicals are spilled and/or being evaporated into the atmosphere, DO NOT switch any electrical equipment on or off.**
- **Refer to Material Safety Data Sheets (MSDS) and to the Hazardous Material Handling Guide prior to using product.**

Visual Signs of Instability.

The first signs of chemical aging, peroxide formation or chemical instability are usually visual. To make an early diagnosis and prevent an explosion and potential serious injury, please refer to the following list of visible signs:

- **Discolouration of the liquid/solution.** Check the MSDS for the original colour.
- **Formation of crystals inside the solution,** often an indication of peroxide formation.
- **Formation of crystals around the cap of the bottle** is usually a sign of advanced peroxide formation and **should NOT be tampered with! Call EHSS for immediate removal.**
- Some materials are wetted for safe handling and storage (i.e. picric acid) and should appear paste-like. Once these materials dry out, they become extremely shock-sensitive and explosive.

Disposal - General

Containers: Appropriately-sized glass chemical bottle. Exercise caution if employing a used chemical bottle for reactive waste - confirm that the original contents are compatible with the waste.

- Disposal of reactive chemicals should be handled only by staff knowledgeable in the procedures required.
- **DO NOT** combine reactive chemical wastes with other wastes.
- Label all waste containers with a list of all chemicals contained, their concentrations and quantities, and the generator's name and phone number.

Explosives (Shock Sensitive / Heat Sensitive Materials)

Definition: Chemicals readily sensitive to friction, shock, or sudden heating, or which can become shock-sensitive when allowed to dry out (eg. picric acid).

Examples: Certain azides, diazo compounds, n-nitro compounds, picrates (especially metal salts), polynitroalkyl compounds, polynitroaromatic compounds, etc.

Procurement: Buy compounds in the smallest size available and only when absolutely necessary. **DATE all chemicals when first delivered AND opened.**

Storage: **Protect from shock, elevated temperature, light, ignition sources and other reactive chemicals.** Store all explosive compounds in areas isolated from high-traffic areas and AWAY from other

combustible materials. Use a flammable storage cabinet. Clearly label the area where explosives are stored.

Handling: Check containers regularly for crystallization of liquids (eg. peroxide formation in ethers), or discolouration of liquid or solid, or drying out. Whenever possible, use the chemicals with added inhibitors.

Disposal: Contact your hazardous waste coordinator or EHSS for safe waste disposal procedures.

Water Reactives

Examples: Alkali metals (sodium), organometallic compounds, halides, hydrides, peroxides, carbides, oxides, phosphides, anhydrides, etc.

Storage: Store in a cool, water-proof area. They should be properly desiccated whenever possible. **DO NOT** store water reactive materials under the sink. Isolate from other reactive materials. Clearly label the area where water reactives are stored.

Handling: **Protect water reactive chemicals from exposure to moisture or accidental contact with water.** When working with water reactives, always have **on hand** a "D" class fire extinguisher.

Disposal: As per general disposal guidelines for reactive chemical waste.

Air Reactives

Examples: Metallic dusts (eg. nickel, titanium, zinc), alkali metals (potassium), hydrides, etc.

Storage: Metallic dusts such as nickel and titanium should normally be stored in containers with some moisture. Other solids should be stored under an inert gas or liquid. Isolate from oxidizing agents. Clearly label the area where air reactives are stored.

Handling: Minimize exposure to air. When working with air reactives, always have **on hand** a "D" class fire extinguisher.

Disposal: As per general disposal guidelines for reactive chemical waste.

Oxidizers and Reducers

Examples: A list of oxidizing and reducing agents is provided in Appendix C. Perchloric acid is particularly hazardous and is described separately.

Storage: **DO NOT store oxidizers and reducers together.** Use separate storage cabinets or shelves. **Isolate oxidizers and reducers from other potentially reactive materials. DO NOT store oxidizers with flammable liquids.**

Handling: **Many oxidizers and reducers are also explosive, water reactive or air reactive - take the appropriate precautions.** Minimize the possibility of large quantities of oxidizers and reducers coming in contact with one another.

Disposal: **DO NOT** put oxidizers and reducers in the same waste container. Otherwise, as per general disposal guidelines for reactive chemical waste.

Perchloric Acid

Definition: At standard temperatures, 73% perchloric acid solution reacts as a strong non-oxidizing acid, is relatively stable, may be stored for extended periods in glass bottles, with **no contact** with oxidizable material. At high temperatures (~160°C), it becomes a strong and active oxidizing agent and a strong dehydrating reagent (anhydrous perchloric acid). Contact with organic matter or other combustible material may cause **fire or explosion**.

Examples of chemicals INCOMPATIBLE with perchloric acid: Plastics (acrylonitrile, nylon, polyester-Dacron, cellulose based lacquers); Metals (copper, copper alloys, perchlorate salts, aluminum, high nickel alloys); Others (cotton, wool, wood, glycerin-lead oxide)

Procurement: Buy anhydrous perchloric acid (>85%) in the smallest size available. **Never store anhydrous perchloric acid for more than 30 days. Date all chemicals when they are first delivered and opened.**

Storage: Store in flammable storage cabinet, **away from organic materials. Do not allow perchloric acid to come into contact with strong dehydrating agents** (concentrated sulphuric acid, anhydrous phosphorous pentoxide) or organic materials. Check containers regularly for formation of crystals around the cap, or discolouration of the clear white solution (yellow discolouration indicates expiry). Any discolouration of the anhydrous acid requires its **immediate disposal. If discolouration or crystal**

formation is noted, do not move bottle or attempt to remove the cap. Contact your hazardous waste coordinator or EHSS for instructions on disposal procedures.

Handling: A face shield and fume hood **MUST** be used. Clearly identify any fumehoods used for perchloric acid work - perchloric acid vapours tend to condense on the insides of fumehoods and the inner lining of ducts, eventually forming perchlorate crystals which are shock-sensitive explosives.

Perchloric acid (73% or less): Keep the quantities handled to a bare minimum. In wet combustion, treat the sample with nitric acid to destroy easily oxidizable matter.

Anhydrous perchloric acid (>85%): **A second person must be informed of the intended use of anhydrous perchloric acid and be in the same room with research worker during the experiment.** A lab coat, safety glasses, thick gauntlets and rubber apron must be worn. **Only freshly prepared acid must be used.** Do not make any more anhydrous perchloric acid than is required for a single day's work.

Disposal:

Perchloric acid (73% or less): Dispose of according to the general disposal guidelines for reactive wastes. **DO NOT** combine with any other types of waste. Contact your hazardous waste coordinator for waste removal.

Anhydrous perchloric acid (>85%): At the end of each day, dispose of any unused anhydrous perchloric acid by dilution and neutralization. Contact your hazardous waste coordinator or EHSS for instructions on disposal procedures.

Peroxide Formers

Definition: Common laboratory chemicals can form peroxides when exposed to air over a period of time. Peroxides can be **treacherously and violently explosive** in concentrated solution or as solids. There are **maximum storage times** depending on the group of chemicals.

Examples of peroxide-forming chemicals, including maximum storage times:

Discard after 3 months: isopropyl ether, divinylacetylene, potassium metal, potassium amide, sodium amide, vinylidene chloride (dichloroethylene).

Discard or test after 6 months: acetaldehyde diethyl acetal, *chloroprene, cumene, cyclohexene, cyclopentene, ether, diethylene glycol dimethyl ether, dioxane, furan, methylacetylene, *styrene, tetrahydrofuran, *vinyl acetate, vinyl ethers, *vinylpyridine.

Discard after 12 months: *butadiene, *tetrafluoroethylene, *vinyl chloride.

(*These monomers **MUST** be stored with a suitable polymerization inhibitor)

Procurement: Buy ethers and other peroxidizable compounds in the smallest size possible to limit amounts exposed to air. **DATE all chemicals when they are opened.**

Storage: Store in air-tight, amber glass bottles, in a dark location and under inert atmosphere if possible. **TEST** all ethers and peroxidizable compounds for peroxide concentration at regular intervals (see the Hazardous Material Handling Guide for procedures or contact EHSS). If peroxide concentrations are acceptable, re-date the container and retest at the next scheduled test date. **If the peroxide concentrations are not acceptable, or if crystals have formed in the bottle or around the cap, do not move the bottle or attempt to remove the cap.** Contact your hazardous waste coordinator or EHSS for instructions on disposal.

Disposal: Methods for removing peroxides from peroxide formers may be found in the *CRC Handbook of Laboratory Safety* (1990) or by contacting EHSS. **If the peroxide concentrations are too high, or if crystals have formed in the bottle or around the cap, do not move the bottle or attempt to remove the cap.** Contact your hazardous waste coordinator or EHSS for instructions on disposal procedures.

5.4 Highly Toxic Materials

Definition

Substances which, when ingested, inhaled or absorbed in relatively small amounts, may cause damage to bodily structure or function. There are many such substances, of both biological and chemical origin. A few examples include arsenic trioxide, cyanides, nickel carbonyl, phosgene, tetrodotoxin, etc. This list is by no means comprehensive.

Personal Protective Equipment

- Lab-coat, safety glasses, appropriate gloves and appropriate breathing apparatus.

Storage

- Highly toxic, carcinogenic or mutagenic materials **MUST BE LOCKED** in a specific storage area (eg. cabinet or cupboard) with access limited only to authorized personnel.

Handling

- **Refer to Material Safety Data Sheets (MSDS) prior to using product.**
- Use only in a well vented area.

Disposal

- Most toxic chemical waste may be disposed of according to the general guidelines for hazardous waste.
- Most highly toxic wastes (eg. cyanides) should be put in separate, appropriately sized waste containers. However, some may be combined with other chemical wastes if compatible. Contact your hazardous waste coordinator or the Environmental Health and Safety Service if unsure how to contain your toxic wastes.
- Waste containers with particularly toxic contents should include the warning "TOXIC" on the label to minimize the hazard for waste handling personnel.
- Make sure waste bottles are **properly sealed and clean**. **Label all containers** with a hazardous waste label indicating all chemicals contained, their concentrations and quantities, and the generator's name and phone number.

5.5 Biohazards

Biohazards is a generic term used to describe all bacteria, viruses, fungi or other infectious agents. These agents are designated according to risk to the individual and community. To ensure maximum safety to both parties, the Medical Research Council of Canada has created guidelines which address these concerns. As well, before commencing new experiments involving biohazardous agents, the researcher **MUST** obtain the approval of the University of Ottawa Biohazards Committee. To determine the required level of containment, decontamination procedures, training and any other special procedures required for the nature of the work being performed, **CONTACT** either the Biohazards Committee or the Radiation/Biosafety Office.

Personal Protection Required

- Lab-coat, safety glasses, disposable gloves and appropriate footwear.
- Appropriate immunizations when required.

Safety Precautions

- **Smoking, eating, drinking and storage of food or tobacco is prohibited in all areas where biohazards are stored or handled.**
- Protective clothing must be worn by all personnel.
- Long hair must be tied back or otherwise restrained.
- Wash hands frequently.
- **WHENEVER EXITING LABORATORY**, remove protective clothing and wash hands.
- Procedures should minimize the creation of aerosols.
- **NEVER pipette by mouth.**
- **Needles MUST NOT be bent or recapped.**
- Follow recommended procedures for decontamination of work surfaces and equipment.

Disposal

- **DO NOT PACKAGE BIOMEDICAL WASTES WITH OTHER TYPES OF WASTES.** Use appropriate storage bags to differentiate hazards.
- **DO NOT OVERFILL** bags or containers.

- For further information contact the Radiation/Biosafety Office.
- Disposal procedures for specific categories of biohazards are as follows:

Human anatomical waste:

Human tissues, organs, body parts; does not include teeth, hair, nails.

- Human anatomical waste must be stored in the **RED plastic bags**. These bags should be refrigerated at 4°C or kept frozen until biomedical wastes collection.

Animal waste:

Animal tissues, organs, body parts, carcasses, bedding, blood and other fluids.

- Animal waste must be stored in the **ORANGE plastic bags** and stored at 4°C until collection. The bags must be tagged with the University of Ottawa **YELLOW necropsy label**.
- Non-infected animal waste should be stored in black plastic bags and stored at 4°C.
- Bedding material may be stored in black plastic bags for regular garbage disposal.

Non-anatomical waste:

Human and animal cultures, stocks, blood, blood-contaminated materials. Excludes urine and faeces.

- Non-anatomical waste must be stored in **YELLOW plastic bags or leak-resistant YELLOW containers**. These bags may be kept in the laboratory for a maximum of 4 days, after which they must be refrigerated to 4°C or lower. Human blood or blood contaminated materials should be stored at 4°C or lower.

Sharps waste:

Sharps including needles, scalpels, contaminated glass or other materials that may puncture the skin.

- Waste biomedical sharps must be stored in a **YELLOW puncture and leak-proof waste sharps container**. This container must be labelled with the biohazard symbol. Sharps containers with liquid or blood/fluid products must be refrigerated.

5.6 Radioactive Materials

The procurement, use and disposal of radioactive material is controlled by the Canadian Nuclear Safety Commission. This federal agency ensures control through numerous regulations and by conditions appended to the Consolidated Radioisotope Licence issued to the University of Ottawa. In turn, the university ensures compliance with these regulations and conditions through the Radiation Safety Committee and the radiation safety program administered by the Radiation/Biosafety Office. No one is permitted possession or use of radioactive material unless approved by the Radiation Safety Committee.

Definition

Radioactive materials found at the University of Ottawa generally fall into two categories:

1. Sealed sources: Radioactive materials that are encapsulated within devices (liquid scintillation counters) or within another material that prevents direct contact or dispersal of radioactive material.
2. Open sources: Radioactive materials in a form that permits direct contact. Common forms of open source radioactive material include:
 - Aqueous radioactive materials
 - Solid radioactive materials (powders or contaminated materials such as pipette tips, Pasteur pipettes, test tubes, petri dishes, gloves, syringes)
 - Liquid scintillation cocktails containing dissolved radioactive material

General Rules

- Comply with the *Canadian Nuclear Safety Commission* and the conditions of radioisotope permits.
- Radioactive material must be strictly controlled and tracked as to its possession, use and disposal.
- Use time, distance and shielding to keep radiation exposure as low as reasonably achievable.
- Keep laboratory locked when unattended.
- Keep unauthorized persons out of laboratory.

Personal Protective Equipment Required

- You **must** wear a lab-coat, safety glasses, and disposable gloves.
- You **MUST** wear a dosimeter if it is required by the permit.

Storage

- Mark waste containers and storage facilities for radioactive materials with a radiation warning symbol.
- Store radioactive materials in a secure area.
- Ensure adequate shielding is in place.

Safety Precautions

- **DO NOT work with radioactive materials if you have open cuts or abrasions.**
- **On a regular basis (AT LEAST WEEKLY), MONITOR, and if necessary, decontaminate equipment, trays, floor and working surfaces. All loose contamination should be removed. Keep a record of the measurements.**
- Use disposable absorbent liners on trays or other work surfaces.
- Anticipate and prepare for an accident.
- Wash hands before leaving the laboratory.
- Laboratory equipment used for radioactive work must not be used for other purposes.
- Use a fumehood for any work with dry powder or volatile substances.
- **DO NOT** eat, drink, store food or smoke in areas where radioactive materials are used.
- **DO NOT** pipette radioactive solutions by mouth.

Disposal

The Canadian Nuclear Safety Commission strictly regulates all radioactive waste, as to the quantities of waste disposed of in any waste streams. These disposal requirements are reviewed every two years and are revised to reflect both national and international standards. Strict training, documenting and reporting requirements are also mandatory for disposal of this classification of waste. Due to the complexity and the scope of these requirements, waste disposal of aqueous, solid and liquid scintillation waste will not be outlined in this document. For further information, please contact the Radiation/Biosafety Office.

5.7 Cryogenic Materials**Definition**

Cryogenic materials are primarily characterized by extremely low temperatures; cryogenic liquids typically have boiling points between -100°C and -270°C . Consequently, they must be liquified under high pressure. These conditions create certain hazards:

- Their cold boil-off vapour **rapidly freezes human tissue**. Cold burns and frostbite caused by cryogenic liquids can result in **extensive tissue damage**.
- Materials such as carbon steel, plastics, and rubber become brittle or even fracture under stress at these temperatures. Proper material selection is important.
- Their low temperatures can condense contaminants from the atmosphere. Liquid nitrogen can condense oxygen from the surrounding atmosphere, creating an explosive mixture if any organic material is also condensed. Liquid hydrogen can do the same, forming an explosive hydrogen-oxygen solid. All cryogenics can condense sufficient moisture from the air to block the opening in storage vessels, creating a dangerous pressure build-up.
- All cryogenic liquids produce large volumes of gas when they vaporize. For example, liquid nitrogen will expand 696 times as it vaporizes. If these liquids vaporize in a sealed container, they can produce **enormous pressures** which could rupture the vessel. For this reason, pressurized cryogenic containers are usually protected with multiple pressure relief devices, usually a pressure relief valve and a frangible disc.
- Vaporization of cryogenic liquids (except oxygen) in an enclosed area (eg. elevators) can cause **asphyxiation**. Vaporization of liquid oxygen can produce an oxygen-rich atmosphere which will **support and accelerate the combustion of other materials**. Vaporization of liquid hydrogen can form an **extremely flammable mixture with air**.

Personal Protective Equipment

- Protect skin from contact. Wear lab-coat, safety glasses, face shield, and loose-fitting, dry leather gloves.

Storage

- Store and use in well ventilated areas.
- Store in well insulated container designed to minimize loss of product from boil-off (eg. Dewar flask).

Handling

- Metallic objects such as watches, rings, bracelets or other jewellery should not be worn.
- Use only materials capable of withstanding extreme cold without becoming brittle (metallic containers).
- Perform the following tasks **SLOWLY** to minimize boiling and splashing: charging or filling a warm container with cryogenic liquid; inserting objects into a cryogenic liquid.
- Use tongs to withdraw objects immersed in a cryogenic liquid.
- **NEVER** touch uninsulated pipes or vessels containing cryogenic liquids.

Disposal

- Most cryogenic materials will evaporate. For any further assistance, contact your hazardous waste coordinator or supervisor.

5.8 Compressed Gases**Procurement**

- It is recommended that gas cylinders be purchased from suppliers with a take-back policy. Cylinders from other companies, i.e. Sigma and Aldrich, must be disposed as hazardous wastes.

Storage and Set Up*General:*

- All gas cylinders, full or empty, must be properly secured at all times. Always store gas cylinders in the **upright** position.
- The valve protection cap must always be attached when a cylinder is not connected to a regulator.

While in Use:

- Use only in well ventilated areas. **DO NOT** vent through window.
- **Toxic, flammable and corrosive gases MUST** be dispensed in a properly functioning exhaust system.
- **Flammable gas cylinders, lines and equipment** must be bonded and grounded.
- **DO NOT** connect full and empty cylinders together in line. Serious suck-back can occur when an empty cylinder is attached to a pressurized system.
- **Never tamper with safety devices in valves or cylinders.** Do not use adaptors or Teflon tape to attach regulators to gas cylinders. Do not lubricate the high pressure side of a regulator.

Handling*Transportation:*

- Move cylinders only with an approved cylinder cart.
- **DO NOT** move cylinder without the protective cap.
- Never attempt to lift or move cylinder by holding onto the collar at the top of the cylinder. The collar is not welded onto the cylinder and may dislodge.
- **DO NOT** allow a cylinder to drop and avoid violent collisions with other objects.

While in Use:

- **NEVER** use a cylinder that is not properly identified.
- **NEVER** subject any part of a compressed gas cylinder to high temperatures or flames.
- **When discharging gas into a liquid**, a trap or suitable check valve must be used to prevent liquid from re-entering the cylinder or regulator.
- **NEVER** direct high pressure gas at a person.
- *Flammable gas cylinders:* Avoid running flammable gas lines near heat sources or open flame. **NEVER use an oxygen regulator on a flammable gas cylinder or vice versa. DO NOT extinguish a flame involving highly combustible gas until the source of gas has been shut off, otherwise it can reignite causing an explosion.**

Disposal

- Return cylinders which are of no further use promptly to the supplier even if only partially used.
- When returning empty cylinders close the valve before shipment; leave some positive pressure in the cylinder (approximately 10% of original capacity is recommended).
- Replace any valve outlet and protective caps originally shipped with cylinder.
- Contact your hazardous waste coordinator for cylinder removal.

5.9 Additional Hazardous Materials Requiring Special Disposal**Sharps****Definition:**

- i) Needles, needles attached to syringes, scalpels blades, other types blades such as razor blades, precision knives.
- ii) Glass or other materials capable of causing punctures or cuts and which has come into contact with human or animal blood or body fluid.

Disposal:

- Waste sharps **MUST** be stored in the designated **yellow puncture and leak-proof waste sharps containers**. These containers are available from Faculty Stores.
- **DO NOT** attempt two-handed recapping of needles.
- **DO NOT** bend or cut needles to save space (cutting may produce dangerous aerosols).
- **DO NOT** overfill the waste containers (fill to a maximum of 75% full).
- Sharps containers with liquid or blood/fluid products must be refrigerated.
- Once the container is suitably full, secure the lid and attach an appropriate label indicating name of contact, telephone number and source location. Containers of biohazardous sharps must also be labelled with the biohazard symbol.
- Contact your hazardous waste coordinator to arrange for sharps container removal.

Metals

- **Metals are not to be disposed of to the sewer.**
- Check for complete oxidation before preparing the material for disposal. If only surface oxidation has occurred, the metal might still be salvageable. **IF NOT**, prepare a waste container for waste metals, labelled with hazardous waste stickers.
- Most metals may be stored in glass or plastic bottles, in a regular storage cabinet or on storage shelves.
- **Finely divided metals such as zinc, barium or magnesium can be highly pyrophoric and should be stored under nitrogen or an inert gas and in a flammable storage cabinet.**
- Use same container for all compatible waste metals. Once full, seal container and list the contents on the hazardous waste label.
- Contact your hazardous waste coordinator for removal.

Photographic Chemicals

- Photographic waste including all fixers and developers used to process photographic film, Xray film, autoradiography film and prints are recyclable. For more information, contact EHSS.
- **Photographic waste is classified as corrosive waste** and must therefore be stored according to the corrosive waste guidelines (Section 5.2).
- **Do NOT mix fixers and developers.**
- Pour photographic waste into 5-gallon drum slowly and if possible in a well vented area or fume hood. If waste bottle is warm or even hot, wait until cool before recapping.
- Once waste bottle is full, make sure it is properly sealed and labelled.
- **Store corrosive materials on the lowest shelf.**

Batteries

- **Waste batteries are considered a toxic metal waste** and therefore should not be disposed to the landfill. Batteries are recyclable. For more information on recycling, contact your hazardous waste coordinator or Physical Resources Service.

- Gloves should be worn if the batteries outer casings are damaged and/or leaking.
- Once the life of the batteries has expired, place old batteries in recycling receptacles. Check for the receptacle nearest to your location.
- **Lithium batteries are considered to be reactive waste (water reactive)** and therefore should be stored separate from regular household batteries or mercury and cadmium batteries.
- Batteries with live ends should be taped to prevent accidental contact in the recycling receptacle.

APPENDIX A Safety Services

A1-Protection Services

Protection Services provides the university community a number of services. These include: a fire prevention coordinator, foot patrol, first aid and an after-hours call in system. Further information is available by contacting EXT.5942.

Emergency Response Teams

The Emergency Response Teams (ERT) are available to the university community to provide immediate assistance in the event of an emergency. Separate teams exist for the main campus and for Roger Guindon Hall. The Emergency Response Teams consist of volunteers who have developed the organization in conjunction with personnel from Protection Services. Members of the teams have been trained for various levels of emergency response and are equipped to handle most emergency situations. In addition, the ERT provides assessment assistance (eg. mercury spill procedures) and if available, may loan specialized equipment to the university community where required. **In emergency situations, dial Emergency EXT. 5411 to activate the team.** For assessment assistance or non-emergency situations/information, consult your immediate supervisor or the building administrator for the appropriate extension to contact an ERT member.

Fire Prevention Coordinator

The Fire Prevention Coordinator is provided as a service under Protection Services. The mandate of the fire prevention coordinator is to oversee the execution of regular fire drills, the installation, maintenance and inspection of fire extinguishers and the investigation of incidents involving fires. In addition, the fire prevention coordinator inspects buildings and provides recommendations with regards to fire safety. Any questions concerning fire safety should be directed to this office at EXT.5747.

A2-Environmental Health and Safety Service

The Environmental Health and Safety Service (EXT.5892) provides technical support to the University community so that activities may be carried out in a sound environmental manner. Its mandate includes the development, coordination and implementation of University-wide environmental management policies, procedures, plans and programs encompassing hazardous substances, biosafety and radioactive materials.

In addition, it provides specialized services such as coordinating the disposal of biohazardous, chemical and radioactive materials, providing information and training, conducting assessments and inspections.

The Radiation/Biosafety Office administers the Consolidated Radioisotope Licence issued to the University by the Canadian Nuclear Safety Commission. It also ensures that all regulations and conditions of that licence are complied with. All users of radioactive material must therefore be registered with this office and be operating under an authorized permit. This office also ensures that work with biohazardous agents is conducted in compliance with the Medical Research Council Guidelines, and that reasonable care is used in the conduct of activities.

A3-Human Resources Service

Services provided through the Human Resources Service include: staffing, training and development, workshop registration, information systems, and occupational health, disability and leave. Any queries should be addressed to EXT.5832.

Occupational Health, Disability and Leave Office

Formerly known as the Occupational Health and Safety Service, the Occupational Health, Disability and Leave Office is made up of a manager, who is an occupational health nurse, a safety officer, and two leave administrators. A physician provides consulting services on a part time basis, for matters requiring medical expertise concerning work related issues or concerns.

The mandate of the Occupational Health, Disability and Leave office is to ensure and promote safe and healthy working conditions for all employees at the University. The service is primarily preventative rather than curative and it is designed to supplement rather than replace medical services available to employees through their personal physician and community clinics such as the one on campus. The office also promotes and monitors compliance with the requirements of provincial legislation on matters pertaining to occupational health and safety and workers' compensation.

In order to achieve this and as required under the Occupational Health and Safety Act, the University of Ottawa has established a Joint Health and Safety Committee that consists of six component committees: the University Health and Safety Committee (UHSC) and five Sectoral Health and Safety Committees (Science and Engineering, Protection and Physical Resources, Smyth Road, Central and Northern). The UHSC is predominantly concerned with University wide issues, with emphasis on policy, recommendations, and activities which concern several SHSCs. The individual sectoral committees are predominantly concerned with local issues.

Employees who have questions or concerns related to their work environment, may contact the occupational health manager at 562-5800 extension 1472, or the Occupational Health and Safety Officer at extension 3052. In cases of emergency, work incidents or injury, the safety officer can be reached by pager at 760-9796.

A4-Physical Resources Service

The primary mandate of Physical Resources is to maintain the buildings and grounds of the University. Examples of maintenance's principal functions include: heating, ventilation and air-conditioning; electricity and plumbing; campus roads; traffic signs; housekeeping; maintenance of grounds (icy conditions); transportation; testing of the emergency showers on a bi-annual basis; and, maintenance of temporary buildings.

Physical Resources also coordinates non-hazardous waste collection and recycling and implements the University's energy conservation program.

Physical Resources Service provides assistance in the event of maintenance emergencies. All maintenance emergencies should be directed to 562-5800, EXT.2222, 24 hours a day, 7 days a week. A maintenance emergency refers to situations where the condition of buildings, grounds and vehicles can affect the safety of users, or can create a dangerous situation (eg. ventilation failures).

A5-Health Services

Health Services is open to all. It is a University based clinic prioritizing the needs of students. Some of its services are exclusive to students and funded by the University through students' fees. Medical services are provided to students, staff and the community. Physicians include family practitioners, and specialists in Gynaecology, Obstetrics, Dermatology, and Psychiatry.

Additionally, the service staffs Health Educators and provides Health Promotion.

A6-Committees

In addition to the services listed above, there are several relevant committees within the University of Ottawa. These are:

- University Occupational Health and Safety Committee;
- Sectoral Occupational Health and Safety Committees;
- Biohazards Committee;
- Radiation Safety Committee;
- Management Committee on the Environment; and,
- Committee on Health, Safety and the Environment.

For information on the University or Sectoral Occupational Health and Safety Committees, contact either your local health and safety representative, the occupational health manager at EXT.1472, or the Occupational Health and Safety Officer at EXT.3052. Information on the Biohazards Committee or the Radiation Safety Committee may be obtained from the Radiation/Biosafety Office, EXT.5892. Contact the Environmental Health and Safety Service, EXT.5892 for information on the Management Committee on the Environment or the Committee on Health, Safety and the Environment.

Joint Occupational Health and Safety Committee

The Joint Health and Safety Committee is an advisory group of worker and management representatives. At the University of Ottawa there are 6 committees. On each committee, at least half of the representatives must represent "workers" (see Occupational Health and Safety Act S.8.5). The committee has the following rights and responsibilities:

- Conduct monthly inspections to identify workplace hazards;
- Obtain information from the employer on Health and Safety matters;
- Make recommendations to the employer on Health and Safety matters;
- Investigate work refusals in accordance with the Act;
- Investigate serious accidents in accordance with the Act;
- Obtain information from the Workers Compensation Board; and,
- Review annually WHMIS training programs.

For a complete explanation of the function and role of the committee, see *A Guide for Joint Health and Safety Committees and Representatives in the Workplace* published by the Ontario Ministry of Labour.

Management Committee on the Environment

The mandate of this committee includes:

- To provide a forum where environmental issues can be discussed and addressed by managers having a direct line responsibility for such issues.
- To ensure that all managers having direct line responsibility for environmental issues are fully apprised of new or pending legislation and their impact on the University.
- To review the adequacy of administrative processes in place to ensure that the University is in compliance with all legal and other applicable regulations.
- To review summary reports from audits dealing with specific environmental issues and the plan of action arising from the recommendations made in such reports. Provide comments and advice to the Administrative Committee with regards to the adequacy of the plan of action.
- To advise the Administrative Committee on issues requiring executive management decisions or action.
- To ensure that proper communication and training programs are in place to familiarize and train the professorate, support staff and students with proper procedures, their obligations and responsibilities, if

- any, and the disciplinary measures applicable for non-compliance.
- To develop and modify where necessary the administrative processes to adapt to new regulations and to correct any weaknesses.

Committee on Health, Safety and the Environment

The mandate of this committee includes:

- To approve, review and modify, as required, a comprehensive University policy on environmental issues. This policy would include matters of the environment, and health and safety issues.
- To ensure that administrative processes exist and are adequate to ensure that the University is complying with all applicable regulations on environmental protection and that the physical state of the workplace and of the learning environment at the University of Ottawa meets applicable standards.
- To obtain and review regular reports from the Management Committee on the Environment dealing with the state of the environment and of health and safety at the University to ensure that the University addresses all known conditions quickly and effectively.
- To request and receive reports dealing with specific issues of interest or of concern to the Committee.
- To receive from the Advisory Committee on the Environment reports addressing the University community's concerns about the environment and containing their recommendations for a proactive role in this area.
- To report to the Board of Governors on the management of the environmental, health and safety issues which should be of direct concern to Board members in light of their legal responsibilities.
- To ensure that proper procedures exist to document problems, to record policy or procedural directions, to record the assignment of responsibility for solving those problems, and to record the interim or final solution.

APPENDIX B

Workplace Hazardous Materials Information System (WHMIS)

In Ontario, WHMIS applies to all workplaces as defined in the *Occupational Health & Safety Act*. It is implemented by provincial and federal legislation and is designed to provide employers and employees with information regarding hazardous materials in the workplace.

There are three ways in which information on hazardous materials is to be provided. These are:

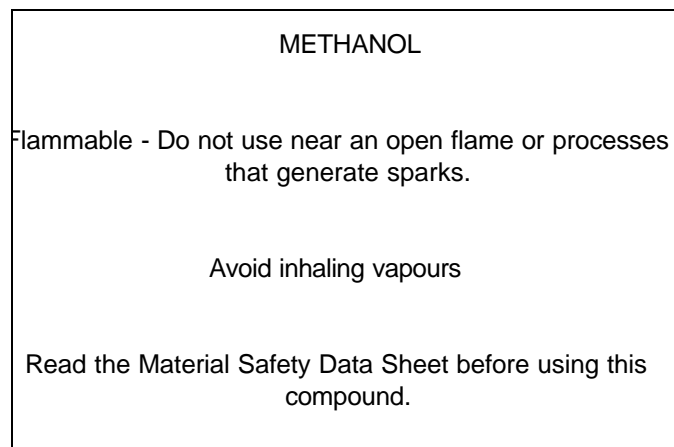
- Labels on the containers of hazardous materials;
- Material Safety Data Sheets (MSDS) to supplement the label information; and,
- Worker education programs.

Labels

Suppliers of hazardous materials (or controlled products as defined in existing legislation) are required to label their products according to a specified format. However, in some cases, the user will be required to create a workplace label. A workplace label is a label developed in-house and contains the following information:

- Identity of the product;
- Information on the safe handling of the product; and,
- Reference to the MSDS.

The workplace label does not require nor restrict a hatched WHMIS border. Additional information such as a broken border, hazard symbols, risk phrases and protective equipment symbols may optionally appear on the workplace label, but are not required. An example of a workplace label is provided below.



If a controlled product is decanted into another container for use in the workplace (i.e. preparing standard solutions for future use) the container must be labelled with the name of the product, safe handling information and an MSDS statement. The labelling requirements do not apply if:

- the controlled product is used immediately (no label required); or,
- the controlled product is decanted and used by a single worker only during the shift of the day it was filled (contents of the container must be identified though no other labelling is required).

You may find that a number of controlled products from outside of Canada are not furnished with the full WHMIS supplier label, although the intent of the label may be the same. Sigma - Aldrich, for example supplies the University with controlled products yet the label may not have a WHMIS border and no reference to an MSDS. The exclusion of a reference to an MSDS on the Sigma - Aldrich label requires the University to provide a supplementary workplace label to overcome any deficiencies from the original label.

Material Safety Data Sheets (MSDS)

An MSDS is a technical bulletin or document that summarizes the health and safety information on a controlled product: providing a list of all the hazardous ingredients, information on safe storage, handling and use, information on protective measures and emergency procedures for workers.

Many chemicals and products are purchased from outside of Canada and may be accompanied with an MSDS which does not comply with Canadian WHMIS standards. Some MSDSs may come without a preparation date, therefore include a date on the MSDS for your own records. This is relevant as the MSDS are required to be updated every three years. The waste disposal procedures indicated on an MSDS from outside the country may be appropriate for that country yet not for Canada or Ontario. For example, if an MSDS from the United States indicates that you may dispose of a material to the sewer, prior to discharging the material, check with your hazardous waste coordinator or the Environmental Health and Safety Service for clarification.

In some cases you may need to prepare a workplace MSDS for products produced in the laboratory on a regular basis and which are stored for long periods. In such instances prepare an MSDS with as much information as is known on the product. For further information contact the Environmental Health and Safety Service.

Worker Education Programs

WHMIS requires training to be provided to those who work with or are potentially exposed to controlled products. **Training is mandatory for all laboratory personnel.** It includes an explanation of the legal requirements as well as specific instructions on the safe handling of controlled products, and the procedures for dealing with accidents involving controlled products. For further information on the WHMIS courses offered by the University, contact the Environmental Health and Safety Service.

This appendix is designed to provide basic information on WHMIS. For more comprehensive information refer to *WHMIS University of Ottawa Training Manual For Laboratory Staff* and/or *Workplace Hazardous Materials Information System (WHMIS): A Guide to the Legislation* prepared by the Ministry of Labour, Occupational Health and Safety Division.

In addition, supervisors and principal investigators are required to provide specific training, such as proper and safe use of equipment and handling of specific chemicals, to workers using facilities they are in charge of.

APPENDIX C

Incompatible Hazardous Materials Families

The term "incompatible chemicals" refers to chemicals that can react with each other:

- violently;
- with evolution of substantial heat;
- to produce flammable products; or,
- to produce toxic products.

Table C1 contains general classes of incompatible chemicals. These examples are illustrative of common laboratory chemicals. **They are not intended to be exhaustive.**

TABLE C1 - General Classes of Incompatible Chemicals
(Chemicals from Column A must not be combined with chemicals from Column B)

A	B
ACIDS	METALS, BASES
Oxidizing Agents	Reducing Agents
Chlorates	Ammonia
Chromates	Carbon
Chromium Trioxide	Metals
Dichromates	Metal Hydrides
Halogens	Nitrites
Halogenating Agents	Organic Compounds
Hydrogen Peroxide	Phosphorus
Nitric Acid	Silicon
Nitrates	Sulphur
Perchlorates	
Peroxides	
Permanganates	
Persulfates, Metals	

Table C2 provides a more complete list of specific compounds that can pose reactivity hazards. **The chemicals in the left-hand column should be transported, stored, used and disposed of in such manner that they DO NOT accidentally come into contact with the corresponding chemicals in the right-hand column.**

TABLE C2 - INCOMPATIBLE FAMILIES

This chemical:	Is INCOMPATIBLE with:
Acetic Acid	Chromic acid, nitric acid, hydroxyl compounds, ethylene glycol, perchloric acid, peroxides, permanganates
Acetone	Concentrated nitric and sulfuric acid mixtures, chlorinated solvent/alkali mixtures
Acetylene and monosubstituted acetylenes	Chlorine, bromine, copper, fluorine, silver, mercury
Alkali, alkaline earth metals such as powdered	Water, carbon tetrachloride or other chlorinated hydrocarbons, carbon dioxide, halogens

aluminium, magnesium,
calcium, lithium, sodium
and potassium

Aluminium and its alloys
(particularly powders)

Acid or alkaline solutions, ammonium persulphate and water, chlorinated compounds, nitrates, and organic compounds in nitrate/nitrite salt baths.

Ammonia (anhydrous)

Mercury (in manometers, for example), chlorine, calcium hypochlorite, iodine, bromine, hydrofluoric acid (anhydrous)

Ammonium nitrate

Acids, powdered metals, flammable liquids, chlorates, nitrites, sulphur, finely divided organic or combustible materials

Aniline

Nitric acid, hydrogen peroxide

Arsenical materials

Any reducing agent

Azides

Acids

Barium peroxide

Combustible organics, oxidizable materials, and water

Barium rhodanide

Sodium nitrate

Bismuth and its alloys

Perchloric acid

Bromine

Ammonia, acetylene, butadiene, butane, methane, propane (or other petroleum gases), hydrogen, sodium carbide, benzene, finely divided metals, turpentine

Calcium or sodium
carbide

Moisture (in air) or water

Calcium oxide

Water

Carbon (activated)

Calcium hypochlorite, all oxidizing agents

Carbon tetrachloride

Sodium

Chlorates or perchlorates

Ammonium salts, acids, powdered metals, sulfur, finely divided organic or combustible materials

Chlorine

Acetone, acetylene, ammonia, benzene, butadiene butane and other petroleum gases, hydrogen, metal powders, sodium carbide, and turpentine

Chlorine dioxide

Ammonia, hydrogen sulphide, methane, and phosphine

Chloroform

Strong bases, ketones and strong base, alkaline metals, aluminium, strong oxidizers

Chromic acid and
chromium trioxide

Acetic acid, naphthalene, camphor, glycerol, alcohol, flammable liquids in general

Copper

Acetylene, hydrogen peroxide

Cumene hydroperoxide

Acids (organic or inorganic)

Cyanides	Acids or alkalies
Flammable Liquids	Ammonium nitrate, chromic acid, hydrogen peroxide, halogens
Fluorine	Most materials
Hydrazine	Hydrogen peroxide, nitric acid, or any other oxidant
Hydrocarbons such as benzene, butane, gasoline, propane, etc.	Fluorine, chlorine, bromine, chromic acid, sodium peroxide
Hydrocyanic acid	Nitric acid, alkali
Hydrofluoric acid or anhydrous hydrogen fluoride	Ammonia (aqueous or anhydrous)
Hydrogen peroxide 3%	Chromium, copper, iron, most metals or their salts
Hydrogen peroxide 30% to 90%	Chromium, copper, iron, most metals or their salts, aniline, any flammable liquid, combustible materials, nitromethane, and all other organic matter.
Hydrogen sulphide	Fuming nitric acid, oxidizing gases
Hypochlorites	Acids, activated carbon
Iodine	Acetylene, ammonia (aqueous or anhydrous), hydrogen
Lithium	Acids, moisture in air, and water
Lithium aluminium hydride	Air, chlorinated hydrocarbons, carbon dioxide, ethyl acetate, and water
Mercuric Oxide	Sulphur
Mercury	Acetylene, alkali metals, ammonia, nitric acid with ethanol, fulminic acid, and oxalic acid
Nitrates	Sulphuric acid
Nitric acid (concentrated)	Acetic acid, aniline, chromic acid, hydrocyanic acid, hydrogen sulphide, flammable liquids, flammable gases, copper, brass, any heavy metals
Nitrites	Acids, potassium or sodium cyanide
Nitroparaffins	Inorganic bases, amines
Oxalic acid	Silver, mercury
Oxygen (liquid or enriched air)	Flammable gases, liquids, or solids such as acetone, acetylene, grease, hydrogen, oils, and phosphorus
Perchloric acid	Acetic anhydride, bismuth and its alloys, alcohol, paper, wood, grease, oils, and reducing agents

Peroxides (organic)	Acids (organic or mineral), avoid friction, store cold
Phosphorus (white)	Chlorates and perchlorates, nitrates and nitric acid
Phosphorous pentoxide	Organic compounds or water
Phosphorous (red)	Oxidizing materials
Phosphorous (white)	Air (oxygen) or other oxidizing material
Picric acid	Ammonia heated with oxides, or salts of heavy metals and friction with oxidizing agents, or friction associated with picric acid crystals
Potassium	Air (moisture and/or oxygen), carbon tetrachloride, carbon dioxide, water
Potassium chlorate or perchlorate	Acids and their vapours, combustible materials, especially organic solvents, phosphorus, and sulphur
Potassium permanganate	Glycerol, ethylene glycol, benzaldehyde, glycerine, and sulphuric acid
Selenides	Reducing agents
Silver	Acetylene, oxalic acid, tartaric acid, ammonium compounds, fulminic acid, nitric acid with ethanol
Sodium	As for potassium
Sodium amide	Air (moisture and oxygen) or water
Sodium chlorate	Acids, ammonium salts, oxidizable materials and sulphur
Sodium hydrosulfite	Air (moisture) or combustible materials
Sodium nitrite	Ammonia compounds, ammonium nitrate, or other ammonium salts
Sodium peroxide	Ethyl or methyl alcohol, glacial acetic acid, acetic anhydride, benzaldehyde, carbon disulfide, glycerin, ethylene glycol, ethyl acetate, methyl acetate, furfural
Sulphides	Acids
Sulphur	Any oxidizing materials
Sulphuric acid	Chlorates, perchlorates, permanganates (compounds of light metals, such as sodium, lithium, and potassium)
Tellurides	Reducing agents
Water	Acetyl chloride, alkaline and alkaline earth metals, their hydrides and oxides, barium peroxide, carbides, chromic acid, phosphorous pentoxide, phosphorous oxychloride, phosphorous pentachloride, sulphuric acid and sulphur trioxide
Zinc Chlorate	Acids or organic materials

Zinc (particularly powder)

Acids or water

Zirconium (particularly powder form)

Carbon tetrachloride and other halogenated hydrocarbons, in peroxides, sodium bicarbonate, and water

APPENDIX D
Chemical Resistance Ratings of Common Glove Materials

(E=Excellent, G=Good, F=Fair, P=Poor)

Chemical	Natural Rubber	Neoprene	Nitrile	Vinyl
Acetaldehyde	G	G	E	G
Acetic acid	E	E	E	E
Acetone	G	G	G	F
Acrylonitrile	P	G	--	F
Ammonium hydroxide (sat.)	G	E	E	E
Aniline	F	G	E	G
Benzaldehyde	F	F	E	G
Benzene ^a	P	F	G	F
Benzyl chloride ^a	F	P	G	P
Bromine	G	G	--	G
Butane	P	E	--	P
Butyraldehyde	P	G	--	G
Calcium hypochlorite	P	G	G	G
Carbon disulfide	P	P	G	F
Carbon tetrachloride ^a	P	F	G	F
Chlorine	G	G	--	G
Chloroacetone	F	E	--	P
Chloroform ^a	P	F	G	P
Chromic acid	P	F	F	E
Cyclohexane	F	E	--	P
Dibenzyl ether	F	G	--	P
Dibutyl phthalate	F	G	--	P
Diethanolamine	F	E	--	E
Diethyl ether	F	G	E	P
Dimethyl sulfoxide ^b	--	--	--	--
Ethyl acetate	F	G	G	F
Ethylene dichloride ^a	P	F	G	P
Ethylene glycol	G	G	E	E
Ethylene trichloride ^a	P	P	--	P
Fluorine	G	G	--	G
Formaldehyde	G	E	E	E
Formic acid	G	E	E	E
Glycerol	G	G	E	E
Hexane	P	E	--	P
Hydrobromic acid (40%)	G	E	--	E
Hydrochloric acid (conc.)	G	G	G	E
Hydrofluoric acid (30%)	G	G	G	E
Hydrogen peroxide	G	G	G	E
Iodine	G	G	--	G
Methylamine	G	G	E	E
Methyl cellosolve	F	E	--	P
Methyl chloride ^a	P	E	--	P
Methyl ethyl ketone	F	G	G	P
Methylene chloride ^a	F	F	G	F
Monoethanolamine	F	E	--	E
Morpholine	F	E	--	E
Napthalene ^a	G	G	E	G
Nitric acid (conc.)	P	P	P	G
Perchloric acid	F	G	F	E
Phenol	G	E	--	E
Phosphoric acid	G	E	--	E
Potassium hydroxide (sat.)	G	G	G	E
Propylene dichloride ^a	P	F	--	P
Sodium hydroxide	G	G	G	E
Sodium hypochlorite	G	P	F	G
Sulphuric acid (conc.)	G	G	F	G
Toluene ^a	P	F	G	F
Trichloroethylene ^a	P	F	G	F
Tricresyl phosphate	P	F	--	F
Triethanolamine	F	E	E	E
Trinitrotoluene	P	E	--	P

^a Aromatic and halogenated hydrocarbons will attack all types of natural and synthetic glove materials. Should swelling occur, the user should change to fresh gloves and allow the swollen gloves to dry and return to normal.

^b No data on the resistance to dimethyl sulfoxide of natural rubber, neoprene, nitrile rubber or vinyl materials are available; the

manufacturer of the substance recommends the use of butyl rubber gloves.

Source: National Research Council, *Prudent Practices for Handling Hazardous Chemicals in Laboratories*, National Academy Press, Washington, D.C., 1981, pp. 159-160.

APPENDIX E Bibliography

A Practical Introduction to Environmental Management on Canadian Campuses. D. Thompson and S.A. Babel. National Round Table Series on Sustainable Development, 1995.

CRC Handbook of Laboratory Safety. N.V. Steer, ed., Second Edition. CRC Press Inc., 1979.

Electrical Safety Code. 20th Edition. Ontario Hydro, 1990.

First Aid, Safety Oriented. Third Edition. St. John Ambulance, 1990.

First Aid. 18th Edition. The Canadian Red Cross Society, 1988.

Hazardous Chemicals, A Manual for Schools and Colleges. Oliver and Boyd. Scottish Schools Science Equipment Research Centre, 1980.

Hazardous Chemical Safety. J.T. Baker Chemical Co., 1981.

Industrial Gases Fact Book and Safe Practices Guide. Air Products and Chemicals Inc., 1992.

Laboratory Safety Handbook. First Edition. McMaster University, 1992.

Laboratory Safety Manual. Second Edition. McGill University, 1991.

NFPA 30: Flammable and Combustible Liquids Code. National Fire Protection Association, 1990.

NFPA 45: Fire Protection for Laboratories Using Chemicals. National Fire Protection Association, 1986.

Picket Ontario OH&S Act and Regulations (General Edition). L. Blake, ed. Carswell Thomson Professional Publishing, 1994.

Prudent Practices for Handling Hazardous Chemicals in Laboratories. National Research Council. National Academy Press, 1981.

Safety in Academic Chemistry Laboratories. Fifth edition. American Chemical Committee on Chemical Safety, 1990.

Safety in Academic Chemistry Laboratories. American Chemical Society, Committee on Chemical Safety, March 1974.

Safety in Biological Laboratories. E. Hartree and V. Booth, eds. Biochemical Society Special Publication No. 5, 1977.

University of Ottawa Guide to Handling, Storage and Disposal of Hazardous Wastes. Environmental Health and Safety Service.

WHMIS: University of Ottawa Training Manual for Laboratory Staff. Environmental Health and Safety Service.

Workplace Hazardous Materials Information System (WHMIS): A Guide to the Legislation. Ontario Ministry of Labour, Occupational Health and Safety Division, May 1989.

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