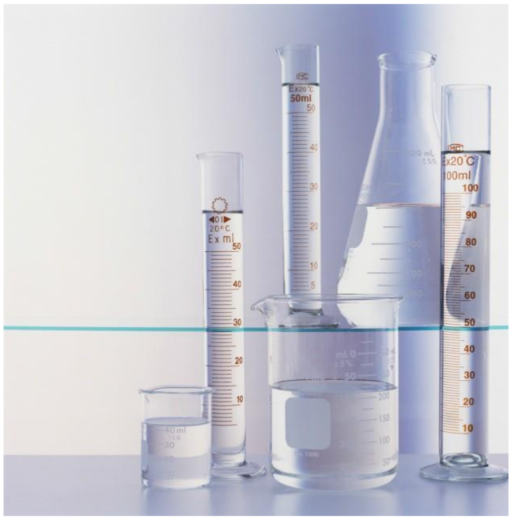
UNIVERSITY of GUELPH



Environmental Health and Safety

Laboratory Safety

Manual

4th edition 2018

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1. Environmental Health and Safety Policy

The University of Guelph is committed to providing safe and healthy workplaces. The Occupational Health and Safety Act, R.S.O. 1990 and prescribed Regulations define the essential standards for health and safety performance for employers, employees and contractors; these standards may be complemented by other legislation and may be exceeded by specific University Safety Policies and departmental procedures for risk management and due diligence.

The University is committed to preventing occupational injuries and illnesses and expects managers and supervisors at all levels to be responsible and accountable for injury and illness prevention. Management is committed to resolving health and safety challenges in a co-operative approach with employees, to evaluating and controlling risks to staff, students, visitors and volunteers, to participating in workplace inspections, to monitoring on-the-job safety performance, to auditing for health and safety program success, and to improving health and safety performance.

The University is committed to training and motivating employees for safety performance and to sustaining and updating their safety knowledge. The University strives to integrate safety knowledge and/or safety performance expectations into its academic curricula and into its operations. Personal safety and responsibility shall be promoted for employees both on and off the- job and for those who live and learn at University of Guelph campuses.

The University requires that all employees shall regard safety as a priority in all employment related activities and they shall not endanger the health and safety of themselves or others in the workplace. Employees are expected to be familiar with prescribed safety requirements and institutional policies pertaining to their jobs, to report safety hazards or contraventions to their supervisors, and to support employee and management initiatives for improving workplace health and safety conditions. Failure to abide by these legislative standards or by applicable University policies, standards or programs, may result in disciplinary action up to and including dismissal. By extension, students, visitors and contractors of the University are also expected to comply with all relevant legislation and University policies.

The University acknowledges a responsibility for and a commitment to protection of the environment on a continuous improvement basis by applying the principles of the Environmental Protection Act, R.S.O. 1990 and prescribed Regulations as a minimum standard by which to manage University operations. The University is committed to the conservation and improvement of the environment by minimizing environmental impacts arising from its activities and promotes and supports environmental management policies and environmentally responsible practices at every level and every department. This policy shall be reviewed annually and shall be co-signed and posted by management in all academic and administrative units.

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2. Introduction

Providing a safe and healthy place to work and study is of utmost importance to the University. Researchers in the laboratories at the University of Guelph conduct extensive research as well as provide valued educational opportunities to thousands of undergraduate and graduate students over a broad spectrum of disciplines. To address the health, safety and environmental challenges specific to the laboratories, this manual, encompassing guidelines and procedures have been developed.

This manual 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 in the University's research, service and teaching laboratories.

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

3. Definitions

The Act – Ontario Occupational Health and Safety Act.

competent person – means a person who,

- is qualified because of knowledge, training and experience to organize the work and its performance;
- is familiar with the Act and the regulations that apply to the work; and
- has knowledge of any potential or actual danger to health or safety in the workplace. (ONTARIO OH&S ACT SECTION 1(1))

due diligence – taking *all* precautions reasonable in the circumstance to protect the health and safety of the worker.

EHS – Environmental Health and Safety.

incident – an event that results in injury to people and/or damage to the environment, equipment, property and/or material.

injury – an event that results in physical harm to an employee.

laboratory – for the purposes of this manual, a laboratory is considered to be any space where scientific research, experimentation or analysis is conducted. Computer "labs" are excluded from this definition.

laboratory personnel – any employee, student or visitor conducting scientific research, experimentation or analysis within a laboratory.

near miss – an event that under different circumstances could have resulted in physical harm to an individual or damage to the environment, equipment, property and/or material.

OHW – Occupational Health and Wellness.

research laboratory – a laboratory designed primarily for research.

service laboratory – a laboratory providing contracted analysis or experimental procedures for another agency either within or outside of the University usually for a fee, e.g. Laboratory Services Division.

supervisor – a person who has charge of a workplace or authority over a worker. (ONTARIO OH&S ACT SECTION 1(1))

teaching laboratory – a laboratory designed with an instructional function related to a University course for students.

4. Training

It is the responsibility of supervisors to confirm that:

- All laboratory personnel have received sufficient introduction and training on specific equipment, procedures and materials in the laboratory where they will be working.
- All training is documented with the documentation maintained for all personnel.

In addition to project specific training, the supervisor is responsible for orienting new personnel to make aware of emergency and safety procedures including, but not limited to, emergency evacuation routes, emergency or safety procedures specific to the laboratory as well as departmental safety policies and procedures and applicable policies and procedures included in the Laboratory Safety Manual and the University of Guelph Health and Safety Policies

Supervisors are to confirm that all new laboratory personnel have successfully completed all applicable courses as prescribed in the EHS Training Matrix prior to beginning applicable work

(i.e. Lab Safety and WHMIS training is to be completed prior to working in the lab, Radiation Safety and, Biosafety training is to be completed prior to working with radioisotopes or biohazards as applicable).

These courses are offered via on-line and/or in-class formats. See the Environmental Health and Safety website for more information on course offerings.

The supervisor shall require all training of laboratory personnel be documented and maintained throughout the employment of the worker or until graduation of a student.

5. Incidents

5.1. Incident Reporting

All incidents and near misses are to be reported to Occupational Health and Wellness (OHW) the Injury/Incident Report Form. To meet regulatory requirements, these forms are to be submitted to OHW within 24 hours except for critical injuries which are to be called into EHS immediately. After hours, EHS can be contacted through Campus Community Police at extension 52000 or 519-840-5000. Critical injuries are those injuries that meet at least one of the following criteria:

- places life in jeopardy;
- produces unconsciousness;
- results in substantial loss of blood;
- involves fracture of a leg or arm but not a finger or toe;
- involves amputation of a leg, arm, hand or foot, but not a finger or toe;
- consists of burns to a major portion of the body; or
- causes the loss of sight in an eye. (R.R.O. 1990, Reg. 834 as am. O. Reg351/91)

Employees should seek first aid at or near the location of the injury. First aid stations for the Guelph Campus are:

- Occupational Health and Wellness, Alexander Hall Room 179
- Student Health Services, J.T. Powell Building
- Campus Police/Fire Prevention, 24-hour, mobile service accessed through x 52000 or 519-840-5000

If there is any health concern following an incident, follow up with medical professions should be initiated:

- For employees, contact OHW x 54283
- For students, contact Student Health Services x 52131

Follow-up may include medical assessment and/or surveillance.

5.2. Incident Investigation

Many lessons can be learned from incidents and near misses. Incident investigation is an important component of the continuous improvement of safety practices and procedures. However, to be effective, the active participation of supervisors and workers is essential. Investigations are intended to uncover contributing factors and root causes, which may not be immediately evident upon initial review of the incident. It is essential that the scene of an accident is preserved so that a thorough and accurate investigation can be performed. Scenes of critical injuries must legally be preserved until permission for clean-up is given from the Ministry of Labour inspector.

To thoroughly investigate an incident, consider the following strategies:

- Consider both why it happened and why the situation wasn’t prevented or detected before it became an incident or near-miss.
- Continue to ask “why” until you drill down to detail that can no longer be broken down.
- Consider all possible contributing elements. The following categories should be considered:
    - personnel (e.g. personnel appropriately trained? competent?);
    - machinery (e.g. was equipment operating appropriately? maintenance up to date?);
    - methods (e.g. were procedures appropriate for the application and were they being followed appropriately?);
    - environment (e.g. housekeeping, lighting, physical condition of the workplace); and
    - materials (e.g. hazardous materials involved, personal protective equipment).

EHS personnel are available to assist in investigations and will perform their own investigations as necessary.

6. Workplace Hazardous Materials Information System (WHMIS 2015)

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 with warning labels, Material Safety Data Sheets (MSDSs)/Safety Data Sheets (SDSs) and training on how to use the information provided.

6.1. WHMIS2015 – Hazard Group, Class and Category

Hazard Group

There are two major groups of hazards under WHMIS 2015:

- **Physical hazards group** is based on the physical or chemical properties of the substance (for example flammability, reactivity, or corrosivity)
- **Health hazards group** is based on the ability of the product to cause a health effect - such as eye irritation, respiratory sensitization (may cause allergy or asthma symptoms or breathing difficulties if inhaled), or carcinogenicity (may cause cancer). Each hazard group includes hazard classes that have specific hazardous properties.

You may also see the Environmental classes listed on labels and Safety Data Sheets (SDSs). This could include Explosives, Hazard to the Aquatic Environment and Hazard to the Ozone Layer. Including information about environmental hazards is permitted but not mandatory.

Hazard Classes

Hazard classes are a way of grouping substances with similar properties.

There are two recognized hazard Classes: Physical Hazard Classes and Health Hazard classes, both of which have subclasses as described in the following sections.

Physical Hazard Classes:

The following are the physical hazard classes: Combustible Dust, Corrosive to Metals, Flammable Aerosols, Flammable Gases, Flammable Liquids, Flammable Solids, Gases under Pressure, Organic Peroxides, Oxidizing Gases, Oxidizing Liquids, Oxidizing Solids, Pyrophoric Gases, Pyrophoric Liquids, Pyrophoric Solids, Self-Heating Substances and Mixtures, Self-Reactive Substances and Mixtures, Substances and Mixtures which, in contact with water, emit flammable gases, Physical Hazards Not Otherwise Classified*

Health Hazard Classes:

Health hazard classes introduce some additional types of hazards that are not included in "old" WHMIS but enhance protections for workers are divided into those causing acute effects and those causing chronic effects.

Acute hazards include: Acute Toxicity (LD50 and LC50), Aspiration Hazard, Biohazardous Infectious Materials, Serious Eye Damage and Irritation, Skin Corrosion and Irritation, Health Hazards Not Otherwise Classified.

Chronic hazards include: Respiratory or Skin Sensitization, Germ Cell Mutagenicity, Carcinogenicity, Reproductive Toxicity and Lactation Effects, Target Organ Toxicity - Repeated Exposure and Single Exposure, Health Hazards Not Otherwise Classified.

Hazard Category

The hazard classes are further divided into categories. Categories are assigned a number (from 1 to 5). Some hazard classes have only one category (e.g., corrosive to metals), others may have two categories (e.g., carcinogenicity (cancer)) or three categories (e.g., oxidizing liquids). There are a few hazard classes with five or more categories (e.g., organic peroxides).

In a few cases, sub-categories are also assigned and are identified with a number and a letter (e.g., 1A and 1B).

For example:

- Category 1 is always the greatest level of hazard which means it is the most hazardous within that class). If Category 1 is further divided, Category 1A within the same hazard class is a greater hazard than category 1B.
- Category 2 within the same hazard class is more hazardous than category 3, and so on.

There are a few exceptions to this rule. For example, for the Gases under pressure hazard class, the hazard categories are "Compressed gas", "Liquefied gas", "Refrigerated liquefied gas" and

"Dissolved gas". These classes relate to the physical state of the gas when packaged and do not describe the degree of hazard.

In addition, the Reproductive Toxicity hazard class has a separate category called "Effects on or via lactation". "Effects on or via lactation" was not assigned a specific numbered category. Reproductive toxicity also has Categories 1 and 2 which relate to effects on fertility and/or the unborn child.

6.2. 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.

Supplier Labels

A supplier label is required for containers from the supplier containing 100 mL or more of the material.

There are two main types of WHMIS2015 labels: supplier label, and workplace label.

A supplier label is developed and attached to a container by the supplier and will appear on all hazardous products received at a workplace.

WHMIS 2015 supplier labels must be bilingual, easy to read, with the pictograms, signal words and hazard statements grouped together. A comparison of labels under the current WHMIS legislation and the previous legislation is indicated below.

“old” WHMIS (1998) label includes the following:

1. Product Identifier
2. Supplier name
3. Symbol
4. Risk phases
5. Precautionary measures
6. Hatched border

WHMIS2015 label includes the following:

1. Product Identifier
2. Supplier Identifier
3. Pictograms
4. Hazard Statement
5. Signal word
6. Precautionary measures
7. Red square border

Signal word

There are only two signal words used, "Danger" or "Warning". Danger is used for high risk hazards and Warning is used for less severe hazards. If a signal word is assigned to a hazard class and category, it must be shown on the label, and listed in section 2 (Hazards Identification) of the Safety Data Sheet (SDS). – see unit 8. Some hazard classes or categories do not have a signal word assigned to them.

Hazard Statement

Each hazard class and category have an assigned hazard statement. Hazard statement are brief, standardized sentences that inform the user about the most significant hazard of the product.

Figure A - An example of the supplier label under "old" WHMIS

METHANOL
DANGER
POISON
FLAMMABLE
VAPOUR HARMFUL
MAY CAUSE BLINDNESS IF SWALLOWED

Keep away from heat, sparks and flame. No smoking. Container must be grounded when being emptied. Vapour may travel long distance. Avoid contact with eyes and skin. Do not inhale vapours or mist. Do not take internally. Harmful if absorbed through the skin.

FIRST AID: In case of contact, immediately flush eyes and skin with plenty of water for at least 15 minutes.

If swallowed, induce vomiting by sticking finger down throat, or by giving soapy water to drink. Repeat until vomit is clear.

If affected by vapour, move to fresh air.

If breathing has stopped, apply artificial respiration.

GET MEDICAL ATTENTION IMMEDIATELY.

PRECAUTIONS: Wear chemical-goggles and resistant gloves. Wash thoroughly after handling. Use with enough ventilation to keep below TLV. Keep container closed. Never use pressure to empty container.

MÉTHANOL
DANGER
POISON
INFLAMMABLE
VAPEURS NOCIVES
PEUT PROVOQUER LA CÉCITÉ, SI AVALÉ

Garder loin de la chaleur, des étincelles et des flammes. Ne pas fumer. Brancher le contenant à une prise de terre avant de le vider de son contenu. Les vapeurs peuvent s'étendre sur de longues distances. Éviter tout contact avec les yeux et la peau. Ne pas respirer les vapeurs. Ne pas absorber. Nocif si absorbé par la peau.

PREMIERS SOINS: En cas de contact avec les yeux ou la peau, laver à grande eau pendant au moins 15 minutes.
Si avalé, provoquer le vomissement en introduisant un doigt dans la gorge ou en faisant absorber de l'eau savonneuse à la victime. Répétez jusqu'à cessation du vomissement.

Sortir au grand air, si indisposé par les vapeurs.

Si la respiration est interrompue, recourir à la respiration artificielle.

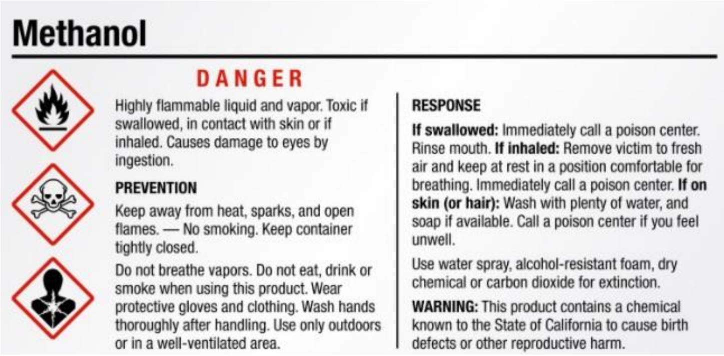
OBTENIR DES SOINS MÉDICAUX IMMÉDIATS.

PRÉCAUTIONS: Porter des lunettes protectrices (pour produits chimiques) et des gants résistants. Se laver minutieusement après usage. Utiliser dans un endroit bien aéré, afin de maintenir un niveau de vapeurs tolérable. Garder le contenant fermé. Ne jamais user de pression en vidant le récipient.

SEE MATERIAL SAFETY DATA SHEET FOR PRODUCT
VOIR FICHE SIGALÉTIQUE

ABC Company
Anytown, Ontario Telephone 123-4567

Figure B - An example of the supplier label under WHMIS2015



Methanol

DANGER

Highly flammable liquid and vapor. Toxic if swallowed, in contact with skin or if inhaled. Causes damage to eyes by ingestion.

PREVENTION

Keep away from heat, sparks, and open flames. — No smoking. Keep container tightly closed.

Do not breathe vapors. Do not eat, drink or smoke when using this product. Wear protective gloves and clothing. Wash hands thoroughly after handling. Use only outdoors or in a well-ventilated area.

RESPONSE

If swallowed: Immediately call a poison center. Rinse mouth. **If inhaled:** Remove victim to fresh air and keep at rest in a position comfortable for breathing. Immediately call a poison center. **If on skin (or hair):** Wash with plenty of water, and soap if available. Call a poison center if you feel unwell.

Use water spray, alcohol-resistant foam, dry chemical or carbon dioxide for extinction.

WARNING: This product contains a chemical known to the State of California to cause birth defects or other reproductive harm.

Workplace label

Workplace label is required when:

- A hazardous product is produced at the workplace and used in that workplace
- A hazardous product is decanted (e.g., transferred or poured) into another container, or
- A supplier label becomes lost or unreadable

There are two situations when a workplace label is not necessary. When a hazardous product is poured into a container and it is going to be used immediately, or when it will remain under the control of the person who decanted it. For example, when the person who poured the product into another container will be the only person who will use it and the product will be used for one day. However, the container must still be identified with the product identifier (name). If the product is not used right away or if more than one person will be in control of the product, a full workplace label is required.

A workplace label must contain the following information:

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

Laboratory Labels

Laboratory samples more than 3 ml that are to be used solely in a laboratory shall be labelled with product identifier or name, reference to SDS and precautionary statement. If product developed in laboratories meets WHMIS 2015 classification, lab must classify and provide a supplier label and SDS.

Samples prepared for analysis in the laboratory where the analysis will take place, that remain under the control of the researcher producing the sample, and that will remain within the laboratory where produced, need to be labelled with the product identifier only.

6.3. Safety Data Sheets

Safety Data Sheets (SDS) provide detailed information about physical, chemical and toxicological properties and hazards of the hazardous materials, as well as recommended handling and emergency procedures. In the past, Safety Data Sheets had to be reviewed or revised by the supplier at least every three years.

SDSs are to be updated within 90 days when new information or scientific data for the chemical is available.

SDS include the following sections

1. Identification
2. Hazard(s) identification
3. Composition/ information on ingredients
4. First-aid measures
5. Fire-fighting measures
6. Accidental release measures
7. Handling and storage
8. Exposure controls/personal protection
9. Physical and chemical properties
10. Stability and Reactivity

11. Toxicological information
12. Ecological information (**Non-mandatory**)
13. Disposal considerations (**Non-mandatory**)
14. Transport information (**Non-mandatory**)
15. Regulatory information (**Non-mandatory**)
16. Other information

Current SDSs are available via the EHS website.

Supervisors are to provide access to these electronic SDSs for all laboratory personnel. Laboratory personnel are strongly encouraged to regularly review SDSs for all hazardous materials being used.

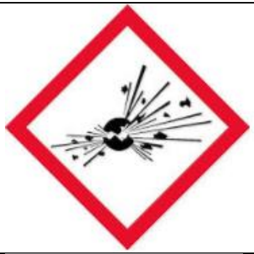
6.4. WHMIS Training

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 proper interpretation of hazard information provided on labels and SDSs. Generic WHMIS training is provided via in-class and online formats through EHS. For training schedule and to register visit EHS Online Course Registration.

6.5. Understanding hazard warning information

WHMIS Pictograms

Table 1 - Summary of WHMIS2015 pictograms, their associated description and examples

Name	Pictogram	Description	Examples
Flame		Identifies materials that will readily burn	• Flammables • Pyrophorics • Self-Heating • Materials that emit flammable gas • Self-Reactives • Organic peroxides
Exploding bomb		Identifies materials that are explosive	• Self-Reactives • Organic peroxides
Skull and crossbones		Identifies materials that are severely toxic. Depending on the toxicity of the chemical, the skull and crossbones indicate that the chemical may be toxic or fatal.	• Fatal if swallowed • Fatal in contact with skin • Fatal if inhaled • Toxic if swallowed • Toxic in contact with skin • Toxic if swallowed
Corrosion		Identifies corrosive substances dangerous to living tissues. Corrosives typically will dissolve metals and include acids, bases (such as alkalis), and oxidizers	• Acids • Bases • Oxidizers
Gas cylinder		Identifies gases under pressure, also known as compressed gas	• Inert gases • Toxic gases • Flammable gases • Oxidizing gases

Name	Pictogram	Description	Examples
Health hazard		Identifies materials that are harmful to human health including those that are capable of causing cancer (carcinogens) or mutations (mutagenicity).	Material that are: • Carcinogens • Mutagenicity • Reproductive toxicity • Respiratory sensitizer • Toxic to specific organs • Aspiration toxicity
Environmental hazard		Identifies materials that have an aquatic toxicity and thus are harmful to the environment	Various materials that are toxic to aquatic organisms
Exclamation mark		Provides a general warning about substances that are harmful	Materials including: • Irritants (skin and eye) • Skin sensitizers • Acute toxicity (harmful) • Narcotic effects • Respiratory tract irritant • Hazardous to ozone layer
Flame over circle		Identifies oxidizers - substances that increase the burning of fuels (combustibles and flammables) by increasing the oxygen levels available to the fuels	• Organic peroxides Other oxidizers e.g. concentrated nitric acid, sodium hypochlorite (bleach), oxygen, concentrated or heated perchloric acid, concentrated sulfuric acid, concentrated hydrogen peroxide
Biohazardous infectious		Identifies biological hazards, also known as biohazards (biological substances that pose a threat to the health of living organisms)	• Medical waste • Microorganisms, viruses or toxins that can affect human health. • Can also include substances harmful to other animals

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 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 vapors, or as milligrams per liter or cubic meter of air (mg/L or mg/m^3) 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.

Exposure values (TWAEV, STEV, CEV)

Exposure values are established concentrations that, if not exceeded, will not generally cause adverse health effects to the person exposed. 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)

Flash point

Flash point is the lowest temperature at which a liquid 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. Common laboratory solvents such as acetone, toluene, acetonitrile and methanol all have flash points that are below room temperature.

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.

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 burn or explode 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 ignite. Above this limit, the mixture is too "rich" for ignition i.e. the mixture contains enough fuel, but insufficient oxygen.

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 or combustible laboratory solvents.

Solvent	Flash Point * (°C)	LEL * (% by volume)	Autoignition temp** (°C)	TWAEV * (ppm)
acetic acid, glacial	39	4.0	427	10
acetone	-18	2.5	465	250
acetonitrile	5.6	3.0	524	20
diethyl ether	-45	1.9	160	400
ethanol, absolute	13	3.3	363	1000
ethyl acetate	-4.4	2.0	426	400
methanol	11	6.0	464	200
n-pentane	-49	1.5	260	120

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

7. Hazard Identification and Control

A workplace hazard is any equipment, procedure, material, environment or situation that may cause personal injury or illness, or environmental or property damage. Management of hazards can effectively be accomplished through the following process:

1. Anticipate
2. Recognize
3. Evaluate
4. Control

Every effort should be made to anticipate hazards during the design stage of work to minimize the hazards that need to be managed. Workplace hazards are to be identified and evaluated based on the degree of risk and exposure using tools such as:

- Review of the experiment or process and the planned safety precautions;
- Detailed inspection and/or testing of the hazard;
- Physical observation by trained individuals;
- Investigations of near misses;
- Conducting interviews with workers;
- Reviewing records such as operating manuals, methods, injury reports or minutes of Local Joint Health and Safety Committee meetings.

Once the assessment of the hazard has been completed, appropriate control measures are to be implemented as appropriate to the situation. Below are control strategies, listed in order of effectiveness. The best controls are those that are mistake-proof, being effective independent of the worker, e.g. safety interlocks on centrifuges that prevent the lid from being opened until the rotor has stopped spinning. Management of hazards will often involve a combination of the following strategies.

- Elimination/Substitution e.g. use of digital rather than mercury thermometers
- Engineering Controls e.g. fume hoods, safety interlocks
- Administrative controls, e.g. standard operating procedures
- Personal protective equipment e.g. safety glasses

8. General Laboratory Safety

8.3. Good Work Practices/General Safety

Lab work requires focus and undivided attention to prevent accidents are and provide for appropriate response in the event of an emergency.

- Know and understand the hazards, safe handling and operating procedures of the materials, equipment and methods being used. Review MSDSs/SDSs, equipment manuals and standard operating procedures as applicable.
- Avoid the use of personal audio devices and cell phones as these may disrupt concentration as well as prevent recognition of an emergency alarm, call for help etc.
- Report missing labels to laboratory supervisors. Never use substances of unknown identity.
- Consult your supervisor before proceeding with any aspect of your experimentation that you are unsure of (e.g. safe handling of material, operation of equipment, experimental technique etc.
- Mouth pipetting is strictly prohibited.
- Avoid storage of personal belongings (e.g. bags, coats etc.) in the lab except in designated areas free of hazardous materials.
- Never "sniff-test" a chemical.
- Running, horseplay and practical jokes are prohibited.
- Report accidents and near misses promptly to your supervisor.

8.4. Housekeeping

Good housekeeping practices are essential in every workplace. However, they become especially important in the laboratory environment where spills from broken reagent containers, sample bottles, reaction vessels, etc., can create unnecessary exposures to potentially hazardous substances. Laboratory personnel are to keep their work spaces as clean as the work allows. Laboratory supervisors are responsible for the overall cleanliness of the lab. The following housekeeping points will help lead to a neat, organized, efficient and, most importantly, safe work environment.

- Clean dirty glassware on a regular basis and don't allow to accumulate in sinks, on benches or in surrounding areas;
- Store reagents appropriately when not in use;
- Dispose of old or unused samples and reagents in a timely manner;
- Store materials or equipment such that it does not obstruct aisles, fire extinguishers, safety showers, eye wash stations or another emergency equipment;

- Keep items are away from the edge of bench tops, so they cannot easily be knocked off;
- Do not allow stored items, to project beyond the front of shelf or counter limits;
- Avoid storage of large, awkward, heavy or breakable items on high shelves;
- Clean up experiments upon completion and tidy all work i accordingly at the end of each day;
- Store apparatus used infrequently when not in use;
- Recycle or appropriately dispose of equipment no longer used;
- Secure electrical cords, hoses, and air lines

8.5. Food storage and consumption

Storage and consumption of food and/or drink (including water) within the research, teaching or service laboratories is strictly prohibited. The use of laboratory equipment including, but not limited to, glassware, refrigerators, freezers, microwaves and other ovens etc., to store or prepare food is strictly prohibited. Ice from laboratory ice makers is not to be consumed.

8.6. Smoking

Smoking is strictly prohibited in all University buildings including laboratories and in or near all chemical or waste storage areas. Tobacco products are not to be brought into the laboratory.

8.7. Personal Hygiene

To prevent unforeseen accidents or exposures, the following points are to be followed to maintain personal hygiene while working in the laboratory.

- Tie back or otherwise secure long hair. This is important to prevent exposures from hazardous materials as well as to prevent the hair from becoming entangled in a moving part of equipment. This is also good practice to prevent contamination of research samples.
- Remove Neck ties or otherwise secure (preferably behind a lab coat).
- Avoid touching your face or hair while wearing gloves.
- Wash hands thoroughly after removal of gloves and/or after working with hazardous materials.
- Application of cosmetics or lip balm in the lab is prohibited.

8.8. Working Alone

It is not advisable to conduct laboratory work alone. These situations present additional hazards to personnel as they may find themselves isolated and without help in the event of an emergency.

In the event that a true working alone, situation is warranted and following a hazard review of the work to be done as well as a review of hazards in the laboratory itself, the supervisor may allow specific projects or tasks to be performed while working alone. The supervisor is to be made aware of dates, times and locations of all working alone situations. When working alone, laboratory personnel are encouraged to decide to have someone check-in with them regularly either in person or by phone.

WorkAlone is a feature to the SAFE Gryphon App. WorkAlone is a way for anyone to virtually check in with a family member, friend, co-worker or anyone you choose if the user is working late at night or is working alone or would feel safer if they were being checked up on during this time. WorkAlone is fully customizable and allows the user selects how long the work alone session will last and how many times a "check in" is required.

The following circumstances are **examples** of situations where working alone situations are prohibited:

- Work involving acutely toxic substances (e.g. sodium cyanide);
- Work involving dangerously reactive substances (e.g. peroxides, pyrophorics or water reactives);
- Hot work (i.e. work involving an open flame in a lab where flammable substances are present); and
- Work involving the use of highly corrosive substances (e.g. hydrofluoric acid).

8.9. Unattended Procedures

Certain instrumentation configurations are designed to routinely operate unattended, e.g. liquid and gas chromatographs equipped with autosamplers, centrifuges, autoclaves etc. However non-routine, unattended laboratory procedures should be minimized. If a procedure is to be left unattended, prior review of the hazards with consideration of the materials and procedures being used is to be completed. Only procedures that are deemed to be safe if left unattended may continue without personnel present in the laboratory. The following are requirements for non-routine unattended laboratory procedures.

- Unattended procedures are to be visited periodically and a sign posted outlining the procedure being used with the contact information of the person responsible for the work. The sign is to indicate the start date and time along with the expected completion date and time of the work.
- Unattended procedures using cooling water are to have hoses securely attached and the water adjusted to the minimum flow necessary. Ensure plumbing drains are clear before leaving the procedure.
- Unattended heating is only to be done using heating equipment that reliably maintains stable temperatures.

- If heating is being performed, flammable materials are to be removed from the area.
  This includes flammable hazardous wastes.
- Experiments should be miniaturized if possible.
- Sash doors are to be closed on all fume hoods.

8.10. Visitors in the laboratory

Due to the potential hazards present in laboratory settings, to protect the integrity of the research being performed and for security of the equipment and supplies contained within, visitors to laboratories should be escorted. Supervisors are responsible for considering and approving exceptions to this as appropriate. Careful consideration of the hazards is to be done prior to opening up a laboratory for the purposes of an open house. Should a laboratory be opened to the public, a representative of the laboratory should be present at all times.

Note that documented permission from a parent or guardian and departmental approval may be required for entrance of a minor into a laboratory, e.g. the “Take your kids to work” program. Contact EHS at x53282 for details.

9. Personal Protective Equipment

Personal protective equipment (PPE) is to be used according to the hazards presented in the specific laboratory as determined by the laboratory supervisor. Laboratory areas should be clearly labelled as to the personal protective equipment required, to allow for clear communication to any individual entering the area. Personal protective equipment is not to be used in place of engineering controls such as fume hoods but is to be used diligently to provide supplemental protection.

This section provides minimum standards for personal protective equipment.

9.3. Eye and face protection

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

- Minimum eye protection worn in the laboratory 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, lab coats, etc.

While wearing contact lenses is not prohibited in laboratories, 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 laboratory situations may be found at the following websites:

- Canadian Centre for Occupation Health and Safety – OSH Answers
- CDC-NIOSH – Contact Lens Use in a Chemical Environment

9.4. Hand protection

Selection of Gloves

Gloves are to be used to provide protection against chemical or biological hazards and exposure to extreme temperatures, abrasions or lacerations. Table 3 provides a general guideline to describe appropriate hazard-based selection of gloves.

Table 3 – Guide to Hazard Based Glove Selection

HAZARD	DEGREE OF HAZARD	PROTECTIVE MATERIAL
Abrasion	Severe	Reinforced heavy rubber, staple-reinforced heavy leather
	Less Severe	Rubber, plastic, leather, polyester, nylon, cotton
Sharp Edges	Severe	Metal mesh, staple-reinforced heavy leather, Kevlar™, aramid-steel mesh
	Less Severe	Leather, terry cloth (aramid fiber)
	Mild with delicate work	Lightweight leather, polyester, nylon, cotton
Chemicals and fluids	Risk varies according to the chemical, its concentration, and time of contact among other factors. Refer to the manufacturer, or product MSDS. See section 7.2.1.1	**Dependant on chemical.** Examples include: Natural rubber, neoprene, nitrile rubber, butyl rubber, PTFE (polytetrafluoroethylene), Teflon™, Viton™, polyvinyl chloride, polyvinyl alcohol, Saranex™, 4H™, Barricade™, Chemrel™, Responder™, Trellchem™
Cold		Leather, insulated plastic or rubber, wool, cotton
Electricity		Rubber-insulated gloves tested to appropriate voltage (CSA Standard Z259.4-M1979) with leather outer glove
Heat	Greater than 350°C	Zetex™
	Up to 350°C	Nomex™, Kevlar™, heat-resistant leather with linings
	Up to 200°C	Nomex™, Kevlar™, heat-resistant leather, terry cloth (aramid fiber)
	Up to 100°C	Chrome-tanned leather, terry cloth
General Duty		Cotton, terry cloth, leather
Product Contamination		Thin-film plastic, lightweight leather, cotton, polyester, nylon
Radiation		Lead-lined rubber, plastic or leather

Modified table taken from http://www.ccohs.ca/oshanswers/prevention/ppe/gloves.html, November 15, 2005

Chemical

No one glove material is appropriate for protection against all potential chemical exposures 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 SDS 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 a glove material based on the specific chemical(s) being handled.

- Ansell Chemical Resistance Guide
- Ansell Specware Glove Selection System

Table 4 – 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/cs-admin/oehs/ih/Glove-Selection-Chart.cfm, October 24, 2007

Use and Care of Gloves

The following guidelines should be considered when using gloves:

- Inspect for damage prior to use. Any sign of deterioration, such as holes, tears or discoloration, should prompt immediate replacement of the gloves.
- Ensure appropriate fit and thickness to allow for the required tactile sensitivity.
- Ensure appropriate length to provide adequate protection of the arm.
- To remove: pull the gloves inside out to prevent exposure to any contaminants during removal.
- Remove gloves prior to touching computers or phones, opening doors or otherwise contacting items that would be expected to be free of contamination (either biological or chemical).
- 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 laboratory or work area. Manufacturer's instructions are to be followed as applicable.

9.5. Body Protection – Lab coats and aprons

Lab coats and long pants are to be worn whenever hazardous chemicals, radiological or biological substances are being used or handled. Shorts do not provide protection of the lower legs.

- Lab coats with snaps are preferred over lab coats with buttons to allow for quick removal of the clothing in the case of an emergency.
- Lab coats should have snaps fastened at all times while working in the lab.
- Lab coats are to be stored in the laboratory area to prevent biological or chemical contamination of non-lab areas.
- Lab coats are to be cleaned regularly and laundered separately from all other clothing.

Aprons should be worn in addition to lab coats in situations where there is an elevated splash hazard or the risk of injury following a splash is high. Acid resistant aprons should be worn when working with large volumes (i.e. greater than four litres) of concentrated inorganic acids e.g. HCl, H_2SO_4. The use of aprons alone is discouraged as they provide inadequate protection of the arms.

Coveralls are generally not recommended in laboratory situations where flammable or corrosive liquids are being handled because of their potentially difficult removal should contamination occur.

9.6. Respiratory Protection

This section is to be used in conjunction with Respiratory Protection Programs Policy There are several types of respiratory protection that are appropriate for use in a laboratory setting depending on the work being performed. 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 most respirators and is provided by EHS. Contact the Occupational Hygienist at x54855 for more information.

Disposable dust masks are to be used when nuisance quantities of non-toxic dust are generated from the material(s) being used.

For situations where the air contains unacceptable or unknown concentrations of vapours or fine air-borne particles, a respirator may be required. These respirators are to be chosen and maintained with appropriate fit-testing and monitoring as required.

Respirators are to be stored such that they do not accumulate dust, i.e. in a drawer or box that allows sufficient ventilation to prevent growth of bacteria or mold. Respirators should be labelled with the name of the user. When being used, detection of an odour is confirmation that the respirator is either not providing a good fit or that the filter cartridges have expired.

9.7. Footwear

Closed-toed, closed-heeled shoes constructed of a resistant material (preferably leather) are required while in all laboratory areas. Steel-toed, chemical resistant safety shoes may be warranted in specific cases as determined by the laboratory supervisor. Sandals do not provide adequate protection and are not to be worn in any laboratory situation. High-heeled shoes are strongly discouraged as they increase the potential for tripping or falling.

9.8. Hearing Protection

Equipment such as grinders or homogenizers in laboratories may warrant the use of hearing protection. Hearing protection may consist of ear plugs or ear muffs depending on the amplitude and frequency of the noise. Hearing protection must be worn in areas where the eight-hour time weighted average noise level is greater than 85 dB. Noise monitoring can be performed by EHS personnel if required. Contact the Occupational Hygienist at x54855 for details. In cases where hearing protection is required, routine audiometric surveillance is conducted by OHW. See the Audiometric Health Surveillance program for further information

10.3. Training/Laboratory Orientation

As part of orientation, the supervisor or designate shall familiarize all individuals 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

Personnel responsible for or working within a laboratory are strongly encouraged to participate in fire extinguisher training. This training is offered through the University's Fire Prevention office x52071

10.4. Emergency Equipment

Fire Extinguishers

Discussed further in Section 10.2.

Emergency Showers and Eyewash Stations

Emergency (safety) showers and eyewash stations are the primary methods for decontamination after exposure to a hazardous substance. Treatment in the first 15-20 seconds following an exposure is critical to prevent serious injuries, particularly when working with a corrosive substance.

- Design and construction of eyewash stations and emergency showers are to meet the requirements in American National Standards Institute (ANSI) standard Z358.1-2014.
- Eyewash stations and emergency showers are to be readily available and easily accessible for each laboratory, i.e. less than 30 metres from a hazard and accessible within less than 10 seconds.
- Eyewash stations and emergency showers are to be unobstructed at all times.
- Emergency showers and eyewash stations should have additional signage to prominently display their location.
- Eyewash stations are to be checked by laboratory personnel at least once a week to verify operation and flush the pipes.
- Full inspections of emergency showers are completed quarterly by Physical Resources.

- Any dysfunction of an emergency shower or eyewash station is to be reported to Physical Resources immediately at x53854.

GUIDELINES ARE BASED ON ANSI STANDARD Z358.1-2014.

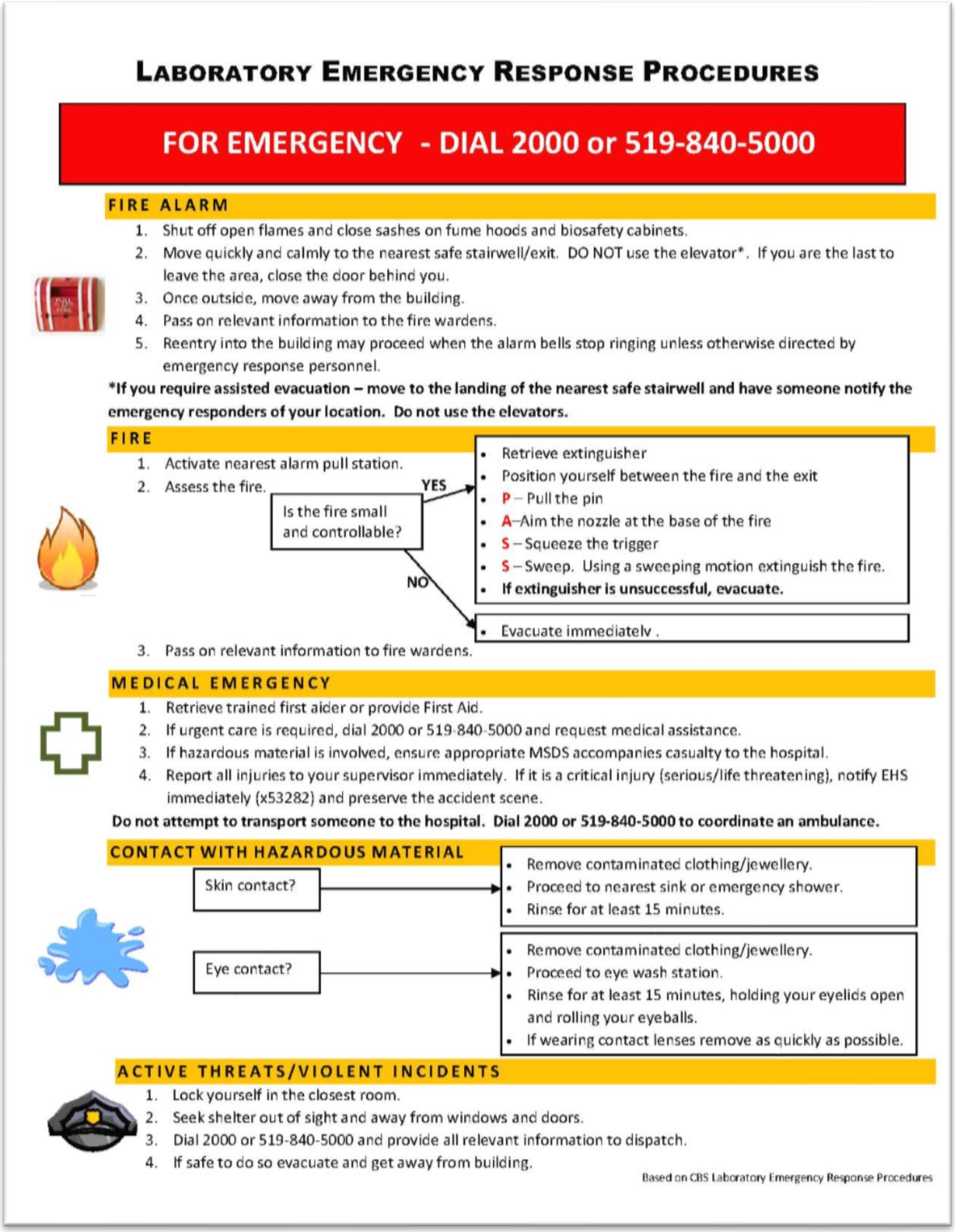
Spill Kits

Discussed further in Section 12.2.

10.5. Laboratory Emergency Procedures

Laboratory emergency response procedures are to be posted in each lab.

Figure C - Laboratory Emergency Response procedures poster



LABORATORY EMERGENCY RESPONSE PROCEDURES

FOR EMERGENCY - DIAL 2000 or 519-840-5000

FIRE ALARM

1. Shut off open flames and close sashes on fume hoods and biosafety cabinets.
2. Move quickly and calmly to the nearest safe stairwell/exit. DO NOT use the elevator*. If you are the last to leave the area, close the door behind you.
3. Once outside, move away from the building.
4. Pass on relevant information to the fire wardens.
5. Reentry into the building may proceed when the alarm bells stop ringing unless otherwise directed by emergency response personnel.

***If you require assisted evacuation – move to the landing of the nearest safe stairwell and have someone notify the emergency responders of your location. Do not use the elevators.**

FIRE

1. Activate nearest alarm pull station.
2. Assess the fire.

Is the fire small and controllable?

YES

- Retrieve extinguisher
- Position yourself between the fire and the exit
- P – Pull the pin
- A–Aim the nozzle at the base of the fire
- S – Squeeze the trigger
- S – Sweep. Using a sweeping motion extinguish the fire.
- **If extinguisher is unsuccessful, evacuate.**

NO

- Evacuate immediately .

3. Pass on relevant information to fire wardens.

MEDICAL EMERGENCY

1. Retrieve trained first aider or provide First Aid.
2. If urgent care is required, dial 2000 or 519-840-5000 and request medical assistance.
3. If hazardous material is involved, ensure appropriate MSDS accompanies casualty to the hospital.
4. Report all injuries to your supervisor immediately. If it is a critical injury (serious/life threatening), notify EHS immediately (x53282) and preserve the accident scene.

Do not attempt to transport someone to the hospital. Dial 2000 or 519-840-5000 to coordinate an ambulance.

CONTACT WITH HAZARDOUS MATERIAL

Skin contact?

- Remove contaminated clothing/jewellery.
- Proceed to nearest sink or emergency shower.
- Rinse for at least 15 minutes.

Eye contact?

- Remove contaminated clothing/jewellery.
- Proceed to eye wash station.
- Rinse for at least 15 minutes, holding your eyelids open and rolling your eyeballs.
- If wearing contact lenses remove as quickly as possible.

ACTIVE THREATS/VIOLENT INCIDENTS

1. Lock yourself in the closest room.
2. Seek shelter out of sight and away from windows and doors.
3. Dial 2000 or 519-840-5000 and provide all relevant information to dispatch.
4. If safe to do so evacuate and get away from building.

Based on CBS Laboratory Emergency Response Procedures

It is the laboratory supervisor's responsibility to consider and plan for possible laboratory emergency situations including those discussed below. These plans are to be documented and effectively communicated to all other lab personnel and are to provide specific information related to the emergency procedures of the laboratories with consideration of the particular materials, equipment, samples, procedures, personnel, etc. Laboratory supervisors are responsible for ensuring that there are appropriate evacuation procedures for persons with disabilities.

All staff and students are to participate in emergency drills as applicable and respond to all fire alarms by promptly following emergency procedures and evacuating the building. Elevators are not to be used during an evacuation. Buildings that have been evacuated may be re-entered once the alarm bells have stopped sounding unless otherwise directed by emergency response personnel.

Fires

Despite comprehensive preventative measures, fires may occur in the lab. In the case of fire:

- Activate fire alarm pull station.
- Call for emergency response. On the Guelph campus call x52000 or 519-840-5000. At other locations including regional campuses, research stations, and Lab Services, AFL contact 911.
- Try to extinguish the fire if you can do so without putting yourself or others at undue risk.
    - Locate a fire extinguisher appropriate for the type of fire.
    - Position yourself between the fire and the exit, so that you always have a route out of the area.
    - Pull the pin.
    - Aim the extinguisher nozzle or hose at the base of the flame.
    - Squeeze the trigger.
    - Sweep. Using a sweeping motion, extinguish the fire.
- Remember that portable extinguishers contain only enough material for 8-45 seconds depending on their size.
- Liaise with emergency responders to communicate all relevant information.
- Seek medical attention if required.

If your clothing catches on fire:

- *Stop*
- *Drop* to the floor
- *Roll* to smother the flames.
- Get to the safety shower and rinse with copious amounts of water.

- Seek medical attention.

If another person's clothing catches on fire:

- Assist them in the Stop, Drop and Roll.
- Assist in smothering the flames by covering them in a fire blanket, clothing or other appropriate item.

Fire safety is discussed in more detail in Section 11.

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

with medical professions should be initiated after any chemical contact:

  - For employees, contact OHW x 52647
  - For students, contact Student Health Services x 52131

Cuts and Needle Stick Injuries

First aid treatment for minor scrapes, scratches, cuts, or needle stick injuries include the following:

- Apply gentle, direct pressure with a clean cloth or bandage to stop bleeding. If bleeding profusely, elevate injury above the level of the heart.
- Clean the wound with running water. Clean surrounding area with mild soap and running water, removing any dirt.
- Cover with a bandage or gauze square attached on all sides with adhesive tape. Avoid removing blood-soaked bandages as this could damage a fresh clot – add additional bandages over top of the originals if necessary.
- Medical attention beyond first aid is required for:
    - Deep cuts that may require stitches.
    - Wounds caused by dirty or soiled objects to determine whether or not tetanus immunization is necessary.
    - Wounds caused by an object that has contacted blood or body fluids to determine if immunization or post-exposure prophylaxis is required.
    - Any injury that doesn't show signs of healing or you notice redness, swelling, warmth or drainage.

For more serious lacerations:

- Call for emergency response. At the Guelph campus call x52000 or 519-840-5000. At other locations including regional campuses, research stations, and Lab Services, AFL contact 911.
- Attempt to stop the bleeding by elevating injured area above the level of the heart and applying direct pressure with a clean bandage or cloth.

Follow up with medical professions should be initiated after any needle injury:

- For employees, contact OHW x 52647
- For students, contact Student Health Services x 52131

Poisoning

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

- Call for an ambulance for serious poisoning. At the Guelph campus call x52000 or 519-840-5000. At other locations including regional campuses, research stations, and Lab Services, AFL contact 911.
- 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 SDS for the toxic substance.
- Always ensure that the victim receives medical attention, even if the exposure seems minor.

Follow up with medical professions should be initiated after any work-related chemical exposure:

- For employees, contact OHW x 52647
- For students, contact Student Health Services x 52131

Power failure

Laboratory supervisors should consider the consequences of prolonged loss of power to equipment, including refrigerators and freezers, in each laboratory.   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, fume hood ventilation may be lost or reduced. See Section 13.

Domestic Water Interruption

In the event of a domestic water interruption:

- Notify Physical Resources x53854 on the Guelph Campus (or Facilities personnel at other locations).
- Stop all work with or near hazardous materials until water is restored. Loss of water translates to inoperable emergency showers, eyewash stations and taps.

Flooding

Laboratory personnel should be aware of the location of the water shutoff for the lab. Electrical plugs, power bars etc. should not be stored directly on the floor for protection against flooding.

- Stop source of flood if possible (e.g. turn off tap, shut off water supply to the lab etc.). If the source is unknown, contain flooding if possible.
- If the source of the flooding is unknown, the flood is uncontrollable, or significant damage is sustained:
- Guelph campus
  - during business hours contact Physical Resources at x53854.
  - outside of normal business hours r x52000 or 519-840-5000 if.
- Other locations
  - Contact Facilities personnel at other locations
- If at any time you feel that your safety is being compromised, evacuate the lab and call for emergency response. At the Guelph campus call x52000 or 519-840-5000. At other locations including regional campuses, research stations, and Lab Services, AFL contact 911.

Chemical Spills

It is responsibility of the laboratory supervisor to train all lab personnel in spill response and equip the lab with proper spill response kit. It is important that you respond to spills only 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 12 for detailed information on training, spill kits, spill classification, response and reporting requirements.

Biological Spills

See the Biosafety Manual for appropriate response procedures.

Natural Gas Leak

Laboratory personnel should be aware of whether or not the lab and building are supplied with natural gas, and if so where shutoff(s) are located for the lab so that it can be turned off in the event of a leak. If a natural gas leak is suspected:

- Turn off the gas supply, if accessible.
- Evacuate the lab.
- Activate fire alarm pull station.

Call for emergency response. At the Guelph campus call x52000 or 519-840-5000. At other locations including regional campuses, research stations, and Lab Services, AFL contact 911.

Fume hood/Biosafety Cabinet Malfunction

If fume hoods or biosafety cabinets become non-functional:

- Stop conducting any work requiring fume hood/biosafety cabinet ventilation.
- Cap/seal all containers in the fume hood/biosafety cabinet appropriately.
- Close sash.
- Notify other lab personnel of the malfunction.
- Contact Physical Resources at x 53854 on the Guelph campus during work hours or contact facilities personnel at other locations.
- If an odour begins to accumulate, all personnel are to evacuate the lab until ventilation is restored.
- If a hazardous leak of chemical, vapors or biohazardous aerosols has resulted, activate the evacuation alarm and evacuate the building.

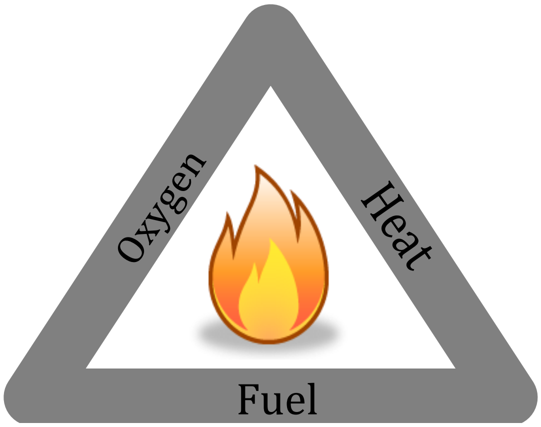
11. Fire Safety

Fire is a very plausible emergency situation that can occur in the laboratory. It is imperative that all reasonable precautions are taken to prevent fires and provide for an understanding of the types of fires, how fires begin, how they are sustained and how they are controlled.

11.3. Fire Triangle

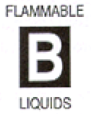
Fire can be described using the fire triangle:

Figure D – Fire safety triangle



Fire cannot begin or be sustained without the three ingredients pictured above and therefore the removal of any one of these items leads to the basis of fire control.

Table 5 - Classes of Fires and Extinguishers

Class of Fire	Class Symbol	Description of the Materials involved
Class A Ordinary Combustibles		Ordinary Combustibles e.g. paper, wood, rubber, many plastics
Class B Flammable Liquids		Flammable Liquids e.g. flammable and combustible liquids, oils, greases, tars, oil based paints, flammable gases, lacquer.
Class C Electrical Equipment		Energized Electrical Equipment e.g. wiring, fuse boxes, circuit breakers, plugged-in electrical equipment.
Class D Combustible Metals		Combustible Metals e.g. sodium, lithium, aluminum, titanium.

The type of fire extinguisher used to control the fire is dependent on the type of fire itself. Extinguishers are rated A, B, C, and D or combinations thereof. Each laboratory should have access to an ABC rated extinguisher. Laboratories using combustible metals may need to have a D rated extinguisher. Contact Fire Prevention at x52071 or via email for further guidance.

Fire extinguishers should be conspicuously located near the exit(s) of the laboratories, be unobstructed and easily accessible at all times. Any use of a fire extinguisher must immediately be reported to Fire Prevention at x52071 or via email so that the extinguisher can be recharged or replaced.

11.4. Maintenance and Inspection of Fire Extinguishers

Fire extinguishers are to be maintained and inspected in accordance with Policy 851.02.03. Annual inspections of the fire extinguishers are coordinated through Physical Resources. Laboratory supervisors are responsible for ensuring that monthly checks are performed. Monthly checks are to include ensuring that:

- the location of the fire extinguisher is conspicuous;
- the unit does not appear or feel empty;
- the locking pin is intact and sealed;
- the pressure is within the correct range, if a pressure gauge is present;

- there is no obvious physical damage, corrosion or leakage;
- the nozzle is not clogged; and
- the area around the fire extinguisher is clear of obstructions.

These monthly checks are to be documented on tags attached to the extinguishers. Any deficiencies are to be reported to Fire Prevention at x52071 or via email

12. Chemical Spill Prevention and Preparedness

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

12.3. Training

Laboratory supervisors are to provide training to lab personnel in appropriate chemical spill response specific to the chemicals contained within their laboratory. Training must be documented, retained in the lab and refreshed regularly.

12.4. Spill Kits

Each laboratory using hazardous chemical materials shall have easy access to a chemical spill kit that is prominently located, readily visible and identifiable. A spill kit may be shared between laboratories providing that all personnel are aware of its location and it is easily accessible always. Exact contents of a spill kit should be based on the hazardous properties of the materials present. Table 6 lists the recommended minimal requirements for spill kits.

Table 6 – 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 ○ Acids, including hydrofluoric acid ○ Bases ○ Flammable liquids ○ Formaldehyde ○ 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 to you may want to add to your chemical spill kit, depending on the hazards present in the lab 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 7 – 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 in the laboratory (including mercury in thermometers), a mercury spill kit shall be available. Table 8 lists the recommended contents for a mercury spill kit.

Table 8 – 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. Inspections should be performed monthly and documented, e.g. on an inspection tag. Inspections should include verifying contents and ensuring that supplies are unexpired and in good condition.

12.5. Spill Classification

Complex spills

Complex spills are those, which involve chemicals or quantities of materials in excess of those outlined in Table 9, and require further assistance for clean-up:

Table 9 – 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 laboratory 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. Laboratory 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 laboratory personnel.

12.6. Spill Response

Complex Spill Response:

- Evacuate the lab, close doors, restrict the area, and notify others in the area of the spill.
- Call x52000 or 519-840-5000. University of Guelph Campus Police will coordinate spill clean-up responses with EHS.
- 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 Bunsen burners, etc.)

    - Restrict or contain the flow of the spilled liquids.
- 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, SDS, identity of other equipment and hazardous materials in the lab.

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 lab of the spill.
- Select and put on all appropriate PPE. It is essential to properly protect yourself.
- Promptly attend to the spill according to Table 10. If unsure of the proper clean-up procedure, contact your supervisor for guidance. EHS is also available to provide guidance at x 53282.

Table 10 – 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.
Caustics, liquid	• If available, neutralize with citric acid or commercially available caustic 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.
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; 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 (dishwasher detergent) or commercial leak detection solution. If leak is obvious omit this step. • If leak continues, and gas is inert, evacuate lab 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. • Depending on the room size and the amount of gas, an oxygen deficient atmosphere may develop. Take particular care to ensure your safety.
Hydrofluoric Acid	• Wear protective clothing including an appropriate respirator and have the Hydrofluoric Acid antidote readily available. • Slowly apply solid calcium carbonate working from the outside in. • After the acid is absorbed, mix thoroughly with plastic scoop to ensure neutralization. • Use pH paper to test completeness of neutralization. • Add more neutralizer if necessary. • Proceed as per general liquid spill clean-up.

Mercury Spill Response

It is recommended to eliminate all mercury from the labs. If mercury is present within the lab, including within thermometers, it is the responsibility of the laboratory supervisor to make available a proper mercury spill kit and train lab personnel in mercury spill response procedures and safe work practices. To be prepared for a mercury spill, lab personnel should have:

a) received mercury spill response training specific to the laboratory environment. Training must be documented and refreshed on at least an annual basis
b) access to mercury related SDS.
c) access to sufficient quantities and types of appropriate spill control materials
d) read and understand this procedure

There are two types of mercury spills:

Incidental spill – spill of **less than 30 ml of mercury,** usually resulting from the breakage of a thermometer in a laboratory setting. This spill can be responded to by trained laboratory personnel.

Complex spill – spill of **more than 30 ml of mercury** and/or where mercury has been spilled to a drain, to a heated surface, to a non-mobile porous surface (carpet), to an inaccessible area (floor cracks, beneath or inside of cabinets, etc.).

Mercury Spill Cleanup Procedure

- Immediately alert area occupants and lab supervisor of the spill incident.
- Attend to any people who may be contaminated.
- Refer to mercury MSDS/SDS and follow first aid procedure. Evacuate the area if spill is classified as complex. Complex spills should be reported immediately to EHS x 53282 during work hours and to Campus Police x52000 or 519-840-5000 after work hours. Interim measures should be taken to prevent unnecessary exposure (shut off oven or heating device if one is involved, vacate the spill area, close doors, secure the area, etc.).
- Placard the door to the laboratory with the following words, "Mercury Spill-Do Not Enter."
- Contain incidental spill and restrict admission to only those cleaning up the spill.
- Access the Mercury Spill Kit (for recommended content refer to section 11 or purchase commercially available kits)
- Put on personal protective equipment: lab coat, safety goggles and a pair of nitrile gloves
- Review the mercury SDS

If available, follow instructions from the commercial spill kit. Otherwise follow the steps below:

- Contain the spill
- Spray mercury suppression spray into immediate air space
- Push all mercury beads together and transfer into plastic disposal container using respirator
- Cover spill area with mercury amalgamation powder or sulfur powder. Allow for amalgamation process (the mixture will solidify or the applied sulfur to a mercury spill will turn from yellow to brown as it forms mercuric sulfide
- Transfer the amalgam or mercury sulfide into disposal container
- Decontaminate area with mercury decontamination liquid, wipes or sponges
- Cover the surface with mercury indicator powder if applicable and assess the presence of remaining mercury
- Transfer all wipes, sponges, gloves etc. into plastic bag and dispose of as hazardous waste
- Label disposal container with yellow hazardous waste tag signed “Mercury Spill Residue” and proceed with hazardous waste disposal procedure
- Wash hands, arms and face Additional

Precautions:

Never use a regular vacuum to clean up mercury or to go over spill areas after they have been cleaned up. Be alert to “tracking.” It may be necessary to use disposable shoe covers if the spilled mercury has impacted a large area. Dispose of any contaminated cloths or footwear by placing them in a sealed plastic bag for disposal. Do not use a broom to sweep up the mercury. It can break the mercury into smaller beads, spreading them. Do not pour mercury down the drain. All mercury contaminated materials must be submitted for disposal as hazardous waste.

Contact EHS at x 53282 for environmental monitoring and clean up guidance if airborne exposure is of concern because of unique circumstances or spill size.

13. Fume Hoods and Biosafety Cabinets

Fume hoods and biosafety cabinets are critical pieces of laboratory equipment and, if used and maintained properly, are the most common and effective engineering controls in place to protect laboratory personnel against exposure to hazardous materials.

13.3. Chemical Fume hoods

All work involving hazardous chemicals should be performed within an appropriate chemical fume hood or ventilation system. Below is a diagram of a typical fume hood system.

Figure E – Diagram of standard fume hood system

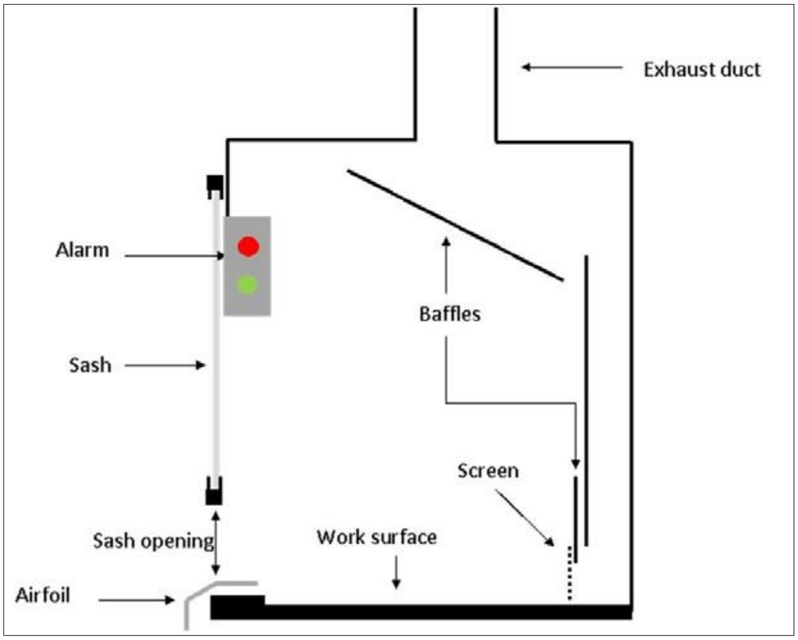


Figure F – Diagram of low flow (high performance) fume hood system

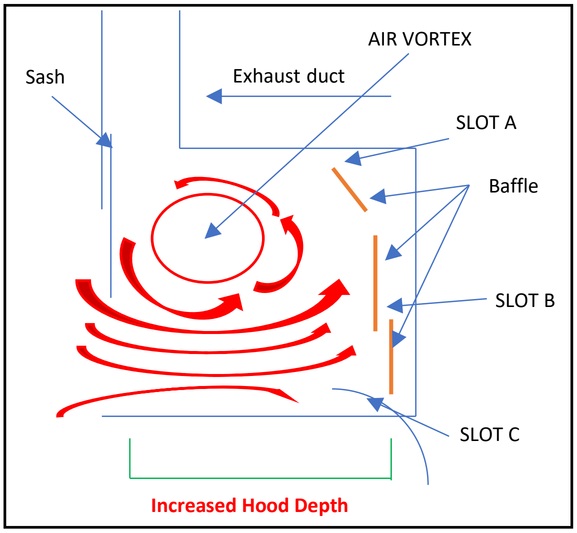


Table 11 – Use and Characteristics of Different Types of Laboratory Ventilation Systems

Type	Description	Purpose
Standard (Constant Volume)	Face velocity increases as the sash is lowered. Air flow directed to the outside through duct work.	Standard use
Bypass and Variable Volume systems (Constant velocity)	Face velocity remains constant as sash is lowered or raised. Air flow directed to the outside through duct work.	Standard use
Perchloric acid /Wash-down	Fume hood with wash-down system and constructed of materials resistant to reaction with perchloric acid. Either standard or bypass ventilation systems.	Use with perchloric acid only.
Self-contained	Air flow through filter (e.g. activated charcoal) and then recirculated into lab environment.	Suitable only for moderate work with substances with low toxicity/hazards. Filters must be chosen based on the chemicals to be used. The purchasing and use of these hoods is suitable in limited situations only.
Spot ventilating systems	Overhead, often moveable, constant flow systems that provide ventilation at very specific locations.	Suitable for moderate bench work with compounds of low toxicity/hazards, placement over instrument exhaust vents, etc.
Low flow (High Performance) fume hood	Designed to operate safety at lower face velocities i.e. 40 - 80 FPM rather than 100 FPM.	Standard use

Digesting with or boiling of Sulphur acid or significant usage of nitrates requires either neutralization of the vapors prior to exhausting through the fume hood or engineered adjustments to the design of the exhaust system for proper performance and longevity of the fume hood along with environmental regulatory compliance.

It is recommended that for normal use, fume hoods have face velocities of 80-120 FPM with a sash opening of 45 cm for effective protection from the materials being used. Newer fume hood models used on campus have face velocity ranging from 40-80 FPM with a sash opening of 45 cm often referred to as Low Flow High Performance fume hoods. Face velocities (as a performance measure) and fume hood alarms are checked annually. On the Guelph campus this program is coordinated by EHS.

On the Guelph campus, Physical Resources is responsible for routine preventative maintenance of fume hood exhaust fans. This includes inspection of pulleys, belts, alignment, flexible connections, dampers and operation of the fan as well as greasing of fan and motor bearings as applicable. Parts are replaced as required. If a problem with fume hood ventilation is identified, on the Guelph campus contact Physical Resources at x53854. At all other locations contact Facilities personnel. Biosafety Cabinets

Refer to the Canadian Biosafety Handbook for detailed information on types, use, operation and maintenance of biosafety cabinets.

Biosafety cabinets are designed to protect people and the environment from contamination by microorganisms as well as prevent contamination of the samples/cultures within the cabinet. The units have high efficiency particulate air (HEPA) filters to clean the supply and exhaust air.

Generally, biosafety cabinets should not be used for chemicals as they may have lower face velocities, recirculate the air within the cabinet leading to potential of vapor accumulation, and consist of filters that are not suitable for the collection of chemical vapors.

Proper Use of Fume hoods/Biosafety Cabinets

As mentioned, chemical fume hoods and biosafety cabinets are the primary source of protection against hazardous materials. For these critical pieces of equipment to be effective, the user is to:

- Confirm the ventilation exhaust system is operational and that the face velocity is acceptable for the intended use.
- Minimize the sash opening for maximum protection.
- Avoid storing chemicals/equipment in the fume hood/cabinet as this restricts the air flow. Flammable solvents/reagents are not to be stored in the fume hood/cabinet.
- Avoid blocking the baffle(s); place equipment upon legs if possible to maintain effective airflow.
- Work a minimum of 10 cm into the fume hood/cabinet.
- Never work in a fume hood/cabinet that is in alarm.

- Have an indication of the performance of the fume hood/cabinet, e.g. a continuous flow meter, alarm etc.
- Seal all waste, reagents, solvents and samples when not being used.
- Mount all permanent equipment appropriately.
- Ensure that all electrical connections are outside of the fume hood/cabinet
- Keep the fume hood/cabinet clean, uncluttered and tidy.
- Protect sinks protected from chemical spills, i.e. that in the event of a spill, it cannot go down the drain.
- Always close the sash when not in use.

Some ventilation systems on the Guelph campus are designed such that the exhaust will be reduced if sensors indicate that there is no use, i.e. the sash is closed, or after a specified time. While this is an important energy conserving initiative, it requires the participation of the fume hood users to be safe and successful. *Closing the fume hood sash is critical for this system to work***.** As well, it is critical that no one mistakenly works in a fume hood that has had its exhaust ventilation reduced.

14. Specific Chemical Hazards

All chemicals used in the laboratories at the University of Guelph should be used with the utmost caution according to good laboratory 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 manual to address the hazards and precautions of all chemicals that may be found in the University's laboratories 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 SDS or references such as the following should be consulted:

- NIOSH Pocket Guide to Chemical Hazards, September 2007 Publication number 2005-149
- Sax's Dangerous Properties of Industrial Materials 11th ed., Richard Lewis. Published by John Wiley and Sons Inc.
- Bretherick's Handbook of Reactive Chemical Hazards7th ed., Peter Urben. Published by Academic Press.

14.3. Flammables

Flammable materials present a serious hazard to laboratory personnel. Steps are to be taken for appropriate use, handling and storage.

- Ground and bond containers appropriately when transferring liquid from one container to another.

- Identify potential ignition sources and removed them from the area surrounding the flammable material.

Laboratories that store, use or handle flammable or combustible liquids are to conform to section 4.12 of the Ontario Fire Code. See section 10 for more information.

Note that due to the highly flammable nature of diethyl ether, diethyl ether extractions are to be performed only in facilities with additional fire suppression systems and ventilation, as well as intrinsically safe wiring.

14.4. 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.

Solids

Solid oxidizing agents can 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.

Liquids

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

- **Perchloric acid**. Use of perchloric acid should be avoided if possible. If its use is necessary, it must be done by personnel trained in specific handling procedures. Work involving heating of concentrated perchloric acid is to be performed in specialized, dedicated wash-down fume hoods (see section 12). Note that anhydrous perchloric acid and perchlorate crystals which may form around the cap of the container are shock- sensitive explosives.
- Nitric acid
- Chromic acid

- 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.

Use of Oxidizers

When using or storing oxidizers in the laboratory, 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. The use of corks or rubber stoppers is not permitted.
- 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.
- Reaction vessels containing oxidizers shall not be heated with oil baths.

Peroxygen Compounds

These are chemically unstable compounds including peroxides, hydroperoxides, and peroxyesters that have a violently reactive oxygen. 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. The following are compound types that can be expected to form peroxides upon prolonged exposure to light or air:

- Ethers
- Aldehydes, ketones
- Compounds containing benzylic, or allylic hydrogens
- Compounds with a vinyl or vinylidene group

The following is a partial list of compounds that can form peroxides:

Table 12 – Partial List of Chemicals that May Form Peroxides

Chemicals that form explosive levels of peroxides without concentration	
• Isopropyl ether • Butadiene • Chlorobutadiene • Potassium amide • Potassium metal	• Sodium amide • Tetrafluoroethylene • Divinyl acetylene • Vinylidene chloride
Chemicals that are a peroxide hazard on concentration	
• Acetal • Cumene • Cyclohexane • Cyclooctene • Cyclopentene • Diacetylene • Dicyclopentadiene • Diethylene glycol dimethyl ether (Diglyme) • Diethyl ether	• *p*-dioxane • Ethylene glycol dimethyl ether • Methyl acetylene • Methyl cyclopentane • Methyl i-butyl ketone • Tetrahydrofuran (THF) • Tetrahydronaphthalene (Tetralin) • Vinyl ethers

Modified table from Prudent Practices in the Laboratory, National Research Council, National Academies of the Press, 2011, Page 72.

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.
- Purchase with peroxide inhibitors whenever possible
- 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.
- Test solutions to confirm they are free of peroxides before concentration as described below.
- If concentration is necessary, avoid evaporating to dryness.
- Use a shield when evaporating or distilling any peroxide-forming compounds.

Testing for Peroxides

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

Alternatively, the following colorimetric test can be performed.

1. Prepare a 5 % (w/v) potassium iodide or sodium iodide aqueous solution. (5 g of KI or NaI per 100 mL of water).
2. Add a couple of drops of iodide solution prepared above to ~ 2 mL of glacial acetic acid.
3. Add ~ 2 mL of the solution in question to the ~ 2 mL of glacial acetic acid/iodide solution.
4. Yellow indicates a low concentration of peroxide (<0.01 %). Brown indicates a high/hazardous concentration of peroxide (> 0.01%).

Note that this test method should not be applied to solutions that may contain inorganic peroxides.

14.5. Corrosives

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

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, hydrofluoric acid* etc.
- Strong bases (aqueous sodium hydroxide, potassium hydroxide, ammonia, etc.)

- Strong dehydrating agents (phosphorus pentoxide, calcium oxide, etc.)
- Strong oxidizing agents (peroxides, etc.)

*Hydrofluoric acid may be fatal through inhalation, absorption or ingestion and causes extensive, deep and painful burns. Avoid use if possible however if its use is unavoidable, personnel are to be specifically trained in its use and emergency response procedures. More information and use requirements are available from the Lab Safety Officer

Corrosive Solids

Inhalation of corrosive dusts presents a particular hazard as the point of contact and the tissue at risk, particularly the airways and 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.

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 below:

- Ammonia
- Hydrogen chloride
- Hydrogen fluoride – inhalation, absorption or ingestion may be fatal. Causes extensive, deep and painful burns. Avoid use if possible, however if its use is unavoidable, personnel are to be specifically trained in its use and emergency response procedures. Formaldehyde
- Bromine
- Chlorine
- Phosgene
- Sulphur Dioxide

Use and Handling of Corrosives

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

- Add acids to water and not vice versa.
- Be prepared for heat generation upon diluting or dissolving in water.
- Complete all work in a chemical fume hood with adequate ventilation (see section 12).
- Personal protective equipment should include:
  - lab coat;
  - goggles;
  - appropriate gloves; and
  - when working with volumes greater than 4 L, a synthetic rubber apron

14.6. Highly Reactive Materials

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

Water reactive

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);
- Formation of corrosive acids.

Examples of water reactive materials include:

- Alkali metals including lithium, sodium and potassium
- Alkylaluminums including triethylaluminum
- Acetyl chloride
- Aluminum chloride
- Aluminum chloride
- Chlorosulphonic acid
- Ferrous sulfide
- Lithium aluminum hydride
- Magnesium
- Maleic anhydride
- Phosphorus
- Phosphorus pentachloride
- Phosphoryl trichloride
- Silanes
- Silicon tetrachloride
- Sodium borohydride
- Stannic chloride
- Sulphur chloride
- Sulphuryl chloride
- Thionyl chloride
- Titanium tetrachloride.

Handle and store water reactive chemicals away from sinks, water baths or other sources of moisture.

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, use in glove boxes, etc. More information and use requirements are available from the Lab Safety Officer.

Examples of pyrophorics include:

- Alkyllithium compounds including *t*-butyllithium
- Boron
- Finely divided metals including calcium, cobalt, cadmium, iron, manganese, chromium, lead, nickel, titanium
- Dichloroborane
- Diborane
- Diethylzinc
- 2-Furaldehyde
- Grignard reagents
- Metal carbonyls e.g. lithium carbonyl, nickel carbonyl Metal hydrides, e.g. sodium hydride
- Non-metal hydrides e.g. diethyl arsine, diethyl phospine
- Phosphine Phosphorus

Organic Peroxides

See section 14.4

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
- Storage locations for explosive materials are to be placarded in accordance with the Explosives Act.
- 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

Picric Acid

Picric acid (2,4,6-trinitrophenol) is a reagent found in departments across campus, being used in microscopy and as a component in some biological specimen preserving solutions. When dehydrated, picric acid itself is a dangerous explosive. When in contact with metal, highly shock-sensitive picrate salts can be formed. The following guidelines are 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 via email immediately to arrange for safe disposal.

14.7. 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 build-up.
- Use only approved low-pressure containers equipped with pressure-relief devices.

  Lunch box Thermos-style 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 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, do not fill containers 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.

14.8. Designated Substances

There are eleven “designated substances” regulated under the Ontario Occupational Health and Safety Act due to their potential to cause serious health implications. Use of designated substances in research or teaching situations should be avoided. However, because suitable substitution may not be possible, some of these substances may be found in university laboratories. Designated substances are listed below:

- acrylonitrile;
- arsenic;
- asbestos;
- benzene;
- coke oven emissions;
- ethylene oxide;
- isocyanates;
- lead;
- mercury;
- silica; and
- vinyl chloride.

The Designated substance regulation under the Occupational Health and Safety Act 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, the regulation contains three key components:

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

Monitoring – requires air emissions monitoring and medical surveillance to determine actual exposure to the substance.   Contact OHW x52647 regarding medical surveillance programs.

It is the responsibility of the laboratory supervisor to meet that the letter and intent of the regulations. In addition to this regulation, additional information and standards have been added in the following sections.

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 are to be stored 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 11 for spill clean-up procedure.

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 laboratories, solutions or samples containing isocyanates should be clearly marked as containing such.

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.

14.9. Nanomaterials

Nanomaterials are defined as particles with at least one dimension that is less than 100 nm. Nanomaterials have been shown to have unique physical and chemical properties when compared to the corresponding micro- or macro-scale compounds. In addition, there also appears to be different mechanisms of toxicity and therefore different and potentially more severe health effects although these differences are currently widely unknown. As such use and handling of nanomaterials must be done with particular care and only after conducting a risk assessment to consider both the potential hazards and appropriate controls. Contact EHS for assistance in conducting a risk and/or exposure assessment. Examples of controls include:

- Identification of areas, equipment and containers that contain or are used with nanomaterials
- Embedding the nanomaterials in a solid matrix.
- Working with the nanomaterials in solution within a chemical fume hood
- Working with solid, dry, dispersible nanoparticles in a fully contained system or conducting the work within a biosafety cabinet (HEPA filtered)
- Being diligent in housekeeping, wet wiping of potentially contaminated areas etc.
- Wearing appropriate personal protective equipment (gloves, lab coat, eye protection, respiratory protection etc.)

14.10. Other Toxic Materials

Some other chemical materials warrant mentioning specifically because of their hazards and/or extensive usage. Their primary hazards are identified below:

- 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. Contact OHW x54283 for more information.
- Hydrogen sulphide – acutely toxic. Attacks the respiratory system. Highly flammable.
- Formalin/Formaldehyde – known carcinogen.

15. Compressed Gases

15.3. 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 damage the cylinder valve resulting in a rapid release of gas that can transform a cylinder into an uncontrollable rocket or pinwheel and cause serious injury or damage. Poorly controlled release of compressed gas in the laboratory can burst reaction vessels, cause leaks in equipment and hoses or result in runaway chemical reactions. 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 cause asphyxiation. See section 13.5 for information regarding cryogenic liquids.

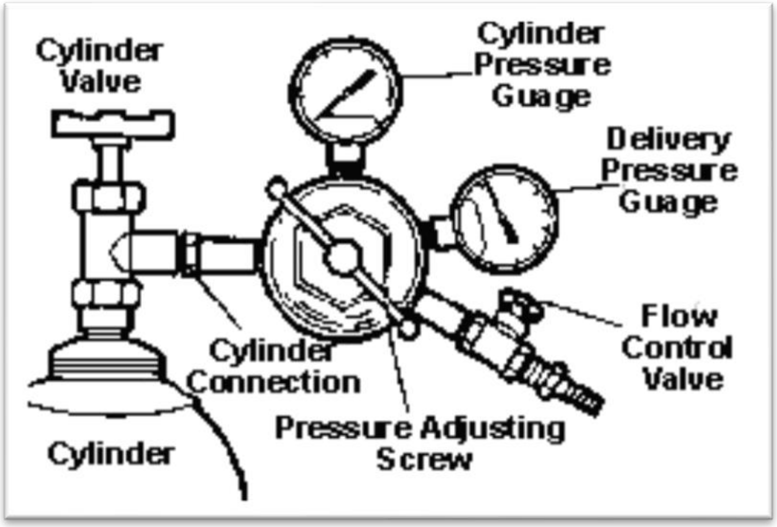
15.4. Handling and Transport of Gas Cylinders

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

- Return unlabeled cylinders unopened to the supplier. Color coding does not provide sufficient identification.
- Remove regulators and replace protective cap when cylinders are not in use or are being transported. Use a cylinder cart for transporting cylinders. Chain or strap cylinders to the cart.
- Avoid riding 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.
- Do not store or use propane tanks designed for outdoor use indoors.
- Label empty cylinders clearly with either “EMPTY”
- 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.
- Ground cylinders containing flammable gases 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.

15.5. Regulators

Figure G – Schematic diagram of compressed gas cylinder and regulator



http://www.safetyoffice.uwaterloo.ca/hse/cryogenics-compressed-gas/cg-use.html

- 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.
- Use a properly sized wrench to attach a regulator to a cylinder. Adjustable wrenches are not to be used as they can damage the fittings.

15.6. Leaks

See information regarding compressed gas leaks in section 14.

15.7. Storage of Gas Cylinders

Storage of gas cylinders is regulated through the Ontario Fire Code Section 5.6.2. Proper storage room/locations for compressed gas cylinders are available throughout the University that meet the requirements of the Fire Code. Only cylinders that are in use are to be located in research or teaching labs.

- Storage areas are to be conspicuously labelled as such.
- 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.

Segregation of Gas Cylinders

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

Figure H – 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

16. Chemical Handling and Storage

Because of limited space, good housekeeping practices, waste disposal costs and the desire to minimize hazardous materials within the laboratories, it is essential to procure only what is needed in terms of reagents, solvents, etc. 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

16.3. EHS Chemical Inventory

Chemical inventories for all laboratories and storage areas are to be maintained either in the EHS electronic chemical inventory system accessible on the EHS website or other format such as Excel spreadsheet. This is necessary to efficiently communicate the contents of each lab or storage area to emergency first responders and to achieve proper inventory control for each lab.

- Log-in ID's and passwords for the chemical inventory system can be obtained by contacting the Lab Safety Officer. Please provide your name, department, and the location of the materials to be inventoried (building and room number)
- Upon receipt of a new chemical, enter information into the inventory applicable to the laboratory.
- Update inventory as a chemical is depleted or disposed.
- Audit inventory on an annual basis to ensure that it is up to date.

16.4. 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 another suitable, leak resistant, robust secondary container.
- Transport off-site requires compliance with federal Transportation of Dangerous Goods regulations.

16.5. 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 off shelves.
- Store large containers on lower shelves.
- Avoid storage above eye level.
- Window ledge, 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 spilling contents.
- Inspect chemicals in storage regularly to ensure that:
    - There are no leaks.
    - Caps and containers are in good condition. Look for signs of discoloration, bulging and pressure build up.
    - Outside of containers are kept free of spills and stains.
    - Containers are properly labelled.

16.6. Storage of Flammables and Combustibles

Flammable liquid – a liquid having a flash point below 37.8°C and having a vapor pressure not more than 275.8 kPa (absolute) at 37.8°C as determined by ASTM D323, "Vapor 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 in the laboratory is regulated by section four of the Ontario Fire Code. Maximum quantities listed below are for single labs (i.e. single fire compartments with a minimum fire resistance rating of one hour).

- Minimize the flammable and combustible material in the open lab area is and is for **immediate use only** (less than a total of 300 L of which no more than **50 L** are flammable liquids, as per Ontario Fire Code)
- Store all additional flammable material (up to a total of 500 L of which not more than **235 L** of flammable liquids) in approved flammable storage cabinets.
- Store flammable materials requiring storage conditions at refrigerated temperatures 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.

Storage Rooms for Flammable and Combustible Liquids

There are several designated flammable storage rooms at the University. 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.

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

16.7. Chemical Segregation

It is critical that chemicals are stored such 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 clearly documented and understood by lab personnel. It is suggested that solvents/reagents etc. be labelled according to the storage system used to allow for continuous, easy and proper storage. A representative chemical segregation system that has been adopted by the University is described on the following pages.

Figure I - Chemical segregation system

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

Table 13 – Chemical storage system

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 lab shelf or in dedicated oxidizer cabinet isolate 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 for 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 lab shelves or in cabinet. Includes carcinogens, teratogens, mutagens	Examples: dichloromethane, dimethylformamide
Low-hazard solids & liquids	Store on lab shelves or in cabinet. Includes weak acids and bases.	Examples: calcium chloride, sodium bicarbonate, copper sulphate

16.8. Partial List of Incompatible Chemicals

The following list is not complete and is intended for use as a guide only. Refer to the appropriate MSDS for incompatibilities of chemicals not found in the following table.

Table 14 – Partial List of Incompatible Chemicals

Chemical	**Is Incompatible with**
Acetic acid	Chromic acid, nitric acid, alcohols, ethylene glycol, perchloric acid, peroxides, permanganates
Acetic anhydride	Hydroxyl-containing compounds e.g. ethylene glycol, perchloric acid
Acetone	Concentrated nitric and sulfuric acid mixtures, hydrogen peroxide
Acetylene	Chlorine, bromine, fluorine, copper, silver, mercury
Alkali and alkaline metals e.g. sodium, potassium, lithium, magnesium, calcium, powdered aluminum	Water, carbon tetrachloride and other halogenated alkanes, carbon dioxide, halogens
Aluminum Alkyls	Water
Ammonia, anhydrous	Mercury, chlorine, calcium hypochlorite, iodine, bromine, hydrogen fluoride
Ammonium nitrate	Acids, powered metals, flammable liquids, chlorates, nitrates, sulfur, fine-particulate organic or combustible materials.
Aniline	Nitric acid, hydrogen peroxide
Arsenic compounds	Reducing agents
Azides	Acids
Bromine	Ammonia, acetylene, butadiene, butane, methane, propane, hydrogen, other petroleum gases, benzene, powered metals
Calcium oxide	Water
Carbon, activated	Calcium hypochlorite, oxidizing agents
Carbon tetrachloride	Alkali and alkaline metals e.g. sodium
Chlorates	Ammonium salts, acids, powered metals, sulfur, fine-particulate organic or combustible substances
Chlorine	Ammonia, acetylene, butadiene, butane, methane, propane, hydrogen, other petroleum gases, benzene, powered metals
Chlorine dioxide	Ammonia, methane, phosphine, hydrogen sulphide
Chromic acid	Acetic acid, naphthalene, camphor, glycerol, turpentine, alcohols, flammable liquids
Copper	Acetylene, hydrogen peroxide
Cumene Hydroperoxide	Organic and inorganic acids
Cyanides	Acids
Flammable liquids	Ammonium nitrate, chromic acid, hydrogen peroxide, nitric acid, sodium peroxide, halogens
Fluorine	Store separately
Hydrazine	Hydrogen peroxide, nitric acid, oxidizing materials

Hydrocarbons, flammable (butane, propane, benzene, etc.)	Fluorine, chlorine, bromine, chromic acid, peroxides
Hydrocyanic acid	Nitric acid, alkalis
Hydrogen fluoride	Ammonia, aqueous or anhydrous
Hydrogen peroxide	Copper, Chromium, iron, metals and metals salts, flammable liquids, aniline, nitromethane, combustibles (solid or liquid)
Hydrogen sulfide	Fuming nitric acid, oxidizing gases
Iodine	Acetylene, ammonia (anhydrous or aqueous)
Mercury	Acetylene, ammonia
Nitric Acid, Conc.	Acetic acid, acetone, aniline, chromic acid, prussic acid, hydrogen sulfide, flammable liquids and gases, nitratable substances e.g. copper, brass, heavy metals, organic products e.g. wood, paper
Nitrites	Acids
Nitroparaffins	Inorganic bases, amines
Oxalic Acid	Silver, mercury and their salts
Perchloric acid	Acetic anhydride, bismuth and its alloys, alcohols, paper, wood, oils
Peroxides, organic	Mineral or organic acids
Phosphorus (white)	Sulfur, air, oxygen-containing compounds such as chlorates
Phosphorus pentoxide	Alcohols, strong bases, water
Potassium	See alkali metals
Potassium chlorate	See chlorates
Potassium perchlorate	See chlorates
Potassium permanganate	Glycerol, ethylene glycol, benzaldehyde, sulfuric acid
Selenides	Reducing agents
Silver and silver salts	Acetylene, oxalic acid, tartaric acid, ammonium compounds.
Sodium	See alkali metals
Sodium nitrate	Ammonium nitrate and other ammonium salts
Sodium peroxide	Methanol, ethanol, glacial acetic acid, anhydride, benzaldehyde, carbon disulfide, glycerol, ethylene glycol, ethyl acetate, methyl acetate, furfurol
Sulfides	Acids
Sulfuric acid	Lithium, sodium, potassium, chlorates, perchlorates, permanganates
Tellurides	Reducing agents

16.9. Storage of Gas Cylinders

See Section 14.5.

16.10. Containment

Care should be taken to store chemicals/reagents/samples/solutions etc. such that the risk of spills is minimized.

- Primary storage containers should be of a composition such that they are able to maintain their structural integrity, under normal storage and use, throughout the lifespan of the material they are holding.
- 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 if the glass is broken.
- *Secondary containment should be used in all storage locations*. This is containment in addition to the primary container to prevent release of material to the environment if the primary container fails. Over-packs, spill trays etc. are examples of secondary containment.

17. Hazardous Waste Disposal

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 in a fume hood as methods of disposal. Not only is this practice a contravention to the legislation, but it can harm the environment, lead to dangerous reactions, create immediate and future hazards for lab and trades personnel, as well as damage the drainage system. The sign shown in Figure G is to be posted near all sinks in all University labs:

Figure J – Sewage disposal of hazardous waste warning sign

WARNING

It is dangerous and unlawful to dispose of
flammable, toxic, corrosive, oily, or
other hazardous waste down drains.

FOR DISPOSAL, CONTACT
ENVIRONMENTAL HEALTH AND SAFETY
PHONE 53282

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 15.

Table 15 – 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 more than the indicated concentration:

Solvent extractable matter of mineral or synthetic origin	15 mg/L
Biological oxygen demand	300 mg/ml
Suspended solids	350 mg/ml
Organic nitrogen, solvent extractable matter of animal or vegetable origin	100 mg/ml
Chlorides, sulphates (SO2)	1500 mg/ml
Aluminum, iron	50 mg/ml
Fluorides, phosphorus	10 mg/ml
Antimony, bismuth, chromium, cobalt, lead, manganese, molybdenum, selenium, silver, tin, titanium, vanadium	5 mg/ml
Copper, nickel, zinc	3 mg/ml
Cyanide	2 mg/ml
Arsenic, cadmium, phenolic compounds	1 mg/ml
Mercury	0.1 mg/ml

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 Guelph campus from offsite as the campus is not an approved waste transfer site or receiver. Hazardous waste generated at the regional campus and research stations must be transported by a hazardous waste contractor directly from these locations.

Hazardous waste disposal fees are considerable; however generally there is no cost to the labs or departments. Below are exceptions where the laboratory supervisor or department will be charged back for costs incurred from hazardous waste disposal.

- The waste generated is from a lab/department that has a cost recovery program (i.e. waste generated from services for which the lab or department is being paid to provide)
- Waste for disposal exceeds the amounts that would be reasonably expected to accumulate over a two-week period. Laboratory supervisors are responsible for ensuring that waste and outdated chemical inventory is efficiently managed. Waste disposal costs resulting from lab “clean-ups” will be charged back to the generator.
- Disposal of atypical wastes, e.g. explosives (such as dry picric acid), PCBs, compressed gases, etc.

Fees related to disposal of hazardous waste generated by the regional campus and research stations are the responsibility of the campus or research station.

17.3. Minimization of Hazardous Waste

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

- Buy only what you need.
- Miniaturize (scale down) experiments.
- 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.

17.4. Packaging and Labelling Requirements

The waste generator is responsible for providing appropriate waste containers as well as 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 items for consideration:

- 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 vapor expansion.
- Container materials must be compatible with the contained wastes (e.g. hydrofluoric acid is not to be stored in glass containers; 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 wastes 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 17.3).
- If reusing bottles, ensure that there is only one identifier on the bottle.

17.5. Chemical Waste

Hazardous chemical waste is picked up regularly by a hazardous waste contractor. Note that chemical containers and consumer products such as 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. The following procedures apply to the Guelph campus and Laboratory Services.

If you have waste for disposal:

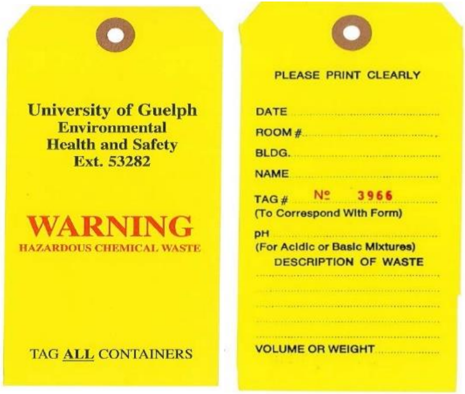
- Complete a hazardous waste disposal tag and attach to waste containers. See sample tag in Figure H. Tags are available from EHS main office. Environmental Health and Safety, Alexander Hall
- Complete "Surplus Chemical and Sharps Disposal Request" form either electronically or by hardcopy. The following 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.
- Submit form to EHS by interdepartmental mail, email ehs@uoguelph.ca or in person to the main 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.
- Suitable waste containers (e.g. safety cans less than 25 L, Nalgene carboys, etc.) will be returned to the generator.

Figure K – Example of hazardous waste tag



University of Guelph
Environmental
Health and Safety
Ext. 53282

WARNING
HAZARDOUS CHEMICAL WASTE

TAG **ALL** CONTAINERS

PLEASE PRINT CLEARLY

DATE ……………………
ROOM # ……………………
BLDG. ……………………
NAME ……………………
TAG # № 3966 ……………………
(To Correspond With Form)
pH ……………………
(For Acidic or Basic Mixtures)

DESCRIPTION OF WASTE
……………………
……………………
……………………
……………………
……………………

VOLUME OR WEIGHT ……………………

Unknown Waste

Waste of unknown composition will not be picked up by the hazardous waste contractor. It is the responsibility of the laboratory supervisor to appropriately identify or categorize the “unknown”. Figure I provides a flowchart to assist in waste categorization.

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

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 the Lab Safety Officer.

Biohazardous Waste

See Biosafety manual for details.

Radioactive Waste

See Radiation Safety Manual for details .

Figure L– Unknown waste categorization flow diagram

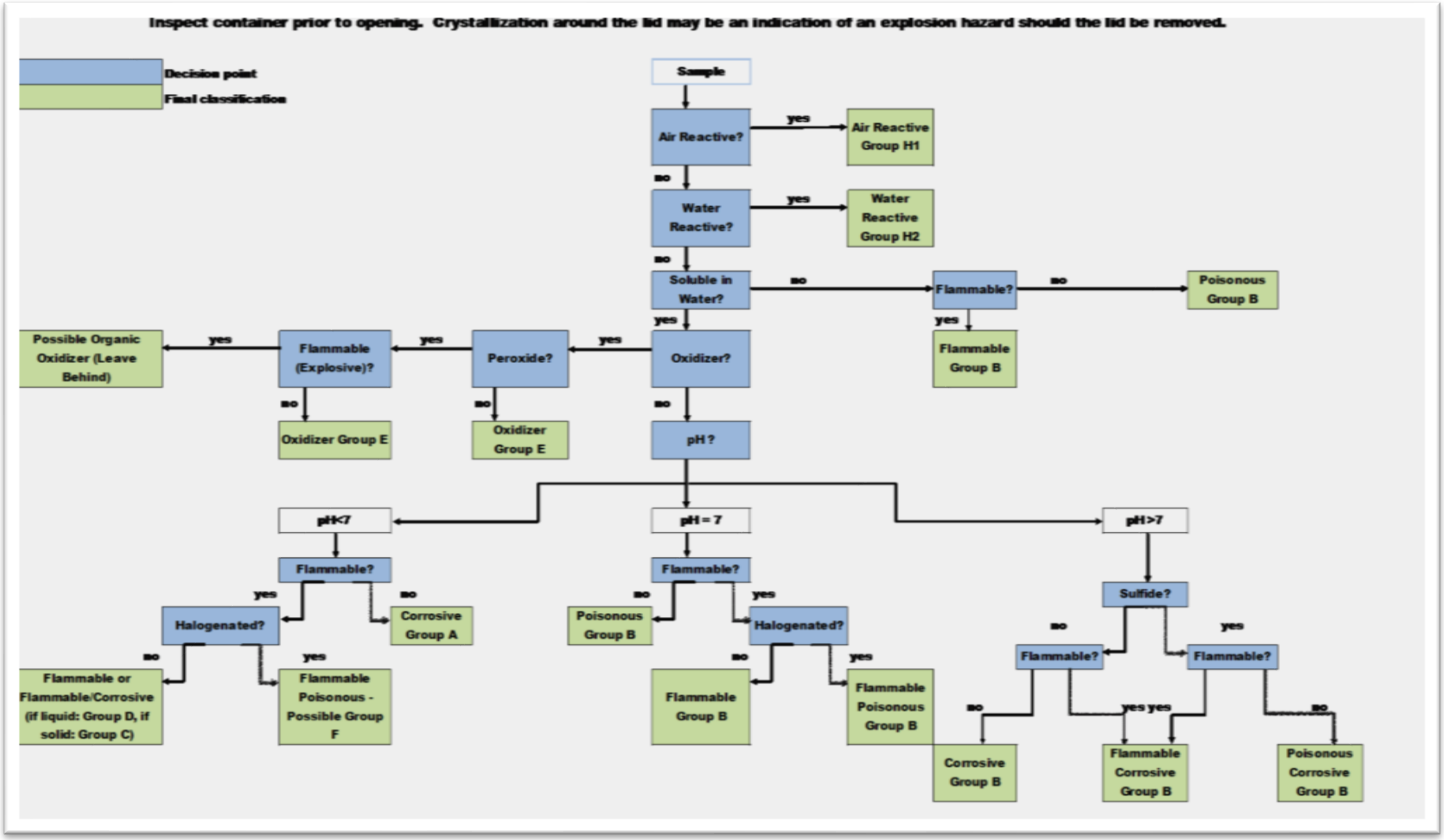


Table 16 – Description of tests used to assess chemical and physical properties of unknown wastes

Property	**Description of Test***
Water reactivity/Water solubility	Add a small a quantity of unknown to a few milliliters of water. Observe any changes e.g. heat, gas formation, flames. Also observe whether the unknown is soluble in water and if insoluble if it is more or less dense than water.
pH	Determine the approximate pH using multirange pH paper.
Flammability	Place a small sample of the unknown in an aluminum test tray (i.e. <5ml). Apply an ignition source for up to 1 second. If it burns, it is flammable/combustible.
Presence of oxidizer	Use commercially available KI/starch test strips. Strip will turn blue in the presence of free iodide indicating the presence of oxidizer
Presence of peroxide	Use commercially available test strips. Follow manufacturer's directions.
Presence of sulphide	Use commercially available test strips. Follow manufacturer's directions.
Presence of halogen	Heat a copper loop to redness in a flame. Cool in distilled or deionized water. Dip into unknown. A green colour around the wire in the flame indicates the presence of halogen.

*Adapted from Prudent Practices in the Laboratory – Handling and Management of Chemical Hazards, 2011, National Research Council, Published by the National Academies Press.

Sharps Waste

Sharps are to be separated from regular waste streams to prevent unnecessary needlestick injuries and/or lacerations.

Broken laboratory glassware

Clean broken glassware including Pasteur pipettes, and broken laboratory glassware, is to be separated into an appropriately marked glass waste container. These containers are available from Physical Resources and consist of 20 L, white plastic pails, lined with a heavy-duty yellow garbage bag. Contact Physical Resources x58129 to request disposal containers. Custodial Services will remove glass waste once the containers are full.

Contaminated broken glassware is to be treated like sharps defined in section 17.4

Syringes, needles, scalpels and blades

- Dispose in standard "Sharps" containers. Full containers will be transferred to a biohazardous waste pick-up site. Contact the Lab Safety Officer for details.
- Complete hazardous waste disposal tag (Figure H) and attach it to the container.

- Complete “Surplus Chemical and Sharps Disposal Request” form and submit to EHS as with chemical waste.

17.6. Batteries

Batteries are to be disposed of as follows:

- Collect in a suitable container sturdy enough to handle the weight of the batteries.
- Complete hazardous waste disposal tag (Figure H) and attach to container.
- Complete “Surplus Chemical and Sharps Disposal Request” form and submit to EHS as with chemical waste.

Batteries may also be dropped off at the Physical Resources stockroom for subsequent pick up by the hazardous waste contractor.

18. Laboratory Equipment and Procedures

Many pieces of laboratory equipment can be hazardous if not used and maintained appropriately. Personnel should be trained on laboratory equipment prior to using the equipment. General precautions for a selection of apparatus are provided in the following sections. Specific operational instructions provided in manufacturer’s instruction manuals and standard operating procedures are to be followed. These manuals/procedures should be located with the equipment or be otherwise easily accessible. Maintenance of or repairs to any laboratory equipment should only be performed by competent personnel trained and qualified to perform such work. Safety devices on laboratory equipment are never to be disabled.

18.3. Acid/Base Baths

Acid and base baths, often used to clean glassware are very corrosive, with the potential to cause significant injury to the personnel using them. Consideration should be given to substituting an acid/base bath with a bath prepared with a laboratory grade detergent. Chromic acid cleaning baths are not permitted without prior consultation with EHS.

- When preparing or handling acid or base baths, personal protective equipment is to include a synthetic rubber apron, safety goggles, a face shield and long synthetic rubber gloves.
- Prepare the bath in a fume hood by first adding cold water, to which a measured amount of acid or base is slowly added.
- Take care to prevent splashing during the loading or unloading of the bath.
- When removing items from the bath, empty any residual liquid back into the bath and rinse thoroughly with water.
- Dispose of the spent bath in accordance with hazardous waste disposal procedures.

18.4. Alcohol Burners

Alcohol burners are gradually replacing the Bunsen burner in the laboratory. Using fuels such as methanol, ethanol or isopropanol, an open flame is generated for use in techniques such as flaming of microbiological loops.

- Fill the burner in a fume hood taking care not to spill or overfill.
- Transfer the burner to the location where it is to be used, away from flammable and combustible material.
- Never light a burner with another burner.
- Never refill a lit burner.
- Take care not to contact the invisible flame.
- Secure long hair, loose clothing and jewelry.

18.5. Atomic Absorption Spectrometers

Sample preparation for atomic absorption (AA) procedures often require handling of flammable, toxic and corrosive products. Familiarize yourself with the hazardous properties of these materials using the MSDS/SDS or other suitable reference and follow the recommended safety precautions. Atomic absorption equipment must be adequately vented, as toxic gases, fumes and vapours are emitted during operation. Other recommendations when carrying out atomic absorption analysis are:

- Wear safety glasses for protection against impact.
- Inspect the integrity of the burner, drain and gas systems before use.
- Inspect the drain system regularly; empty the drain bottle frequently when running organic solvents.
- Allow the burner head to cool to room temperature before handling.
- Never leave the flame unattended. A fire extinguisher should be located nearby.
- Avoid viewing the flame or furnace during atomization unless wearing protective eyewear.
- Hollow cathode lamps are under negative pressure and should be handled with care and properly disposed of as hazardous waste to minimize implosion risks.
- Incorporate flash arrestors in the gas lines of gas delivery systems incorporate

18.6. Autoclaves

Autoclaves present potential burn and explosion hazards and need to be used with the utmost care.

- Autoclaves must have a certificate of inspection prior to use and are inspected annually thereafter. Inspections are coordinated by the Insurance Manager, Financial Services and must be completed by a qualified inspector.

- The inspection certificate is to be posted in a conspicuous location near the autoclave itself.
- Autoclaves are to be serviced on at least a quarterly basis on a preventative maintenance contract. Service visits are to be documented (e.g. on a tag or in an equipment logbook.)
- Inspections and tests are to be performed by trained, qualified personnel.
- Autoclaves are to be equipped with a safety/pressure release valve set at or below the maximum pressure of the autoclave.
- PPE to be worn when loading or unloading an autoclave:
  - heat insulating gloves;
  - goggles and a face shield if a splash hazard exists;
  - splash apron; and
  - closed toed shoes.
- Oils, waxes, certain plastics, flammable materials, radioactive materials and samples containing substances that may emit toxic fumes are not to be autoclaved.
- Glassware is to be of borosilicate composition and checked for inspected for cracks prior to autoclaving. Ensure that any plastic containers to be put into the autoclave are suitable for high temperature, high pressure conditions, e.g. polycarbonate, PTFE and most polypropylene items. Metal trays are also acceptable.
- Loosen lids to all containers to prevent pressure build-up during heating and a vacuum upon cooling.
- Containers of liquid are to be no more than ⅔ full.
- Use secondary containment to prevent spillage i.e. put items in trays that will sufficiently catch spills should they occur.
- When unloading the autoclave:
  - Ensure that the autoclave has depressurized prior to opening door.
  - Stand to the side of the autoclave, away from the door and crack open the door approximately 1” to allow steam to escape and pressure within liquids and containers to normalize
  - Let autoclaved items stand for at least 10 minutes.
  - Open the door and carefully remove the items from the autoclave, transferring them to a safe location where they can cool completely. Superheated liquids can 'bump" when they are removed from the autoclave causing a spray of boiling liquid if proper containers aren't used.
- If the autoclave becomes non-functional, label it as such and initiate maintenance/repairs as appropriate and in accordance with department policies.

18.7. Blenders, Grinders and Sonicators

When used with infectious agents, mixing equipment such as shakers, blenders, grinders, sonicators and homogenizers can release significant amounts of hazardous aerosols, and should be operated inside a biosafety cabinet whenever possible. Equipment such as blenders and stirrers can also produce large amounts of flammable vapours or fine powders depending on the material being used, and therefore should be used within a chemical fume hood.

- Ensure equipment is equipped with safety features that minimize leaking and prevent operation if blades are exposed.
- Select equipment appropriately for the task being performed, e.g. non-sparking (intrinsically safe) motors are used when dealing with flammable solvents.
- Secure any equipment that could move during use to the bench or floor as applicable.
- Ensure equipment is in good condition prior to use.
- Allow aerosols to settle for at least one minute before opening containers.
- Hearing protection may be required when using sonicators or grinders due to the high frequency or high amplitude sound waves produced.

18.8. Centrifuges

Safe use of centrifuges requires proper maintenance and operation. Failed mechanical parts or improper operation can result in release of projectiles, hazardous chemicals and biohazardous aerosols. Maintenance and repairs are only to be performed by trained, qualified personnel. Maintenance service contracts with a qualified repair company obtained through University Purchasing Services should be available for all units. All maintenance is to be documented. To preserve your safety, sample integrity and equipment:

- Ensure that centrifuges have an interlocking device that will prevent both the lid from being opened when the rotor is in motion and the centrifuge from starting when the lid is open.
- Inspect centrifuge tubes to confirm they are free of hairline cracks, stress lines and chipped rims prior to use.
- Choose tube materials such that they provide the necessary chemical resistance and speed rating.
- Avoid over-filling tubes.
- Cap or stopper centrifuge tubes.
- Use sealed centrifuge buckets (safety cups) or rotors that can be loaded and unloaded in a biosafety cabinet or chemical fume hood as appropriate.
- Decontaminate the outside of the cups/buckets and rotors before and after centrifugation.

- Inspect the o-rings on rotor lids regularly and replace if cracked or dry. Never operate a centrifuge if the rotor lid is missing its o-ring.
- Properly balance the centrifuge. Load the rotor with samples arranged symmetrically. Opposing tubes must be of equal weight. If necessary, use "water blank" tubes to balance sample tubes of unequal weight. Do not use sight or volume to conclude that tubes are balanced. Use an electronic balance to balance tubes before using in an ultracentrifuge.
- Never exceed the prescribed speed limitations of the rotor or centrifuge.
- Unless fitted with a suitable exhaust system, do not centrifuge materials capable of creating flammable or explosive vapours.
- Remain with the centrifuge until it has reached its programmed speed.
- Abort the run immediately if you hear abnormal vibration, whining or grinding noises. Check the rotor lid and ensure that samples are balanced.
- At the end of the run, clean the rotor and centrifuge according to manufacturer's instructions. Never use abrasive cleaners.
- Rotors are easily damaged. Never use metal tools to remove tubes or clean.
- For each rotor, record speed and run time for each run in a logbook such that rotors can be downgraded and discarded as appropriate.
- If centrifuge is connected to a vacuum pump the pump exhaust is to be connected to a trap.
- If biohazardous materials are being centrifuged and the centrifuge is connected to a vacuum pump, a HEPA filter is to be installed between the centrifuge and the vacuum pump.

18.9. Distillation Equipment

Hazards involved with distillation procedures include those corresponding to the use of flammable liquids, heat and pressures other than atmospheric pressure.

- Secure joints. Vapour leaks can lead to fire, unnecessary exposure and contamination of the workspace.
- Never distill or evaporate organic compounds to dryness unless they are known to be free of peroxides. See section 13.2.4.2 for information on the hazards of peroxides.
- Continuously stir the distillation mixture to prevent bumping of the solution which can result in the apparatus blowing apart. The use of boiling chips may also prevent bumping if the distillation is being performed at atmospheric pressure.
- Ensure that the heating source used provides even heating of the solution, e.g. heating mantle, ceramic cavity heater. The addition of a thermometer near the centre bottom of the distilling flask may provide an early indication of unexpected exothermic decomposition reactions.

- If the distillation is being performed at reduced pressure, evacuate the apparatus gradually to reduce the possibility of bumping.
- After completing a distillation at reduced pressure, cool the system before slowly introducing air. Introduction of air into a hot system may create an explosive environment.
- Solvent stills are to be set-up in the fume hood.
- Reduced pressure distillation set-ups or those involving the use of particularly hazardous materials are to include appropriate shielding.
- Consider using systems designed to shut down if cooling water fails.

18.10. Electrophoresis

The use of voltages of approximately 2000 V and currents of more than 80 mA in electrophoresis procedures create the potential for a lethal electrical shock if the equipment is not operated properly.

- Use physical barriers to prevent inadvertent contact with the equipment.
- Properly ground electrophoresis equipment.
- Ensure electrical interlocks are used.
- Inspect electrophoresis equipment regularly for damage and potential buffer tank leaks.
- Locate equipment away from high traffic areas and away from wet areas such as sinks or washing apparatus.
- Use of ground fault circuit interrupters is recommended.
- Display warning signs to identify the electrical hazards (i.e. “Danger – High Voltage”).
- Turn off power before connecting leads, opening the lid or reaching into the chamber.
- Ensure that lead connectors are insulated.

18.11. French or Hydraulic Presses

Presses can be valuable pieces of laboratory equipment; however careful use is necessary for safe operation.

- If being used for cell disruption, take care to protect against the release of potentially biohazardous aerosols.
- Secure loose clothing and long hair, and any other items are clear of the press before operation.
- Wear appropriate protective eyewear.

18.12. Gas Chromatographs

Gas chromatography (GC) procedures involve the use of compressed gases and may involve the use of flammable solvents and toxic chemicals. Be sure that you are familiar with the use and handling of compressed gases. See section 15. Familiarize yourself with the hazardous properties as well as the recommended precautionary measures and handling instructions of any hazardous materials being used, by referring to MSDSs or other reliable reference material. The following guidelines provide guidance for the safe operation of GCs.

- Wear proper eye protection. GC columns are fragile, and breakage could result in small projectiles during handling. As well, samples are prepared in various hazardous solvents that could be damaging to the eyes upon contact.
- When cutting a GC column, be sure that the cut is made away from the body.
- Cap GC column cutters or otherwise store to prevent injury when not in use.
- Discard small pieces of GC columns as sharps waste.
- Allow the oven to cool before installing or removing a column or injector or performing any maintenance.
- Turn off gases prior to removing or installing a column.
- Test for leaks after the installation of the column and whenever a leak is suspected. This should be done using a technique that will not damage or sacrifice the integrity of the instrument.
- Depending on the detector, the effluent of the instrument may need to be vented or otherwise filtered, e.g. electron capture, mass spectrometer and other non-destructive detectors. Spot ventilation systems accomplish this.
- Electron capture detectors (ECD) have a radioactive source and therefore need to be registered as part of the University's Radiation program. These detectors are not to be relocated or discarded without permission from the Radiation Safety Officer. Contact the Radiation Safety Officer at x54888 for more information about CNSC requirements.
- Turn off the instrument and gases, with the power cord disconnected prior to performing any maintenance.

18.13. Glassware

Proper use of glassware can prevent many injuries in the laboratory.

- Use only the right size and type of glassware for any given operation.
- Inspect glassware to ensure good condition prior to use (i.e. no cracks, chips, significant scratches).
- Discard broken glassware in appropriate containers.

- Cut glass tubes/tubing by scoring using a file or equivalent. Cover the glass with a piece of cloth and break at the score over a piece of cloth/paper to catch any pieces.
- Wear leather or other cut-resistant gloves when inserting glass tubing into a stopper or flexible tubing. Fire polish tubing ends and lubricate glass to make connection easier. Ensure that stopper holes are appropriately sized and carefully insert tubing by gently twisting back and forth.
- Wear leather gloves when removing glass tubing from flexible tubing or a stopper. If difficult, carefully cut with a scalpel blade or other appropriate glass cutter. Make cuts away from the body.
- Store glassware is away from the edges of benches such that it cannot be easily knocked down.

18.14. Glove Boxes/Glove Bags

Gloves boxes and bags are isolated, fully sealed, containment units, fitted with armholes and gloves such that highly toxic, air reactive or pyrophoric materials can be manipulated safely.

- Generally, glove boxes are operated under negative pressure so that any leakage is into the box. However, if operated under positive pressure to maintain a dry and/or anaerobic environment and highly toxic materials are being used, sufficient leak testing is required prior to use.
- If being used with highly toxic materials, exhaust is to be treated prior to release to the environment. Treatment could involve the use of activated charcoal filters or chemical scrubbers.

18.15. Heating Baths

Heating baths are designed to heat materials to a constant temperature. They may be filled with a variety of materials including water, mineral oil, sand, glycerin, paraffin or silicone oils, depending on the bath temperature required. Bath temperatures may be as high as 300°C. The following are precautions for heating baths:

- Locate on a stable surface, away from flammable and combustible materials including wood and paper.
- Cool bath before relocation.
- Ensure baths are equipped with controls that will turn off the power if the temperature exceeds a preset limit.
- Set the thermostat well below the flash point of the heating liquid in use.
- Equip with a non-mercury thermometer to allow a visual check of the bath temperature.
- Do not fill over ⅔ full.

- Take care to not allow water to get into oil baths as violent splattering may result.

Steams baths are often safe alternatives for heating because they provide a consistent temperature that will not exceed 100°C. C are must be taken to prevent scalding due to dermal exposure to the steam or steam lines.

Water baths are the most common bath found in the laboratory. When using a water bath:

- Clean regularly; a disinfectant, such as a phenolic detergent, can be added to the water.
- Avoid using sodium azide to prevent growth of microorganisms; sodium azide forms explosive compounds with some metals.
- Decontamination can be performed by raising the temperature to 90°C or higher for 30 minutes once a week.
- Unplug the unit before filling or emptying.

18.16. High Performance Liquid Chromatographs

High performance liquid chromatography (HPLC) procedures often require handling of compressed gas (helium) and flammable and toxic chemicals. Be sure that you are familiar with the use and handling of compressed gas cylinders. See section 15. Familiarize yourself with the hazardous properties as well as recommended precautionary measures and handling instructions of any hazardous materials being used, by referring to MSDSs or other reliable reference material. The following guidelines provide guidance for the safe operation of HPLCs.

- Be sure to wear appropriate eye protection. Since the HPLC is operated at high pressures, it is possible for fittings to fail, resulting in a sudden release of solvent.
- Inspect and empty the waste containers as required.
- Vent waste collection vessels.
- Use secondary containment of waste containers.
- Never clean a flow cell by forcing solvents through a syringe: syringes under pressure can leak or rupture, resulting in sudden release of syringe contents.
- High voltage and internal moving parts are present in the pump and autosampler. Switch off the electrical power and disconnect the power cord when performing routine maintenance.

18.17. Hydrogenators

When used properly, commercially available hydrogenators allow hydrogenation reactions performed at elevated pressures using various catalysts to be carried out safely.

- Choose the apparatus appropriately for the specific reaction to be performed.
- Inspect the reaction vessel prior to each use to ensure that there are no scratches, chips, etc. that would make them unsuitable for use in high pressure experiments.

- Ensure that oxygen is removed from the reaction solution before introduction of hydrogen.
- Ensure that the safe pressure limit of the vessel is not approached especially when heating.
- At the end of the reaction, purge system repeatedly to prevent the production of a hydrogen-oxygen mixture.
- Take particular care to ensure that catalysts are not allowed to dry once filtered from reaction mixtures as they are usually saturated with hydrogen and may spontaneously ignite upon exposure to air. Filter cakes should be immediately transferred to water and purged with an inert gas such as nitrogen or argon.

18.18. Lasers

The use of lasers and the corresponding management of their hazards are to comply with ANSI Z136.1, Safety Policy 851.09.01 and the procedures outlined in the Radiation Safety program. The hazards associated with the use of class 3A, 3B or 4 lasers include eye or skin burns, fire and electrocution. Below are key aspects of laser hazard management:

- Operation, repair and maintenance are to be performed by competent, trained and qualified personnel only.
- Appropriate protective eyewear and protective clothing are to be worn as determined by the class of the laser.
- Manufacturer installed safety devices such as shields, or interlocks are never to be altered, disconnected or removed without written approval from the laboratory supervisor.
- Contact the Radiation Safety Officer for more information.

18.19. Mass Spectrometers

Mass spectrometers (MS) require the handling of compressed gases and flammable and toxic chemicals. Be sure that you are familiar with the use and handling of compressed gas cylinders.

See section 15. Familiarize yourself with the hazardous properties as well as recommended precautionary measures and handling instructions of any hazardous materials being used, by referring to MSDSs or other reliable reference material. Specific precautions for working with the mass spectrometer include:

- Avoid contact with heated parts while the mass spectrometer is in operation.
- Inspect gas, pump, exhaust and drainage system tubing and connections before each use.
- Pumps are to be vented outside the laboratory, as pump exhaust may contain traces of the samples being analyzed, solvents and reagent gas.
- Used pump oil is to be handled as hazardous waste.

18.20. Microtomes

Microtomes are an important tool used in the preparation of sample sections for microscopy and must be handled with care to protect against lacerations.

- Take care when installing or removing blades
- Keep blade guards in place when leaving the microtome for short periods of time.
- Remove blades when finished for the day
- Carry and store blades within a covered container that holds them in place
- Never attempt to catch a dropped blade
- Clamp samples securely prior to sectioning
- Never leave blades on the bench (including blades used for rough trimming)
- Apply brake tightly when required
- Turn off microtome when not in use

18.21. Nuclear Magnetic Resonance Spectrometers

Nuclear magnetic resonance spectrometers (NMRs) use superconducting magnets thereby introducing hazards related to high strength magnetic fields and cryogenic liquids, i.e. liquid nitrogen and liquid helium which are used for cooling. Improper operation of the instrument or improper activities near the instrument could lead to significant personal injury or death, costly equipment damage and loss of data.

- Post warning signs at or beyond the 5-gauss line indicating the hazards. (5- gauss line describes the distance from the centre of the magnet where a magnetic field strength of 5 gauss is experienced. This is the strength of a magnet where the field strength is strong enough to act upon ferromagnetic objects.)
- Individuals with medical devices (e.g. cardiac pacemakers and metal prostheses) must remain outside the 5-gauss line. The magnetic fields generated are strong enough to affect the operation and integrity of some of these medical devices.
- Keep ferromagnetic materials outside the 5-gauss perimeter. Strong magnetic fields surrounding the NMR attract objects containing steel, iron, and other ferromagnetic materials. This includes most ordinary tools, electronic equipment, compressed gas cylinders, steel chairs, and steel carts. Unless restrained, such objects can suddenly fly toward the magnet which can cause personal injury and extensive damage to the NMR. Only non-ferromagnetic materials should be used near the instruments. If in doubt, keep it out!
- Floppy disks, tapes, cards with magnetic strips, cellular phones, laptops and mechanical watches should remain outside the 5-gauss perimeter. Strong magnetic fields can damage the strip of magnetic media found on credit cards, ATM cards, driver's licenses, and other kinds of

cards. Floppy disks, tapes, cellular phones, and laptop computers are also susceptible to damage inside this perimeter. Mechanical wrist and pocket watches will also malfunction and be permanently damaged when exposed to a strong magnetic field.

- In the event of damage to the magnet, the magnet may quench. Leave the room immediately.

  A quench refers to the sudden release of gases from the dewar. Rapid expansion of liquid helium or nitrogen to gas can displace breathable oxygen in an enclosed space creating the possibility of asphyxiation. Do not re-enter the room until the oxygen level has returned to normal.
- Only qualified, trained and competent personnel are to complete helium or nitrogen fills.

  See section 13.5for the hazards and precautions associated with cryogenic liquids. Appropriate protective equipment including a minimum of safety glasses and gloves are to be worn.
- Oxygen sensors equipped with alarms are recommended in NMR rooms where the release of cryogenic liquid could lead to displacement of the oxygen in the air to critical levels creating the possibility of asphyxiation.
- During variable temperature experiments, do not exceed the boiling or freezing points of your sample. A sample subjected to a temperature change can build up excessive pressure which can break the tube. Wear safety glasses near the magnet when performing variable temperature experiments.
- Inspect NMR sample tubes prior to use and discard any tubes that are cracked, chipped, scratched or in otherwise poor condition.
- Use care when handling NMR sample tubes as they are very fragile.
- Do not operate in the presence of flammable gases or fumes.
- Do not look down the upper barrel of an NMR if a probe is in place. Pneumatic ejection of a sample from the probe could cause injury.
- Take care that solvents used for sample preparation will not undergo unwanted reactions with the analyte.

18.22. Ovens, Hot Plates and Heating Mantles

Ovens are commonly used in the lab to evaporate water from samples, provide a stable elevated temperature environment and dry glassware. Heating mantles are used to heat reaction or sample solutions in round bottom flasks or reaction vessels, and hot plates are used to heat various general laboratory solutions. Bunsen burners are not to be used to heat reaction, sample or general laboratory solutions. The following precautions should be followed to for safe use:

- Ensure that laboratory ovens and hot plates are designed such that they prevent contact between flammable vapours and heating elements/spark-producing components.

- Avoid heating toxic, even mildly volatile materials in an oven unless it is continuously vented outdoors.
- Glassware that has been rinsed with an organic solvent is to be rinsed with distilled water or equivalent before being placed in an oven for drying.
- Hot plates or ovens whose thermostat fails are to be removed from service until repaired. Heating devices whose temperature unknowingly rises above that required could create significant fire hazards.
- Heating mantles are to be used in conjunction with a variable autotransformer and care is to be taken not to surpass the maximum voltage of the mantle as recommended by the manufacturer.
- Discontinue use of any heating mantle whose heating elements have become exposed.

18.23. Ultraviolet lamps

Exposure to ultraviolet light (UV) may result in serious and painful injury to the eyes or skin depending on the specific wavelength of the light to which the individual is exposed, the intensity of the light and the duration of exposure.

- Conspicuously label all UV lights sources with the following warning (or equivalent) "Warning – this device produces potentially harmful UV light. Protect eyes and skin from exposure."
- Ensure that the UV light source is shielded.
- Wear appropriate PPE and is sufficient to protect the eyes and skin. PPE should at least include a UV resistant face shield, gloves and a lab coat.
- Depending on the situation, shielding of the equipment itself or work area may be warranted.

19. Physical Hazards

19.3. Electrical

Electrical hazards have been mentioned in relation to specific equipment in section 18; however one needs to be aware of general electrical safety practices.

- Inspect electrical cords regularly and have any frayed or damaged cords replaced.
- Extension cords are permitted for temporary set-ups only.
- "Piggy-backing" of extension cords is prohibited.
- Locate electrical equipment to minimize the possibility of it being affected by spills, floods, condensation etc.
- Make laboratory personnel aware of power shut-offs.
- Protect against accidental contact with exposed electrical circuits.

- Use of ground fault interrupter circuits is preferable in receptacles located near sinks.
- Electrical plugs are never to be modified in any way.
- Adapters to allow 3-prong plugs to be used with 2-prong outlets are not permitted.

Any electrical equipment purchased, regardless of voltage, must be approved as indicated by the presence of a field approval mark from the Canadian Standards Association (CSA), Electrical Safety Authority (ESA), or an equivalent field approval mark acceptable under the Electrical Safety Code, i.e. Ontario Hydro (OH), Entela, International Approval Services (IAS) or Intertek Testing Services. The cost of the Electrical Safety Authority field approvals and modifications, if required, is the responsibility of the acquiring department.

19.4. High Pressure and Vacuum

Working with pressures other than atmospheric, creates additional stress on the apparatus involved, of which glassware is of particular concern. Risk of explosions and implosions needs to be minimized and precautions are to be taken in the event that they occur.

- Use glassware suited for high pressure or vacuum (e.g. thick walled).
- Take precautions to minimize flying glass in the event of an implosion/explosion, e.g.:
    - Wrap glassware in a criss-cross pattern with strong adhesive tape.
    - Use safety coated glassware.
    - Use wire screening or suitable mesh to cover flasks.
- Conduct work behind a safety shield.
- Do not strain glassware
- Appropriately secured glassware
- Include pressure relief valves in apparatus set-up for high pressure work.
- Before opening a desiccator under vacuum, ensure that the interior pressure has returned to atmospheric pressure.

19.5. Machine Guarding

Injuries can occur from contact with rotating or moving parts as well as pinch points found in various mechanical equipment and instrumentation found throughout laboratories.

- Laboratory personnel are to be aware of emergency shut-offs for all equipment.
- Manufacturer installed guards and safety interlocks are not to be removed or modified without written approval from the laboratory supervisor. This documentation is to be maintained and include the reason the modification is required.

- Other equipment containing moving or rotating parts or pinch points not equipped with manufacturer installed guards is to be appropriately guarded so as to protect the operator.

20. Ergonomics

Awkward postures, excessive forces, high repetition and contact stresses can all lead to ergonomic related injuries. Laboratory personnel should be aware of their body positioning and take precautions to properly design and set-up work to minimize the risk of injury. Contact OHW at x54283 for ergonomic assessments.

21. Laboratory Decommissioning

Laboratory supervisors are to ensure that laboratories to be vacated for the purpose of renovation, re-occupation or demolition are appropriately decontaminated and decommissioned such that the facilities are free from physical, chemical, radioactive and biological hazards and are safe for subsequent contractors and/or occupants. The Biosafety and Radiation Safety programs should be consulted for decommissioning requirements of labs with biosafety and/or radioactive hazards.

- Chemical containers are to be labelled and sealed appropriately.
- Laboratory glassware is to be empty and clean.
- Equipment including, but not limited to, refrigerators, autoclaves, ovens, freezers, incubators, fume hoods and storage cabinets are to be cleaned out and appropriately decontaminated.
- All chemicals within equipment are to be drained from the equipment (e.g. pump oil).
- Lab benches and fume hood work surfaces are to be washed down.
- Compressed gas cylinders that are to be moved must have regulators removed and caps secured. If possible, compressed gas cylinders are to be returned to the supplier and arrangements for future deliveries to the new site made if applicable.
- Dispose of hazardous waste according to proper procedures. Laboratory supervisors will be responsible for costs associated with any unknown chemical wastes that cannot be sufficiently identified or categorized without the assistance of an outside contractor.
- Dispose of non-hazardous waste according to proper procedures and not left in the laboratory.
- Laboratory supervisors will be responsible for costs associated with disposal of hazardous materials and decontamination of equipment and facilities.
- For those laboratory supervisors that are leaving their position at the University for any reason (retirement, other employment etc.), clean out associated common lab areas of material and equipment belonging to the departing employee.

The laboratory supervisor is responsible for completing Laboratory and Equipment Decontamination and Decommissioning Report(s) as applicable, and making the necessary arrangements to have the laboratory inspected and the report signed by both the chair/head of the department and the appropriate representative(s) from EHS.

Appendix A – Changes from the Previous Edition

Changes to the previous edition, (2008) include:

- Minor edits and clarification to the text throughout; updated resources and website links
- Section 4 – Addition of the locations of first aid stations. Clarification of follow-up procedures with medical professionals for students
- Section 9 – Removal of reference to Emergency Contact/Hazard sign as it is not currently available.
- Section 9 – Addition of Emergency Procedures posters
- Section 9 – Incorporation of emergency response procedures for regional campuses, research stations and Laboratory Services, AFL
- Section 9 – Identification of First Aid Stations on the Guelph campus
- Section 10 – Replacement of Figures B (Fire Triangle)
- Section 10 – Update of annual inspection procedures for fume hoods
- Section 12 – Update of annual testing of fume hood performance and alarms
- Section 12 –Replacement of Figure C (Chemical Fume hood)
- Section 13 - Clarification of peroxide forming materials
- Section 13 - Addition of nanomaterials
- Section 15 – Inclusion of legislation for chemical storage
- Section 15 – Inclusion of requirements for flammable and combustible storage rooms
- Section 16 - Clarification and further description of tests used in the characterization of unknown wastes
- Section 17 - Addition of microtomes

Changes to the 2nd edition, (2011) include:

- Minor edits and clarification to the text throughout; updated resources, website links and phone numbers
- Section 12 - Updated Mercury Spill Response procedure

Changes to the 3rd edition, (2016) include:

- The entire document was changed to comply with OADA requirements
- Title page – U of G logo replaced with current one

- Section 6 – OLD WHIMIS information has been removed and new WHMIS2015 manufacturer label was included
- Section 13 – New image of the Low Flow High performance was included