UNIVERSITY of GUELPH

CHANGING LIVES IMPROVING LIFE

ENVIRONMENTAL HEALTH & SAFETY

Chemical Safety Handbook

2008 Edition

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1. Introduction

The health, safety and well-being of the university community and the protection of the environment are of utmost importance to the University. Through various functions, University of Guelph personnel are responsible for the handling, use and storage of potentially hazardous chemical products. In order to address the health, safety and environmental challenges specific to the usage of hazardous chemicals outside of laboratory environments, this handbook, and the encompassing guidelines and procedures, have been developed.

This handbook is to provide supplemental information to the University of Guelph and departmental health and safety policies as well as define minimum standards for safe practices at the University. Workers involved in laboratory work should refer to the Laboratory Safety Manual for more detailed direction on chemical safety in the laboratory.

Our goal is a safe and healthy environment for faculty, staff, students and visitors.

2. Definitions

EHS – Environmental Health and Safety.

OHS – Occupational Health Services.

Supervisor – a person who has charge of a workplace or authority over a worker. (Ontario OH&S Act Section 1(1))

3. Workplace Hazardous Materials Information System

The Workplace Hazardous Materials Information System (WHMIS) is a legislated program that is applicable to all University of Guelph employees and students who work in areas where hazardous materials are used. The purpose of this legislation is to ensure that everyone in a workplace is provided with the information needed to identify hazardous materials and to take the appropriate precautions when working with these materials. WHMIS accomplishes this through the use of warning labels, Material Safety Data Sheets (MSDSs) and training on how to use the information provided.

3.1 Labels

The label is the primary source of hazard information. The requirements for label content are dependent upon whether the container is from a supplier or a workplace, and whether the hazardous material is a laboratory product, a sample for analysis or neither.

3.1.1 Supplier Labels

A supplier label is required for containers containing 100 mL or more of the material. Supplier labels must contain the following information in both English and French and be enclosed by a distinctive border coloured to contrast with the background of the label:

- Product identifier or name
- Supplier identifier (supplier's name)
- Reference to the MSDS
- Hazard symbol(s)
- Risk phrase(s) (description of the main hazards of the product)
- Precautionary measures
- First aid measures

Supplier labels for materials sold in a container with less than 100 mL do not require risk phrases, precautionary measures or first aid measures to be included.

3.1.2 Workplace Labels

A workplace label must contain the following information:

- Product identifier or name
- Precautionary measures
- Reference to the MSDS

3.2 Material Safety Data Sheets

MSDSs (Material Safety Data Sheets) provide detailed information about physical, chemical and toxicological properties and hazards, as well as recommended handling and emergency procedures. MSDSs must be reviewed and/or revised by the supplier at least every three years. Unexpired MSDSs are to be readily available for all controlled products on site. Up-to-date, electronic MSDSs are available via the EHS website. Supervisors are to ensure that personnel have access to MSDSs for all hazardous materials they may use or contact. Personnel are strongly encouraged to regularly review MSDSs for all hazardous materials being used.

3.3 Training

Training is required to provide detailed instruction on the site specific procedures necessary to carry out work safely, as well as provide the basis for accurate interpretation of the hazard information provided on labels and MSDSs.

3.4 Understanding hazard warning information

3.4.1 WHMIS Symbols

The classes of controlled chemical products and their corresponding symbols or pictograms, as well as general characteristics and handling precautions are outlined in Table 1.

3.4.2 Toxicological properties: LD_{50} AND LC_{50}

Exposure to hazardous materials can occur by:

- absorption;
- ingestion;
- inhalation; or
- injection.

LD_{50} and LC_{50} values are commonly used measurements for the toxicity of a substance.

LD_{50} (Lethal Dose 50) is the amount of a substance that, when administered by a defined route of entry (e.g. oral or dermal) over a specified period of time, is expected to cause the death of 50% of a population. The LD_{50} is usually expressed as weight of test substance per kilogram of body weight (mg/kg or g/kg).

LC_{50} (Lethal Concentration 50) is the concentration of a substance in air or water (depending on the test population) that, when administered by inhalation over a specified period of time, is expected to cause the death in 50% of a population. The LC_{50} is usually expressed as parts of test substance per million parts of air/water (ppm) for gases and vapours, or as milligrams per litre or cubic metre of air (mg/L or mg/m3) for dusts, mists and fumes.

Note that the lower the LD_{50} or LC_{50}, the more toxic the material. For example sodium chloride (table salt) has an LD_{50} (oral, rat) of 3000 mg/kg and sodium cyanide has an LD_{50} (oral, rat) of 6.4 mg/kg.

Table 1 – Summary of WHMIS classes, their associated characteristics and proper handling and storage procedures.

	Class A - Compressed Gas	Contents under high pressure. Cylinder may explode or burst when heated, dropped or damaged.
	Class B - Flammable and Combustible Material	May catch fire when exposed to heat, spark or flame. May burst into flames.
	Class C - Oxidizing Material	May cause fire or explosion when in contact with wood, fuels or other combustible material.
	Class D, Division 1 Poisonous and Infectious Material: Immediate and serious toxic effects	Poisonous substance. A single exposure may be fatal or cause serious or permanent damage to health.
	Class D, Division 2 Poisonous and Infectious Material: Other toxic effects	Poisonous substance. May cause irritation. Repeated exposure may cause cancer, birth defects, or other permanent damage.
	Class D, Division 3 Poisonous and Infectious Material: Biohazardous infectious materials	May cause disease or serious illness. Drastic exposures may result in death.
	Class E - Corrosive Material	Can cause burns to eyes, skin or respiratory system.
	Class F - Dangerously Reactive Material	May react violently causing explosion, fire or release of toxic gases, when exposed to light, heat, vibration or extreme temperatures

http://www.ccohs.ca/oshanswers/legisl/whmis_classifi.htmL, November 2005

3.4.3 Exposure values (TWAEV, STEV, CEV)

An exposure limit is the concentration of a substance below which no adverse effects would be expected. Exposure values can be expressed as the following:

- TWAEV (8-hour Time-Weighted Average Exposure Value): average concentration to which most workers can be exposed during an 8-hour workday, day after day, without adverse effects
- STEV (Short-Term Exposure Value): maximum average concentration to which most workers can be exposed over a 15 minute period, day after day, without adverse effects
- CEV (Ceiling Exposure Value): the concentration that must never be exceeded (applies to many chemicals with acute toxic effects)

3.4.4 Flash point

Flash point is the lowest temperature at which a substance produces enough vapour to ignite in the presence of an ignition source. The lower the flash point of a substance, the greater the fire hazard. Liquids such as acetone and gasoline have flash points that are below room temperature.

3.4.5 Autoignition temperature

Autoignition temperature is the temperature at which a material will ignite, in the absence of an ignition source. The lower the autoignition temperature of a substance, the greater the fire hazard.

3.4.6 Flammable limits

Flammable or explosive limits are the range of concentrations of a material in air that will burn or explode in the presence of an ignition source. Explosive limits are usually expressed as the percent by volume of the material in air:

LEL (lower explosive limit) or LFL (lower flammable limit): lowest vapour concentration that will explode or burn if ignited. Below this limit the concentration of fuel is too "lean" for ignition, i.e., the mixture is oxygen rich but contains insufficient fuel.

UEL (upper explosive limit) or UFL (upper flammable limit): highest vapour concentration that will explode or ignite. Above this limit, the mixture is too "rich" for ignition.

The flammable range consists of concentrations between the LEL and the UEL.

Table 2 – Flash points, lower explosive limits, autoignition temperatures and exposure limits of several flammable and combustible materials.

Solvent	Flash Point * (°C)	LEL * (% by volume)	Autoignition temp** (°C)	TWAEV * (ppm)
acetone	-18	2.5	465	250
diesel	54	0.7	254	100
gasoline	-45	1.4	Not available	300
toluene	4.4	1.1	422	100
Varsol	60	0.6	227	300

TWAEV – 8-Hour Time Weighted Average Exposure Value
LEL – Lower Explosive Limit
*NIOSH Pocket Guide to Chemical Hazards, NIOSH publication number 2005-151 or if unavailable corresponding MSDS
** Corresponding MSDS

4. General Chemical Safety

4.1 Good Work Practices/General Safety

Know and understand the hazards, safe handling and operating procedures of the materials being used. Review MSDS's and standard operating procedures as applicable.

- Ensure hazardous materials are labelled according to all applicable legislation (e.g. WHMIS, the Pesticides Act, and/or the Explosives Act).
- Report missing labels to supervisors. Never use substances of unknown identity.
- Never "sniff-test" a chemical.
- Report accidents and near misses promptly to your supervisor.

4.2 Food storage and consumption

Storage and consumption of food and/or drink (including water) in areas where hazardous substances are exposed is prohibited.

4.3 Smoking

As per Policy 851.03.07, smoking is strictly prohibited in all University buildings including in or near all chemical or waste storage areas. Tobacco products are not to be brought into the areas where hazardous substances are exposed.

4.4 Personal Hygiene

To prevent unforeseen accidents or exposures, the following points are to be followed when working with hazardous materials:

- Tie back or otherwise secure long hair.
- Avoid touching your face or hair while wearing gloves.
- Wash hands thoroughly after removal of gloves and/or after working with hazardous materials.
- Wear closed-toed, closed-heeled shoes.

5. Personal Protective Equipment

Personal protective equipment (PPE) is to be used according to the hazards presented by the specific material being used as determined by the supervisor. Personal protective equipment is not to be used in place of engineering controls but is to be used diligently to provide supplemental protection.

The following sections provide minimum standards for personal protective equipment.

5.1 Eye and face protection

This section is to be used in conjunction with Policy 851.05.03. Canadian Standards Association (CSA) approved eye protection is to be worn by students, employees and visitors in all areas where hazardous or unknown substances are being stored, used or handled, where there is a risk of splash, projectiles or air borne particles and/or where there is harmful radiant energy.

- Minimum eye protection when working with hazardous materials consists of approved safety glasses with permanent side shields. Safety glasses are designed to protect against impact and do not provide significant splash protection. Therefore safety glasses should only be worn in cases of light work not involving significant volumes of liquids.
- Goggles are to be worn when there is a risk of splashing a hazardous material. Indirect vented goggles are preferred.

- Eye protection is to provide adequate impact and splash resistance appropriate for the work being done.
- Ultraviolet (UV) protective eyewear is required where there is risk of exposure to UV light.
- Face shields are to be used if an explosion or significant splash hazard exists such that there is a need to provide further protection to the face.
- Face shields are to be used in conjunction with primary eye protection (safety glasses or goggles depending on the hazard).
- Full size shields that can be placed directly in front of the hazard may also be used to provide additional protection to the entire body. These too, are only to be used in conjunction with goggles, protective clothing, etc.

While wearing contact lenses is not prohibited when working with hazardous materials, an assessment of the specific circumstance or environment is to be made to decide whether or not wearing contact lenses presents a hazard to the worker and therefore if it should be prohibited. Contact lenses themselves do not provide eye protection. Further information regarding the wearing of contact lenses in situations involving hazardous materials may be found at the following websites.

Canadian Centre for Occupation Health and Safety – OSH Answers:
http://www.ccohs.ca/oshanswers/prevention/contact_len.html

CDC-NIOSH – Contact Lens Use in a Chemical Environment:
http://www.cdc.gov/niosh/docs/2005-139/

5.2 Hand protection

5.2.1 Selection of Gloves for Work with Chemicals

No one glove material is appropriate for protection against all potential chemical hazards as the permeation rate (rate at which the chemical seeps through the glove material) of the different glove types varies significantly with the chemical in question. Consultation of the MSDS along with consideration of the usage will provide guidance in determining an appropriate glove. Table 3 provides some basic information about selecting gloves suitable for various chemical applications.

The following links provide more detailed information regarding the proper selection of glove materials based on what specific chemical(s) are being handled.

- Ansell Chemical Resistance Guide:
  http://www.ansellpro.com/download/Ansell_7thEditionChemicalResistanceGuide.pdf
- Best Manufacturing Company's Chemrest:
  http://www.chemrest.com/

- Oklahoma State University's Chemical Guide: http://www.pp.okstate.edu/ehs/hazmat/gloves5.htm

Table 3 – Characteristics, Advantages, Disadvantages and Uses of Selective Chemical Resistant Glove Materials.

TYPE	ADVANTAGES	DISADVANTAGES	FOR USE WITH:
Natural rubber latex	Low cost, good physical properties, dexterity	Poor against oils, greases, organic solvents. May cause allergic reactions.	Bases, acids, alcohols, dilute aqueous solutions. Fair vs. aldehydes, ketones.
Natural rubber blends	Low cost, dexterity, generally better chemical resistance than natural rubber.	Physical properties often inferior to natural rubber. May cause allergic reaction.	Bases, acids, alcohols, dilute aqueous solutions. Fair vs. aldehydes, ketones.
Polyvinyl chloride (PVC)	Low cost, very good physical properties, average chemical resistance.	Plasticizers can be stripped.	Strong acids and bases, salts, aqueous solutions, alcohols, oils, greases and petroleum products.
Neoprene	Average cost, average chemical resistance, average physical properties, high tensile strength, high heat resistance.	Poor vs. chlorinated hydrocarbons	Oxidizing acids, alcohols, anilines, phenol, glycol ethers, solvents, oils, mild corrosives
Nitrile	Low cost, excellent physical properties, dexterity	Poor vs. chlorinated organic solvents, many ketones	Oils, greases, aliphatic hydrocarbons, xylene, perchloroethylene, trichloroethane. Fair vs. toluene.
Butyl	Good resistance to polar organics, high resistance to gas and water vapour	Expensive, poor vs. hydrocarbons, chlorinated solvents	Glycol ethers, ketones, esters, aldehydes, polar organic solvents
Polyvinyl alcohol (PVA)	Resists broad range of organics, good physical properties.	Very expensive. Water sensitive, poor vs. light alcohols, acids and bases.	Aliphatic and aromatic hydrocarbons, chlorinated solvents, ketones (except acetone), esters, ethers
Fluro-elastomer (Viton®)	Good resistance to organic and aromatic solvents. Flexible.	Extremely expensive. Poor physical properties. Poor vs. some ketones, esters, amines	Aromatics and aliphatic hydrocarbons, chlorinated solvents, oils, lubricants, mineral acids, alcohols.
Norfoil, Silver Shield™, 4H™	Excellent chemical resistance.	Poor fit, stiff, easily punctures, poor grip.	Use for Hazmat work. Good for range of solvents, acids and bases.

Modified table taken from: http://www.ecu.edu/oehs/LabSafety/GloveMaterialsChart.htm, November 15, 2005

5.2.2 Use and Care of Gloves

The following guidelines should be considered when using gloves:

- Gloves should be inspected for damage prior to use. Any sign of deterioration, such as holes, tears or discoloration, should prompt immediate replacement of the gloves.
- Gloves should be of an appropriate fit and thickness to allow for the required tactile sensitivity.
- Gloves should be an appropriate length so as to provide adequate protection of the arm.
- Gloves should be removed by pulling the gloves inside out to prevent any exposure during removal.
- Gloves are to be removed prior to touching computers or phones, opening doors or otherwise contacting items that would be expected to be free of contamination.
- Wash hands thoroughly after removal of gloves.
- Never reuse disposable gloves.
- Reusable gloves should be stored and maintained in such a way as to prevent exposure (e.g. in a Ziploc bag) and should be stored within the work area. Manufacturer's instructions are to be followed as applicable.

5.3 Body Protection – Protective clothing

The use of protective clothing is to be carefully considered whenever hazardous chemicals are being used or handled. Selection of the protective clothing is to be based on an assessment of the hazards being encountered giving careful consideration to both the volume and the toxicity of materials. Protective clothing could include lab coats, sleeve protectors, shirts, pants, jackets, coveralls or full body suits. The level of protection provided by various types of protective clothing may range from protection against minor splashes or contamination of street clothes (e.g. lab coat) to the provision of an effective physical barrier to the chemical in question (e.g. Hazmat suit).

Protective clothing is to be stored outside of office areas or other locations where food and/or drink is permitted. Shorts are not suitable attire when working with hazardous chemicals. Protective clothing is to be cleaned or replaced regularly and is to be laundered separately from all other clothing.

Aprons should be worn as additional protection in situations where there is an elevated splash hazard. Synthetic rubber aprons should be worn when working with large volumes (i.e. greater than four litres) of concentrated inorganic acids e.g. hydrochloric and sulphuric acids. The use of aprons alone is discouraged as they provide inadequate protection of the arms.

5.4 Respiratory Protection

See Policy 851.05.06. The use of a respirator should only be considered when permanent engineering controls are inadequate or non-functional e.g. emergency spill situations. Users must be registered in the University of Guelph Respirator program and appropriately trained and fitted prior to using a respirator. Fit-testing is required for all respirators and is provided by EHS. Contact the Occupational Hygiene Safety Officer at x54855 for more information.

6. Emergency Procedures

Each chemical storage room is to have a completed hazard and emergency contact sign (seen in Figure A) posted on the outside of the storage room door. Supervisors are responsible for ensuring these signs are generated using an online application accessible at the following location at http://www.uoguelph.ca/ehs/hazmat%20signage/index.html.

Figure A – Hazard and emergency contact sign

Date (dd/mmm/yyyy)	xx / xxx / xxxx	Department	xxxxxx
Building Name	xxxxxx	Department Chair	xxxxxx
Building Number	xxxxxx	College	xxxxxx
Room Number	xxxxxxx	Dean of College	xxxxxx

EMERGENCY CONTACT INFORMATION

Supervisor	xxxxxx	Alt. Supervisor (if applicable)	xxxxxx
Phone Extension	xxxxxx	Phone Extension	xxxxxx
Alternate Number (if applicable)	xxxxxx	Alternate Number (if applicable)	xxxxxxx

After hours, contact Campus Police at Ext. 2000

Laboratory Personnel	xxxx	Laboratory Personnel	xxxx
	xxxx		xxxx
	xxxx		xxxx
	xxxx		xxxx

Location of Material Safety Data Sheets xxxxxxxx
(Electronic or Physical Location)

6.1 Equipment

Supervisors are responsible for ensuring that all individuals are familiar with the use and locations of the following equipment in all areas in which they will be working:

- Fire extinguisher
- Eye wash station
- Safety shower
- Evacuation alarm
- Emergency routes and exits
- First aid kits
- Spill kits

6.2 Chemical Related Emergency Procedures

6.2.1 Chemical Contact

For skin contact:

- For a small, easily accessible area of the skin, e.g. the hand
  - Proceed to the nearest sink.
  - Remove contaminated clothing and jewellery.
  - Rinse for at least 15 minutes.

- For a large or inaccessible area of skin
  - Remove contaminated clothing and jewellery
  - Go to the nearest emergency shower.
  - Rinse for at least 15 minutes.
  - Seek medical attention if required. Provide applicable MSDS to medical personnel.

For contact with the eyes:

- Go to the nearest eyewash station.
- Rinse for at least 15 minutes.
- If wearing contact lenses, remove them as quickly as possible, while continuing to flush.
- Hold your eyelids open with your fingers.
- Roll your eyeballs, so that water can flow over the entire surface of the eye.
- Lift your eyelids frequently to ensure complete flushing.
- Cover the injured eye with dry sterile gauze pads.
- Seek medical attention. Provide applicable MSDS to medical personnel.

OHS is to be contacted at x54283 for follow-up after any chemical exposure.

6.2.2 Poisoning

Over-exposure to toxic substances can occur through inhalation, absorption, ingestion or injection. When assisting a victim of poisoning:

- Call for an ambulance (dial x2000) for serious poisoning.
- Ensure that the area is safe to enter before attempting to aid the victim.
- If safe to do so, move the victim away from the contaminated area and provide first aid as required.
- Contact the Poison Control Centre at 1-800-268-9017 for further instructions.
- Provide emergency medical personnel with the MSDS for the toxic substance.
- Always ensure that the victim receives medical attention, even if the exposure seems minor.

OHS is to be contacted at x54283 for follow-up after any work-related chemical exposure.

6.2.3 Power failure

Any refrigerators or freezers containing flammable materials that require storage below room temperature must:

- Be connected to the back-up power supply.

Or

- Have an alternate refrigerator or freezer identified such that these materials can be transferred for continued safe storage.

Emergency procedures for such refrigerators/freezers should be posted on the refrigerator or freezer itself.

As well, in the event of a power failure, ventilation may be lost or reduced.

6.2.4 Domestic Water Interruption

In the event of a domestic water interruption:

- Notify Physical Resources x53854.
- Stop all work with or near hazardous materials until water is restored. Loss of water translates to inoperable emergency showers, eyewash stations and sinks.

6.2.6 Chemical Spills

It is important that you only respond to spills if you are trained in proper spill response, are comfortable and confident in the proper procedures for cleaning up the spill, can clean-up the spill safely and the spill is considered "incidental".

See section 7 for detailed information on training, spill kits, spill classification, response and reporting requirements.

7. Chemical Spill Prevention and Preparedness

Prevention of chemical spills is the most important step to chemical spill response. However personnel should be aware of spill clean-up procedures and be prepared to respond should a spill occur.

7.1 Training

It is the responsibility of the supervisor to ensure that sufficient personnel are trained in chemical spill response specific to the chemicals contained within their work area. Training should be documented and refreshed on at least an annual basis.

7.2 Spill Kits

Each work area using hazardous chemical materials must have easy access to a chemical spill kit that is prominently located, readily visible and identifiable. Exact contents of a spill kit should be based on the hazardous properties of the materials present. Table 4 lists the recommended minimal requirements for spill kits.

Table 4 – Minimum Requirements for Chemical Spill Kits

Item	Characteristics and/or Recommended Quality
Universal Chemical Absorbent Pads and/or Universal Chemical Absorbent Powder (silica free)	• High absorption capacity • Chemically inert • Good for all chemicals o Acids, including hydrofluoric acid o Bases o Flammable liquids o Formaldehyde o Organic peroxides
Plastic Scoop	• Polypropylene
Large Polyethylene Bags	• Strong composition • Leak proof • To be used as pail liners
Gloves	• Nitrile/Silver shield combination preferred • At least 2 pairs
Chemical Goggles	• Splash resistant • At least 2 pairs
20 L Plastic Pail with Lid	• Labelled as “SPILL KIT” • To contain spill equipment • When emptied to be used as disposal container for contaminated absorbents • Leak proof
Plastic Dust Pan and Broom	• Polypropylene bristles

Other items you may want to add to your chemical spill kit, depending on the hazards present are:

- disposable Tyvek® suits;
- synthetic rubber aprons;
- duct tape;
- pH paper;
- hazardous waste tags; and
- specific neutralization mixtures.

When using acid or base neutralization mixtures, one should be prepared for heat generation and sputtering of the liquid.

Table 5 lists examples of specific neutralization mixtures.

Table 5 – Examples of Neutralization Mixtures Available for Spill Response

Neutralizer Type	Examples
Acid Neutralizers	• Sodium bicarbonate • Neutrasorb (colour change once neutralized) • Spill-X-A • Calcium carbonate (for hydrofluoric acid spills)
Caustic Neutralizers	• Citric acid powder • Neutracit-2 (colour change once neutralized) • Spill-X-C
Solvent Neutralizers (reduce vapours and increase flashpoint)	• Activated charcoal • Solusorb • Spill-X-S • Spilfyter vapour suppressor kit

If mercury or mercury compounds are present (including mercury in thermometers), a mercury spill kit is to be available. Table 6 lists the recommended contents for a mercury spill kit.

Table 6 – Mercury Spill Kit Contents

Item	Characteristics and/or Recommended Quality
Sulphur powder or commercially available mercury amalgamation powder	• Effectively amalgamates mercury and suppresses vapours
Mercury vapour suppression spray	• Prevents further mercury vaporization
Mercury decontamination liquid, wipes or sponges	• For surface decontamination
Aspirator	• Could be a Pasteur pipette and bulb
Disposal container with lid	• Preferably plastic
Mercury indicator powder (optional)	• Indicates presence of mercury • Good for suspected contamination issues and for use after clean-up

It is recommended that an inventory list be included on/in spill kits to allow for easy inspection. Monthly Inspections should be performed and documented e.g. on an inspection tag. Inspections should include verifying contents and ensuring that supplies are unexpired and in good condition.

7.3 Spill Classification

Complex spills –Complex spills are those which involve chemicals or quantities of materials in excess of those outlined in Table 7 and require further assistance for clean-up:

Table 7 – Guidelines for the Classification of a Complex Spill

Material	Quantity
Air and water reactive materials	Any quantity
Flammable liquids	Greater than 4 L
Combustible liquids	Greater than 4 L
Non-flammable organic liquids	Greater than 4 L
Concentrated acids	Liquids greater than 1 L Solids greater than 1 kg
Concentrated bases and alkalis	Liquids greater than 1 L Solids greater than 1 kg
Mercury	Greater than 30 mL
Oxidizers	Liquids greater than 1 L Solids greater than 500 g
Highly toxic, highly malodorous materials (e.g. phenol, mercaptoethanol, hydrofluoric acid)	Liquids greater than 100 mL Solids greater than 50 g
Low hazard material	At the discretion of personnel
Compressed gas leaks	If the leak cannot be stopped by closing the valve on the gas cylinder.

The above table provides guidelines for quantities only. Other considerations for classifying a spill as complex include whether or not respiratory protection is required and whether any personal injuries have been sustained. University personnel should never attempt to clean-up a spill if they have not been trained in the proper chemical spill response or are unsure of the proper procedures.

Incidental Spills – These are minor spills, not meeting the requirements of a complex spill that can be responded to by trained personnel.

7.4 Spill Response

Complex Spill Response:

- Evacuate the room/area, close doors if applicable, restrict the area, and notify others in the area of the spill.
- Call x2000.
- If safe to do so:
    - Attend to injured or contaminated personnel.
    - If a flammable material is involved, turn off ignition sources (i.e. shut off power to area, turn off pilot lights, etc.)
    - Restrict or contain the flow of spilled liquid taking particular care to prevent spilled material from entering storm or sewer drains.
- Activate emergency alarm if there is an immediate risk to the safety of other people in the building.
- Be available to provide technical information to emergency responders e.g. chemical identity, MSDS, identity of other equipment and hazardous materials in the work area.

If it is a complex mercury spill, the fire prevention officers are to be notified. They will respond for clean-up with a mercury vacuum capable of effectively sucking up large mercury droplets. Note that regular vacuum cleaners are not to be used for clean-up of mercury in any situation as they will create harmful mercury vapours.

Incidental Spill Response:

- Attend to injured or contaminated personnel.
- If a flammable material is involved, turn off ignition sources
- Restrict the area and notify others in the area of the spill.
- Select and don all appropriate PPE. It is essential to properly protect yourself.
- Promptly attend to the spill according to Table 8. If unsure of the proper clean-up procedure, contact your supervisor for guidance. EHS is also available to provide guidance at x53282.

Please refer to Policy 851.04.04 for information regarding spills to the environment and corresponding reporting requirements.

Table 8 – Response Procedures for Incidental Chemical Spills

Material	Procedure
Acids, liquid	• If available, neutralize with sodium bicarbonate or commercially available acid neutralizer working from the outside in. • Using scoop, mix thoroughly to ensure neutralization. • pH paper can be used to test completeness of neutralization. Commercial neutralizers often change colour to indicate neutralization. • Add more neutralizer if necessary. • Proceed as per general liquid spill clean-up.
Caustics, liquid	• If available, neutralize with citric acid or commercially available caustic neutralizer, if working from the outside in. • Using scoop, mix thoroughly to ensure neutralization. • pH paper can be used to test completeness of neutralization. Commercial neutralizers often change colour to indicate neutralization. • Add more neutralizer if necessary. • Proceed as per general liquid spill clean-up.
Solvents	• If available, suppress vapours with activated charcoal or commercially available solvent neutralizer working from the outside in. • Using scoop, mix thoroughly. • Proceed as per general liquid spill clean-up.
General liquids	• Encircle with universal chemical absorbent pads, socks or powder. • Cover the spill with universal chemical absorbent pads or powder. • Allow liquid to be absorbed. • Once absorbed, transfer to garbage bags using scoop and/or dust pan if necessary. • Label bag appropriately with hazardous waste disposal tag and complete hazardous waste disposal form.
Mercury	• Contain the spill. • If available, spray mercury suppression spray into immediate air space. • Push all mercury beads together. • Using the aspirator, transfer mercury beads to plastic disposal container. • Label disposal container appropriately with hazardous waste disposal tag and complete hazardous waste disposal form. • Cover spill area with mercury amalgamation powder. • Allow mercury amalgamation powder/mercury spill to solidify (form amalgam). • Use dust pan and broom or scoop to transfer amalgam into disposal container. • Decontaminate area with mercury decontamination liquid, wipes or sponges. • Transfer all wipes, sponges, gloves etc. used in clean-up to plastic bag, label with hazardous waste disposal tag and complete hazardous waste disposal form.
General solids	• If there is concern about harmful dust generation encircle and cover the spill with universal chemical absorbent powder. • Transfer to garbage bags using scoop and/or broom and dust pan. • Label bag with hazardous waste disposal tag and complete hazardous waste disposal form.
Compressed Gas/Cryogenic Liquid Leaks	• Turn off cylinder valve. • If possible transfer cylinder to fume hood. • Check for leaks using a non-reactive detergent solution or commercial leak detection solution. If leak is obvious omit step. • If leak continues, and gas is inert, evacuate the area and surrounding area and treat as a complex spill. If gas is toxic, flammable or corrosive, activate the emergency alarm, evacuate the building and treat as a complex spill. • N.B. Depending on the room size and the amount of gas, an oxygen deficient atmosphere may develop. Take particular care to ensure your safety.

8. Specific Chemical Hazards

All chemicals should be used with the utmost caution according to safe work practices. There are certain chemicals or classes of chemicals, however that require specific handling precautions that are described briefly in the following sections. It is beyond the scope of this handbook to address the hazards and precautions of all of the chemicals that may be found at the University as well as delve into the details of the hazards of the chemicals mentioned. For further information regarding the toxicity, safe handling and use of specific chemicals, the appropriate MSDS or references such as the following should be consulted:

- NIOSH Pocket Guide to Chemical Hazards, February 2004 Publication number 97-140 (http://www.cdc.gov/niosh/npg/npg.htmL)
- Sax's Dangerous Properties of Industrial Materials 10th ed., Richard Lewis. Published by John Wiley and Sons Inc.
- Bretherick's Handbook of Reactive Chemical Hazards 6th ed., Peter Urben, Leslie Bretherick. Published by Butterworth-Heinemann College.

8.1 Flammables

Flammables are those materials that have a flashpoint of less than 37.8°C. See section 10.4 for full definition. Flammable materials present a serious hazard to personnel. Steps are to be taken to ensure appropriate use, handling and storage.

- Ensure containers made of a conductive material are grounded and/or bonded appropriately when transferring liquid from one container to another.
- Ensure that potential ignition sources are identified and removed from the area surrounding the flammable material.

8.2 Oxidizers

Oxidizers are capable of igniting flammable and combustible material even in oxygen-deficient atmospheres as well as increasing the intensity of a fire by adding to the oxygen supply and causing ignition and rapid burning of normally non-flammable materials. Oxidizers can also:

- React with other chemicals, causing a release of toxic gases.
- Decompose and liberate toxic gases when heated.
- Burn or irritate skin, eyes, breathing passages and other tissues.

8.2.1 Solids

Solid oxidizing agents have the ability to form explosive mixtures with common materials such as sugar, charcoal, starch, sawdust and sulphuric acid. Examples of solid oxidizers include metallic:

- chlorates;
- perchlorates; (these are especially dangerous and their use should be avoided.)
- nitrates;
- chromates; and
- permanganates.

8.2.2 Liquids

Liquid oxidizers are often strong acids as well, making them powerful corrosives. Examples include:

- nitric acid;
- chromic acid; and
- sulphuric acid.

Personal protective equipment when working with these compounds should include a face shield, goggles, synthetic rubber apron, lab coat and synthetic rubber gloves.

8.2.3 Use of Oxidizers

When using or storing oxidizers, the following precautions to take include the following:

- Keep away from flammable and combustible materials.
- Keep containers tightly closed unless otherwise indicated by the supplier.
- Store strong oxidizers in inert, unbreakable containers.
- Mix and dilute according to the supplier's instructions.
- Dilute with water to reduce the reactivity of solutions.
- Wear appropriate personal protective equipment.
- Ensure that oxidizers are compatible with other oxidizers in the same storage area.

8.2.4 Peroxygen Compounds

These are chemically unstable compounds including peroxides that can violently react. Some peroxygen compounds decompose slowly at room temperature, but rapidly at elevated temperatures. However, others decompose readily at room temperature and therefore must be

refrigerated. Organic peroxides can violently explode when subjected to heat, friction, shock, spark, oxidizing and reducing agents or light. These compounds are very difficult to control in a fire due to their ability to generate their own oxygen upon combustion. Peroxygen compounds can seriously irritate the skin and eyes upon contact.

Special consideration should be taken when using any compounds that have the capability of forming peroxides. Diethyl ether, tetrahydrofuran (THF) and p-dioxane are examples of compounds that can be expected to form peroxides upon prolonged exposure to light or air. The MSDSs should be consulted to determine whether or not a substance should be expected to form peroxides.

8.2.4.1 Use, Handling and Storage of Peroxygen Compounds

Specific precautions to take when using, handling and storing peroxygen or peroxide-forming compounds include the following:

- Purchase and use only the minimum amount required.
- Mark the receipt date on the container.
- Mark the date the container was opened on the container.
- Dilute solutions with inert solvents such as aliphatic hydrocarbons. Avoid the use of aromatic solvents, such as toluene, which can initiate the decomposition of some peroxides.
- Avoid preparing peroxide solutions with volatile solvents as losses of solvent due to evaporation can cause unwanted concentration of peroxides.
- Dispense quantities as required. Do not return unused materials to stock container.
- Do not use metal spatulas.
- Do not use glass containers with ground glass or metal lids. Use polyethylene containers with screw cap lids.
- Store and use away from heat, ignition sources and light.
- Store at the lowest temperature that is above the freezing point of the solution and that will not affect the solubility of solution. This will minimize the rate of decomposition of the peroxides.
- Dispose after one month of the container being opened or if unopened, by the expiry date.
- Treat any visible solids around the cap or in the container of peroxygen or peroxide-forming liquids with extreme caution as they could be explosive.
- Ensure that solutions are free of peroxides before concentration.
- If concentration is necessary, avoid evaporating to dryness.
- Use a shield when evaporating or distilling any peroxide-forming compounds.

8.2.4.2 Testing for Peroxides

Commercially available peroxide test strips can be purchased from laboratory supply companies. These allow a simple and quick determination of whether peroxides are present in a solution.

8.3 Corrosives

Corrosive chemicals are commonly found as solids, liquids and gases. These materials have the ability to damage tissue at the site of contact.

8.3.1 Corrosive Liquids

Corrosive liquids can be particularly hazardous as they act rapidly upon contact. Examples of common corrosive liquids are:

- strong acids (chromic acid, hydrochloric acid, nitric acid, etc.);
- strong bases (aqueous sodium hydroxide, potassium hydroxide, ammonia, etc.);
- strong dehydrating agents (phosphorus pentoxide, calcium oxide, etc.); and
- strong oxidizing agents (peroxides, etc.).

8.3.2 Corrosive Solids

Inhalation of corrosive dusts presents a particular hazard as the point of contact and the tissue at risk, specifically the airways and the lungs, is internal, creating an injury that may be difficult to treat and heal. Examples of corrosive solids are lithium oxide, sodium sulphide and phenol.

8.3.3 Corrosive Gases

Corrosive gases enter the body through inhalation as well as being readily absorbed through dissolution in skin and eye moisture. Typical examples are listed as follows:

- ammonia;
- hydrogen chloride;
- bromine;
- chlorine; and
- sulphur dioxide.

8.3.4 Use and Handling of Corrosives

Specific precautions to take when using or handling corrosive materials include the following:

- Ensure that acids are always added to water and not vice versa.
- Be prepared for heat generation upon diluting or dissolving in water.
- Ensure that all work is completed with adequate ventilation.

When working with volumes of corrosives greater than 4 L ensure that personal protective equipment includes at least the following:

- synthetic rubber apron;
- protective clothing (e.g. lab coat, coveralls, etc.);
- goggles; and
- appropriate gloves.

8.4 Highly Reactive Materials

Reactive materials are used for various purposes, often because of their reactive properties. Particular care must be taken to ensure the safe handling, use and storage of these sensitive chemicals.

8.4.1 Water reactives

The following situations may occur with water reactive chemicals upon contact with water:

- liberation of heat (causing potential ignition of the chemical itself or nearby flammable material);
- release of flammable, toxic, or oxidizing gas;
- release of metal oxide fumes (applicable to water reactive metals); and/or
- formation of corrosive acids.

Examples of water reactive materials include lithium, sodium and potassium.

Care must be taken to ensure that water reactive chemicals are handled and stored away from sinks, water baths or other sources of moisture.

8.4.2 Pyrophorics

Pyrophoric chemicals are those which ignite spontaneously upon contact with air. Pyrophorics must be handled and stored in such a way as to prevent exposure to air, e.g. storage under an inert gas or under kerosene.

Examples of pyrophorics include finely divided calcium, iron, lead and nickel.

8.4.3 Organic Peroxides

See section 8.2.4

8.4.4 Explosives

Explosives are regulated by the Canadian Explosives Act and corresponding regulations along with the Ontario Fire Code. Specific requirements when handling explosives are described below:

- Working alone with explosive materials is prohibited.
- Quantities of explosive materials are to be minimized with all additional material disposed of upon completion of the activity.
- Written safety instructions and emergency procedures are to be prepared and must include at least the following information:
    - location of storage and use areas
    - methods to control a fire emergency safely and efficiently
    - contact information

8.4.4.1 Picric Acid

Picric acid (2,4,6-trinitrophenol) can be a dangerous explosive when dehydrated. When in contact with metal, highly shock-sensitive picrate salts can be formed. The following guidelines are to be followed for the storage and handling of picric acid:

- Picric acid must be stored in water.
- Containers of picric acid are to be inspected at least every 6 months and distilled water added to the containers as necessary to ensure that the picric acid never dries out.
- Containers and lids for storage of picric acid or solutions of picric acid are not to be of metal construction.
- Metal spatulas are never to be used to remove material from its container.
- Always wipe the neck of the bottle, and the cap with a wet cloth before returning to storage.

If a container of dry picric acid is discovered, it is not to be touched and EHS is to be contacted at x56401 immediately to arrange for safe disposal.

8.5 Cryogenic Materials

Cryogenics are very low temperature materials such as dry ice ($CO_{2(s)}$), liquefied air, nitrogen, helium, oxygen, argon and neon. The following hazards are associated with the use of cryogenics:

- asphyxiation due to displacement of oxygen (for materials other than liquefied air and oxygen);
- freezing and fracturing of materials from extreme cold;
- frostbite;
- explosion due to pressure build up; and
- condensation of oxygen and fuel, such as hydrogen or hydrocarbons, resulting in explosive mixtures.

The following are precautions for handling cryogenics:

- Control ice buildup.
- Use only approved low-pressure containers equipped with pressure-relief devices. Lunch box Thermos bottles are not acceptable.
- Protect skin and eyes from contact; wear eye protection and insulated gloves.
- Wear safety goggles when breaking large pieces of dry ice or using mixtures of dry ice and solvent.
- Wear a face shield when removing samples from storage dewars due to the possibility of rupture from pressure build-up.
- Use and store in well-ventilated areas. Alarmed oxygen sensors are required in areas where the volume of gas could result in the displacement of oxygen to a level lower than what is tolerable by people, thereby causing an asphyxiation hazard.
- Keep away from sparks or flames.
- Use materials resistant to embrittlement (e.g. rubber tubing).
- Watches, rings, bracelets or other jewelry that could trap fluids against flesh should not be worn when handling cryogenic liquids.
- To prevent thermal expansion of contents and rupture of the vessel, ensure containers are not filled to more than 80% of capacity.
- Never store dry ice in a refrigerator/freezer (especially deep chest freezers). Dry ice will sublimate at -78°C and could asphyxiate the person opening the equipment.

8.6 Designated Substances

There are eleven “designated substances” regulated by the Ontario Occupational Health and Safety Act due to their potential to cause serious health implications. Use of designated substances should be avoided if possible. Designated substances are listed below:

- acrylonitrile;
- arsenic;
- asbestos;
- benzene;
- coke oven emissions;

- ethylene oxide;
- isocyanates;
- lead;
- mercury;
- silica; and
- vinyl chloride.

Designated substance regulations apply to employers and workers at workplaces where the substance is present and is likely to be inhaled, ingested or absorbed by the worker. The regulations require that the time weighted average exposure of the worker to the substance be less than limits prescribed in the regulations. Generally, designated substance regulations contain three key components:

Assessment – requires the employer to consider the level of exposure or likelihood of exposure to the substance.

Control program – required if the assessment discloses that a worker is likely to be exposed to the substance. This documented program is to include engineering controls, hygiene practices, work practices and facilities to ensure that the worker exposure to the substance is controlled.

Monitoring – requires air emissions monitoring and medical surveillance to determine actual exposure to the substance. Contact OHS at x54283 regarding medical surveillance programs.

Please refer to the Asbestos Management policy and program for information regarding the handling of asbestos.

It is the responsibility of the supervisor to ensure that the letter and intent of the regulations are met. Contact EHS x53282 for more information. In addition to these regulations additional standards have been added in the following sections.

8.6.1 Mercury

Elemental mercury, inorganic mercury salts and organic mercury compounds have the potential to cause serious acute or chronic toxic effects from the various routes of exposure.

- Containers in storage are to be sealed with the cap/lid along with electrical tape, parafilm or an equivalent.
- All use and storage is to be in a well-ventilated area.
- Any skin or eye contact is to be rinsed with copious amounts of water and medical attention is to be sought immediately.

See section 7 for spill clean-up procedure.

8.6.2 Isocyanates

Various isocyanates have been determined to cause severe allergic reactions in certain individuals. Sensitization may also occur such that the allergic reaction becomes progressively worse with each exposure and occurs with exposures to very small amounts of the material. Reactions may include anaphylactic shock which can be fatal and hence requires immediate medical treatment. All rooms, solutions or samples containing isocyanates should be clearly marked as containing such.

8.6.3 Benzene

Benzene is a highly flammable, carcinogenic solvent that has severe effects on the blood and blood-forming organs. All use of benzene should be performed in a fume hood. If practical, the use of benzene should be substituted with another appropriate solvent, such as toluene.

8.7 Other Toxic Materials

Some other chemicals warrant mentioning specifically because of their hazards and/or prevalence on campus. Their primary hazards are identified as follows:

- Ethidium bromide – known mutagen.
- Chloroform – relatively potent anaesthetic, suspected carcinogen.
- Cyanides/Nitriles – acutely toxic. If use is unavoidable, personnel are to be specifically trained in its use and emergency response procedures and have immediate access to a cyanide exposure treatment kit. Contact OHS at x54283 for more information.
- Hydrogen sulphide – acutely toxic. Attacks the respiratory system. Highly flammable.
- Formalin/Formaldehyde – known carcinogen.

9. Compressed Gases

9.1 Hazards of Compressed Gases

Compressed gases are inherently hazardous due to the high pressure inside the cylinders. Knocking over an unsecured, uncapped cylinder of compressed gas can break the cylinder valve resulting in rapid escape of high pressure gas that can transform a cylinder into an uncontrollable rocket or pinwheel, causing serious injury and damage. Poorly controlled release of compressed gas can seriously damage equipment. Compressed gases may also have flammable, oxidizing, dangerously reactive, corrosive or toxic properties. Inert gases such as nitrogen, argon, helium and neon can displace air, reducing oxygen levels in poorly ventilated or restricted areas and causing asphyxiation. See section 8.5 for information regarding cryogenic liquids.

9.2 Handling and Transport of Gas Cylinders

The following points describe safe handling and transport guidelines for gas cylinders.

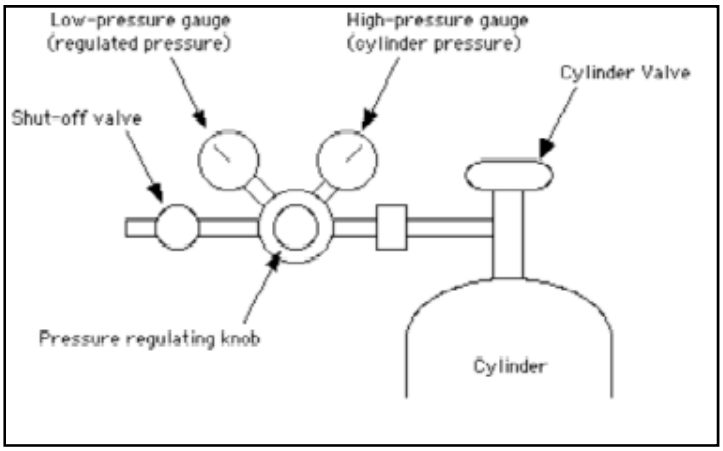
- Return unlabelled cylinders unopened to the supplier. Colour coding does not provide sufficient identification.
- When cylinders are not in use or are being transported, regulators are to be removed and the protective cap is to be attached.
- A proper cylinder cart is to be used for transporting cylinders. Cylinders are to be chained or strapped to the cart.
- Do not ride in an elevator with a gas cylinder. Elevators can be operated safely from the outside. Elevators may not have sufficient ventilation to maintain oxygen levels in the event of a gas leak.
- Ensure that propane tanks designed for outdoor use are not stored or used indoors.
- Label empty cylinders clearly with either “EMPTY” or “MT”.
- Never bleed a cylinder completely empty; leave a residual pressure of at least 25 psi to prevent contamination or “suck back”.
- Do not lubricate regulators. The mixture of lubricant and oxidizing gases could be explosive.
- Do not expose cylinders to high temperature extremes.
- Do not force, lubricate or modify cylinder valves in any way.
- Cylinders containing flammable gases are to be grounded to prevent accumulation of electrostatic charge.
- Never expose skin or clothing to compressed gas flow as high velocity gas could penetrate the skin leading to serious injury.

To use a cylinder:

- Ensure the pressure regulating valve (adjusting screw) is closed.
- Open the cylinder valve slowly.
- Open the pressure regulating valve to the desired pressure.
- To shut off the gas:
- Close the cylinder valve.
- Open the pressure regulating valve to relieve the pressure.

9.3 Regulators

Figure B – Schematic diagram of compressed gas cylinder and regulator



http://tuttle.merc.iastate.edu/ee432/labdocuments/gasflow.pdf, Feb 2, 2006.

- Verify that the regulator is appropriate for the gas being used and the pressure being delivered. Regulators are not universal and have to be chosen based on the gas and cylinder being used. Compressed Gas Association (CGA) connector numbers are to be the same on the regulator and cylinder valve.
- Label all regulators appropriately and do not use interchangeably with different gases
- Do not rely upon the pressure gauge to indicate the maximum pressure ratings; check the regulator's specifications.
- Do not use adaptors or Teflon tape to attach regulators to gas cylinders. Regulator inlet connections are designed to fit the outlet connection of the cylinder valve for a particular gas. Gas tight connections are made using metal to metal seals which can be weakened or plugged through the use of Teflon tape.

9.4 Leaks

See information regarding compressed gas leaks in Tables 7 and 8 in section 7.

9.5 Storage of Gas Cylinders

Storage of gas cylinders is regulated through the Ontario Fire Code Section 5.6. Proper storage room/locations for compressed gas cylinders are available throughout the university that meet the requirements of the Fire Code.

- Storage areas are to be conspicuously labelled.
- All gas cylinders are to be securely supported in an upright position using suitable racks, straps, chains or stands. Cylinders should be secured at ~⅔ of their height. Cylinders with a height of less than 46 cm can be secured in specialized racks.
- All cylinders are to be protected from mechanical damage.
- Cylinders of flammable gases are to be segregated from oxidizing gases (e.g. oxygen stored separately from hydrogen).
- Cylinders are to be located in a dry location away from direct sunlight and heat sources.
- Cylinders are to be well removed from doors, aisles, stairs and elevators.

9.5.1 Segregation of Gas Cylinders

As with other chemical storage, certain compressed gases are incompatible with each other. The following system describes the segregation required for compressed gases.

Figure C – Compressed gas segregation system

COMPRESSED GAS CYLINDER SEGREGATION AND STORAGE PLAN				
	Flammable compressed gases	Oxidizing compressed gases	Non-flammable Toxic compressed gases	Non-flammable, Non-Toxic compressed gases
Flammable compressed gases	✓	×	×	✓
Oxidizing compressed gases	×	✓	✓	✓
Non-flammable Toxic compressed gases	✓	✓	✓	✓
Non-flammable, Non-Toxic compressed gases	✓	✓	✓	✓

✓ – ok to be stored together × – may not be stored together

Examples:

Flammable compressed gases	methane, propane, acetylene, hydrogen
Oxidizing compressed gases	oxygen, bromine, chlorine
Non-flammable Toxic compressed gases	carbon monoxide, hydrogen sulphide
Non-flammable, Non-Toxic compressed gases	helium, nitrogen, air, carbon dioxide, argon

10. Chemical Handling and Storage

Because of limited space, good housekeeping practices, waste disposal costs and the desire to minimize hazardous materials maintained in the work place, it is essential to buy the amount of chemical required rather than buying in bulk. Storage of hazardous materials (including proper placarding of the storage locations) must be in accordance with all applicable legislation which may include the following:

- FIRE CODE - O. Reg. 388/97
- EXPLOSIVES ACT
- LIQUID FUELS - O. Reg. 217/01
- PROPANE STORAGE AND HANDLING - O. Reg. 211/01

10.1 EHS Chemical Inventory

All chemicals in every chemical storage area are to be entered into the EHS electronic chemical inventory system accessible at https://cms.cs.uoguelph.ca. This system is necessary to be able to efficiently communicate the contents of each storage area to emergency first responders, and to ensure that proper inventory control is achieved.

- Log-in ID's and passwords can be obtained from EHS by calling the Occupational Hygiene Safety Officer at x54855.
- Training is provided by EHS. Call x54855 for details.
- Upon receipt of a new chemical, enter information into the applicable sub-inventory.
- Update inventory as a chemical is depleted or disposed.
- Audit inventory on an annual basis to ensure that it is up to date.

10.2 General Transport Practices

- Use a cart when transporting several containers or containers that are large, awkward or heavy. Carts should either have high edges for containment or chemicals should be in secondary containers.
- Carry glass containers in bottle carriers or other suitable, leak resistant, robust secondary container.
- Transport off-site requires compliance with federal Transportation of Dangerous Goods regulations. Refer to Safety policy 851.08.10 or contact EHS at x56401 for more details.

10.3 General Storage Practices

- Ensure that storage shelves are sturdy and secured to the wall or floor.
- Ensure that storage shelves have anti-roll lips or that other appropriate measures are taken to ensure chemicals cannot easily fall of shelves.
- Store large containers on lower shelves.
- Avoid storage above eye level.
- Window sills, heaters and ledges are not to be used as storage areas.
- Avoid storage on the floor unless the chemical container is in its original shipping carton and packing or the container is an approved safety can. Containers stored on the floor can be easily knocked over with contents spilled.
- Inspect chemicals in storage regularly to ensure that:
    - There are no leaks.
    - Caps and containers are in good condition. Look for signs of discolouration, bulging and pressure build up.
    - Outside of containers are kept free of spills and stains.

10.4 Storage of Flammables and Combustibles

Flammable liquid – a liquid having a flash point below 37.8°C and having a vapour pressure not more than 275.8 kPa (absolute) at 37.8°C as determined by ASTM D323, "Vapour Pressure Petroleum Products (Reid Method)".

Combustible liquid – any liquid having a flash point at or above 37.8°C and below 93.3°C

Storage of flammable and combustible liquids is regulated by Section 4 of the Ontario Fire Code. Note that for the purposes of the requirements below “room” is a single fire compartment and does not include a classroom or lecture hall.

- Ensure that the flammable and combustible liquid in the open area of the room is minimized and is for immediate use only.
- Ensure that all additional flammable and combustible liquid in the room is stored in approved flammable storage cabinets.
- Ensure that flammable and combustible liquids are not stored in basements.
- Ensure that storage quantities are minimized and do not exceed a total of 500L of flammable and combustible liquids of which not more than 235 L is flammable.
- Ensure that flammable materials requiring storage conditions at refrigerated temperatures are stored in refrigerators/freezers designed and certified for this purpose. Household refrigerators are never to be used to store flammable liquids.
- Storage containers are to be less than 5 L unless they are safety containers conforming to ULC/ORD-C30 which must be less than 25 L.

10.4.1 Storage Rooms for Flammable and Combustible Liquids

Flammable storage rooms are to meet the following requirements:

- not be located in the basement of a building;
- separated from the remainder of the building with partitions having a minimum one-hour fire resistance rating and self-closing doors, hinged to swing outward;
- have no openings communicating directly with the public portions of the building;
- be equipped with a drain connected to a dry sump or holding tank;
- have liquid-tight seals between interior walls and floor and a liquid tight ramped sill at any door which is not an exterior door;
- have aisles of no less than 1 m;
- have a suitable portable fire extinguisher;
- have suitable spill clean-up materials;
- have appropriate ventilation:

- natural or continuous mechanical ventilation if no vapours can escape into the room;
- continuous mechanical ventilation if flammable vapours may be released into the room (Refer to the Ontario Fire Code for specific requirements for mechanical ventilation).

The maximum quantity of flammable and combustible liquids permitted in flammable storage rooms is 1500 L.

10.4.2 Approved Flammable Storage Cabinets

To be approved for storage of flammables, cabinets must conform to at least one of the following standards:

- Conform to ULC-C1275, “Storage Cabinets for Flammable Liquid Containers”;
- Conform to ULI 1275, “Flammable Liquid Storage Cabinets”;
- Be Factory Mutual Research Approved; or
- Be listed as meeting NFPA 30.

Flammable storage cabinets need to either be actively vented to the outdoors or be capped with the plugs supplied with the cabinet itself. While it is recommended that flammable storage cabinets are not vented, venting is acceptable provided that the design maintains the integrity of the cabinet.

10.5 Chemical Segregation

It is critical that chemicals are stored according to a predetermined storage system to ensure that incompatible chemicals are not stored in close proximity to each other. Storage systems that account for necessary segregation are acceptable provided that they are documented and clearly understood by applicable personnel. It is suggested that solvents/reagents etc. be labelled according to the storage system used to allow continuous, easy and proper storage. A representative chemical segregation system that has been adopted by the University is described on the following pages.

Figure D – Chemical segregation system

CHEMICAL SEGREGATION AND STORAGE SYSTEM

	Water reactive/ Pyrophoric/Self-reactive	Explosives	Flammables (solids & liquids)	Oxidizers (solids & liquids)	Corrosive Acids (solids & liquids)	Corrosive Bases (solids & liquids)	Non-flammable solvents & regulated chemicals	Low-hazard solids & liquids
Water reactive/ Pyrophoric/Self-reactive	✓	×	×	×	×	×	×	×
Explosives	×	✓	×	×	×	×	×	×
Flammables (solids & liquids)	×	×	✓	×	×	✓	✓	×
Oxidizers (solids & liquids)	×	×	×	✓	×	×	×	Secondary containment required
Corrosive Acids (solids & liquids)	×	×	×	×	✓	×	×	< 2 M acidic solutions
Corrosive Bases (solids & liquids)	×	×	✓	×	×	✓	Secondary containment required	< 2 M caustic solutions
Non-flammable solvents & regulated chemicals	×	×	✓	×	×	Secondary containment required	✓	✓
Low-hazard solids & liquids	×	×	×	Secondary containment required	< 2 M acidic solutions	< 2 M caustic solutions	✓	✓

✓ – ok to be stored together × – may not be stored together

Storage Instructions:

Water reactive/ Pyrophoric/Self-reactive	Store in secondary container in secure, cool, dry location. Isolate from other groups. Separate from aqueous solutions. Protect from water (sprinkler systems etc.) If refrigeration is required double contain in bins.	Examples: lithium aluminum hydride, butyl lithium, sodium azide, potassium cyanide, sodium metal
Explosives	Store in secondary container in secure, dry location. Isolate from other groups.	Examples: ammonium nitrate, picric acid, nitro urea, trinitroaniline, trinitrobenzene, trinitrobenzoic acid, trinitrotoluene
Flammables (solids & liquids)	Store in approved flammable storage cabinet or approved flammable storage fridge/freezer Store solids above liquids. Includes combustibles.	Examples: methanol, acetonitrile, hexane, toluene, tetrahydrofuran, acetone, acetic acid
Oxidizers (solids & liquids)	Store in secondary container on shelf or in dedicated oxidizer cabinet Ensure isolation from reducing agents. Ensure compatibility between oxidizers in storage area (see MSDS for details).	Examples: sodium dichromate, potassium permangenate, sodium periodate, sodium hypochlorite, benzoyl peroxide
Corrosive Acids (solids & liquids)	Store within dedicated acid cabinet. Use secondary containers particularly hazardous acids such as hydrofluoric acid. Separate inorganic and organic acids. Aqueous solutions < 2 M and weak, non-corrosive acids are exempt.	Examples: sulphuric acid, hydrochloric acid
Corrosive Bases (solids & liquids)	Store within dedicated caustic cabinet. Aqueous solutions < 2 M are exempt and weak, non-corrosive bases are exempt.	Examples: sodium hydroxide, ammonium hydroxide
Non-flammable solvents & regulated chemicals	Store with secondary containment on shelves or in cabinet. Includes carcinogens, teratogens, mutagens	Examples: dichloromethane, dimethylformamide
Low-hazard solids & liquids	Store on shelves or in cabinet. Includes weak acids and bases.	Examples: calcium chloride, sodium bicarbonate, copper sulphate

Chemicals should be stored based on the first suitable grouping listed above

10.6 Storage of Gas Cylinders

See Section 9.5.

10.7 Containment

- Care should be taken to ensure that chemicals are stored to minimize the risk of spills.
- Primary storage containers should be of a composition such that they are able to maintain their structural integrity throughout the lifespan of the material they are holding under normal storage and use.
- Purchase materials in safety-coated glass bottles if available. These are glass bottles that are covered in a thin plastic coating that is slip and impact resistant. These bottles are designed to contain liquid in the event that the glass is broken.
- Secondary containment should be used in all storage locations. This is containment in addition to the primary container used to prevent release of material to the environment in the event that the primary container fails. Over-packs, spill trays etc. are examples of secondary containment.

11. Hazardous Waste Management

Disposal of hazardous waste is regulated through the provincial Ministry of the Environment (MOE). Hazardous wastes are never to be flushed down the drain or left to evaporate as methods of disposal. Not only is this practice illegal, but it can harm the environment, lead to dangerous reactions; create immediate and future hazards for personnel as well as damage the drainage system. The sign shown in Figure E is to be posted near all sinks in areas using hazardous materials:

Figure E – Sewage disposal of hazardous waste warning sign

Detailed information regarding acceptable discharges to sanitary and storm sewers can be found in the City of Guelph's sewer use by-law. A summary of unacceptable discharges can be found in Table 9.

Table 9 – Summary of Unacceptable Discharges to Sanitary Sewers

Matter of any type, temperature or in any quantity which may:

- be or become a health and safety hazard to any person, animal, property or vegetation;
- cause sewage effluent, sludge or compost to contravene Provincial regulations;
- be harmful to the sewage works; or
- interfere with the proper operation of sewage works or treatment.

Solid or viscous substances in such quantity or size that may cause obstruction to flow of sewer including but not limited to ashes, bones, cinders, sand, mud, straw, shavings, metal, glass, rags, feathers, tar, plastics, wood, unground garbage, animal guts or tissues, paunch manure, whole blood or the product of any garbage grinder.

Sewage or uncontaminated water with a temperature greater than 65°C.

Sewage with pH less than 5.5 or greater than 9.5.

Sewage containing the following in any amounts:

- dyes or colouring materials which may discolour the sewage works effluent;
- items that may cause offensive odours including hydrogen sulphide, carbon disulphide, reduced sulphur compounds, amines or ammonia;
- water from an unapproved source separate from the water distribution system of the City;
- storm water;
- water immiscible liquids;
- fuel;
- PCBs;
- pesticides;
- severely toxic material;
- waste radioactive material (except where discharge is being done in accordance with a licence from the Canadian Nuclear Safety Commission);
- hauled sewage;
- waste disposal site leachate; and
- hazardous wastes (including acute hazardous waste chemicals, hazardous industrial wastes, hazardous waste chemicals, ignitable wastes, pathological wastes, PCB wastes, reactive wastes).

Sewage containing any of the following in excess of the indicated concentration:

Solvent extractable matter of mineral or synthetic origin	15 mg/L
Biological oxygen demand	300 mg/L
Suspended solids	350 mg/L
Organic nitrogen, solvent extractable matter of animal or vegetable origin	100 mg/L
Chlorides, Sulphates (SO4)	1500 mg/L
Aluminum, Iron	50 mg/L
Fluorides, Phosphorus	10 mg/L
Antimony, Bismuth, Chromium, Cobalt, Lead, Mangenese, Molybdenum, Selenium, Silver, Tin, Titanium,Vanadium	5 mg/L
Copper, Nickel, Zinc	3 mg/L
Cyanide	2 mg/L
Arsenic, Cadmium, phenolic compounds	1 mg/L
Mercury	0.1 mg/L

Note that dilution is not an acceptable means of meeting concentration requirements.

Guelph Sewer Use By-law (1996)-15202 (and amendments)

Hazardous waste disposal is managed through the EHS department. Hazardous waste is not to be transported to the main campus from offsite as this contravenes provincial legislation. Hazardous waste generated at regional colleges and research stations must be transported by a hazardous waste contractor directly from these locations.

11.1 Minimization of Hazardous Waste

As an environmentally responsible community, it is important to minimize all waste generated. The following points should aid in waste minimization efforts.

- Buy only what you need.
- Choose non-hazardous substances over hazardous substances e.g. use digital or ethanol-based thermometers over mercury-based thermometers.
- Return unused material to the supplier if possible, e.g. gas cylinders.
- Redistribute usable materials.
- Recycle/recover materials when it can be accomplished efficiently, effectively and safely.

11.2 Packaging and Labelling Requirements

For routine quantities of waste, the waste generator is responsible for providing appropriate waste containers as well as for ensuring that all hazardous waste is packaged and labelled appropriately. The safety of the hazardous waste contractors depends on the waste containers maintaining their integrity, and the waste being accurately identified. The following are requirements for hazardous waste disposal:

- Incompatible materials are not to be combined in a single waste container.
- Chemical liquid waste containers are not to be filled beyond approximately 75% of their capacity to allow for vapour expansion.
- Container materials must be compatible with the contained wastes (e.g. corrosives are not to be stored in metal containers).
- Containers are to be in good condition.
- Wastes are to be identified appropriately (e.g. biohazard bags are not to be used for chemical wastes if no biohazard exists).
- Non-hazardous wastes are to be segregated from hazardous waste to avoid unnecessary expenses.
- Hazardous waste is to be disposed of regularly, i.e. not accumulated.
- Hazardous waste is to be clearly labelled with the identity of the waste as well as the waste generator. This will be accomplished by carefully completing the hazardous waste tag (shown in section 11.3).
- If reusing bottles, ensure that there is only one identifier on the bottle.

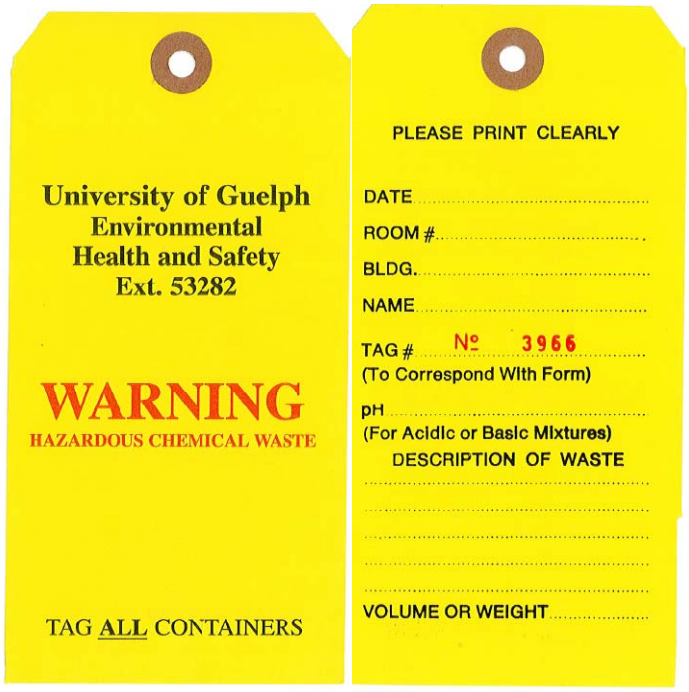
11.3 Chemical Waste

Routine quantities of hazardous chemical waste are picked up regularly by a hazardous waste contractor. Note that consumer products such as batteries, cleaning solvents, paints, paint thinners, oils and pesticides are to be disposed of as hazardous waste. All unused controlled drugs are to be returned to the University Pharmacist. Disposal of large volumes of chemical waste or waste containing polychlorobiphenyls (PCB's) must be pre-arranged through EHS. Contact x56401 for further information.

If you have waste for disposal:

- Complete a hazardous waste disposal tag and attach it to the waste container(s). See sample tag. Tags are available from EHS.

Figure F – Hazardous waste disposal tag



- Complete “Surplus Chemical and Sharps Disposal Request” form. The following information is required:
    - contact name, phone number/email, signature;
    - building number, room number, waste location;
    - chemical composition (No abbreviations. Abbreviations may be meaningless to those transferring waste, hence full chemical names are required.);
    - quantity, container description;
    - tag number; and
    - hazards, physical state, pH if required.
- Form is available at http://www.uoguelph.ca/ehs/paper_forms/wastedis.pdf.
- Submit form to EHS by interdepartmental mail, fax (519-824-0364) or in person to the EHS office.
- Waste will be removed by the waste contractor through at least weekly, scheduled pick-ups. Regular pick-up days will be posted on the EHS website along with any cancellations or changes to the schedule.
- In the event of a problem (incomplete information, no tag, improper/defective packaging, inaccessible location etc.), the waste will be rejected for pick-up and the contact person will be notified as to the problem.
- Suitable, reusable waste containers (i.e. safety cans or nalgene carboys) will be returned to the generator.

11.3.1 Unknown Waste

Waste of unknown composition will not be picked up by the hazardous waste contractor. It is the responsibility of the supervisor to appropriately identify or categorize the “unknown”.

If professional assistance is required to identify or categorize “unknowns”, the resulting charges will be the responsibility of the waste generator.

11.3.2 Explosive Waste

Explosive waste will not be picked up during the regular, scheduled hazardous waste removal. To make arrangements for the disposal of explosives, contact EHS at x56401.