THE UNIVERSITY OF BRITISH COLUMBIA

CHEMICAL SAFETY MANUAL

2017

Risk Management Services

www.rms.ubc.ca

www.riskmanagement.ok.ubc.ca

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Emergency Contact Information Vancouver

Emergency Numbers UBC Campus

Fire, Police, Ambulance	911
First Aid (staff & faculty)	(604) 822-4444
UBC Hazardous Materials (HAZMAT) Response	911
Campus Security	(604) 822-2222
Plant Operations Trouble Calls	(604) 822-2173
UBC Hospital Urgent Care (8 am- 10 am)	(604) 822-7121
Poison Control	(604) 682-5050

B.C. Children's Hospital, B.C. Women's Hospital, B.C. Research Institute for Child and Family Health

Emergency Security and First aid	899
Emergency Code Response	7111

St. Paul's Hospital

Fire	7111
First Aid	5800
Hazardous Materials Response	7111
Security	5800
Security (Non-emergency)	4777

Vancouver Hospital and Health Sciences Centre University Site Koerner, Purdy and Detwiller Pavilions

Fire	0000
First Aid	0000
Hazardous Materials Response	0000

Vancouver Hospital Site, Jack Bell Research Centre, Willow Eye Care Centre, Robert H.N. Ho, VGH Research Pavilion

Fire, First Aid, Hazardous Materials Response	88
Security (urgent)	5800
Security (Non-emergency)	4777

Common Numbers

UBC Risk Management Services	(604) 822-2029
Vancouver Fire Department Non-emergency	(604) 665-6000
R.C.M.P. Non-emergency	(604) 224-1322
UBC Biosafety Office	(604) 822-4353
UBC Emergency Planning Office	(604) 822-1237
UBC Radiation Safety Office	(604) 822-4353
UBC Chemical Safety Office	(604) 827-3409
UBC Occupational Hygiene Office	(604) 822-6098
UBC Environmental Office	(604) 822-9280

Emergency Contact Information Okanagan

Emergency Numbers UBC Campus-Okanagan

Fire, Police, Ambulance	911
Emergency/First Aid/Security	(250) 807-8111
Risk Management	(250) 807-8111
Hazardous Materials (HAZMAT) Response	911
Poison Control	1-800-567-8911

Non-Emergency Numbers

Risk Management Services – Safety & Environment	(250) 807-8656
Risk Management Services – Health & Safety.	(250) 807-8821
Campus Security (Non-Emergency)	(250) 807-9236
Facilities Management	(250) 807-9272
Fire Department (Non-emergency)	(250) 469-8801
R.C.M.P. (Non-emergency)	(250) 762-3300
Health & Wellness (students)	(250) 807-9270
Kelowna General Hospital	(250) 862-4485
Employee & Family Assistance Program (EPAF)	1-800-887-4765

University of British Columbia Safety Policy 7

- *under review* -

Purpose

To articulate the University's objective of providing a safe, healthy and secure environment for all members of faculty and staff, students and visitors, and to delineate responsibility for achieving it.

Policy

The University aims to provide a safe, healthy and secure environment in which to carry on the University's affairs. All possible preventive measures are taken to eliminate accidental injuries, occupational diseases and risks to personal security.

Compliance with the Workers' Compensation Act, WHMIS and related legislation is the minimum standard acceptable. All students and members of faculty and staff are encouraged to strive to exceed these minimum legal standards and to eliminate unnecessary risks.

Definitions

An administrative head of unit is a Director of a service unit, a Head of an academic department, a Director of a center, institute or school, a Principal of a college, a Dean, an Associate Vice President, the Registrar, the University Librarian, a Vice President or the President.

A supervisor is a person, not necessarily an administrative head of unit, who has been delegated supervisory responsibility for others working or studying at UBC.

A worker is a person who is an employee, student or volunteer for the University of British Columbia.

Duties and Responsibilities

The University

It is the responsibility of the University acting through administrative heads of unit to:

- provide a safe, healthy and secure working environment;
- ensure regular inspections are made and take action as required to improve unsafe conditions;
- ensure that health, safety, and personal security considerations form an integral part of the design, construction, purchase and maintenance of all buildings, equipment and work processes;
- provide first aid facilities where appropriate;
- support supervisors and safety committees in the implementation of an effective health, safety and security program;
- ensure compliance with WorkSafeBC, Public Health Agency of Canada, Canadian Food Inspection Agency, and other applicable legislation;
- establish department or building safety committees;
- communicate with the university community or affected groups about events or situations when potentially harmful conditions arise or are discovered;
- ensure adequate resources are available to implement appropriate procedures.

The Supervisor

It is the responsibility of supervisory staff to:

- formulate specific safety rules and safe work procedures for their area of supervision;
- ensure that all employees under their supervision are aware of safety practices and follow safety procedures;
- provide training in the safe operation of equipment;
- inspect regularly their areas for hazardous conditions;
- correct promptly unsafe work practices or hazardous conditions;
- be responsive to concerns expressed about personal security and investigate any accidents, incidents or personal security concerns which have occurred in their area of responsibility;
- report any accidents or incidents involving personal security to the appropriate University authority;
- participate, if requested, on department or building safety committees.

Individual Students and Members of Staff and Faculty

It is the responsibility of individual students and members of faculty and staff to:

- observe safety rules and procedures established by supervisory staff, administrative heads of unit and the University;
- be safety-conscious in all activities, be they work, study or recreation;
- report as soon as possible any accident, injury, unsafe condition, insecure condition or threats to personal security to a supervisor or administrative head of unit;
- use properly and care for adequately personal protective equipment provided by the University;
- participate, if elected or appointed, on departmental or building safety committees.

Detailed Procedures

The Joint Occupational Health and Safety Committees and Research Compliance Committees work to achieve these objectives by providing education and reviewing policies and procedures.

Local Safety Teams carry out the safety programs within their areas and make recommendations to ensure that the safety objectives of the University can be achieved. The terms of reference for these committees and teams are available through the Department of Risk Management Services.

The Department of Risk Management Services and the Campus Security assist departments to implement and maintain effective health, safety and personal security programs, liaise with the regulatory authorities on behalf of the University and support the activities of the Joint Occupational Health and Safety Committees and Research Compliance Committees.

For more information, please consult with the Department of Risk Management Services and/or Campus Security on your campus.

1 Introduction

1.1 Risk Management Services

Responsibilities

UBC's Department of Risk Management Services (RMS) is responsible for:

- developing and maintaining effective accident prevention programs;
- providing the University community with required training;
- assisting the University in complying with health, safety and environmental regulations; and
- enhancing departmental services.

Occupational & Research Health & Safety

Within RMS, the Occupational & Research Health & Safety (ORHS) department collaborates with researchers across campus to ensure that laboratory research is conducted safely and in accordance with applicable regulations. RMS's programs related to research and laboratory work comprise:

- Chemical Safety
- Occupational Hygiene
- Biosafety
- Radiation Safety
- Diving Safety
- Environmental Services

The Chemical Safety Manual

Chemical Safety at UBC is of foremost importance and this manual is provided as a starting point for the development of safe and best management practices in UBC laboratories where hazardous chemicals are used. The material contained within the manual has come from a variety of sources and it is correct to the best of knowledge of the RMS. However, there is no guarantee or warranty that it is without errors or omissions.

In addition to this manual a series of supporting documents are currently being developed by RMS. As they become available, the documents are being posted on the Chemical Safety Resources web page.

1.2 Duties and Responsibilities

The Work Safe BC Occupational Health and Safety Regulation (Section 3.3) and the UBC Safety Policy 7 clearly define the roles and responsibilities of the employer, employee and students at UBC.

The **university**, acting through administrative heads of unit, is responsible for providing a safe, healthy and secure working environment for all those involved in the university's activities.

Supervisors, in their area of responsibility, are accountable for the following: identifying all hazards; ensuring that there are safe work procedures and appropriate emergency procedures; ensuring that all workers and students know and follow those procedures; and correcting unsafe conditions and practices. A supervisor is anyone who has been delegated responsibility for others working or studying at UBC.

All **students** and members of **faculty** and **staff** are responsible for learning and following safe work procedures and emergency procedures as well as reporting all unsafe conditions and incidents or accidents.

1.3 Incident/Accident Reporting

All incidents/accidents involving UBC workers (faculty, staff & student workers) or practicum students must be immediately reported to the responsible supervisor and then on-line through the UBC Central Accident Incident Reporting System (CAIRS). If the injured person is a student, visitor to campus or contractor, the incident/accident must be reported online through the UBC Central Accident Incident Reporting System (CAIRS).

To attend to injuries, the Vancouver campus mobile first aid can be contacted at 604-822-4444. On the Okanagan Campus, Campus Security Emergency Line can be contacted at 250-807-8111. UBC workplaces outside the Vancouver or Okanagan campus will have their own first aid procedures that should be reviewed prior to commencing work.

Any injury that is serious and has a risk of being fatal should be reported by calling 911 immediately!

1.4 Chemical Safety Program

The Chemical Safety Program promotes the safe handling, storage and disposal of chemicals that is compliant with the regulations and recognized best practices. Through the program employees receive chemical safety training, advice and guidance.

The Chemical Safety Course (Vancouver Campus) is offered online through the RMS training program. The course also contains a WHMIS component. A separate WHMIS Training course is available and everyone at UBC must take it.

For questions concerning the handling of hazardous materials, the Manager of Environmental Services at 604-822-9280 or the Environmental Services Advisor at 604-822-9840.

The WHMIS and Chemical Safety Course (Okanagan Campus) is offered by the RMS Okanagan as an on-line course. For questions concerning the handling of hazardous materials contact the Safety and Environment Advisor at 250-807-8656.

A series of appendices, at the end of the manual, is provided as additional resources and tools. A glossary of terms used in describing chemical hazards and regulations is also included at the end of the manual (Glossary of Terms).

1.5 Hazardous Materials Management

RMS coordinates the disposal of hazardous waste materials at the UBC Vancouver campus through the Environmental Services Facility (ESF) located on South Campus.

Chemical waste is collected regularly and taken to ESF. It is then sorted, treated and packaged according to type before being shipped for disposal. Highly reactive compounds, such as picric acid or old containers of diethyl ether, are picked up at the generator's site by a contractor licensed to handle such materials. Information regarding chemical waste disposal can be obtained through the Hazardous Waste Management Manual. The Waste Disposal chapter contains specific information regarding chemical waste management.

RMS manages and handles hazardous materials generated on the Okanagan campus, in accordance with the local, provincial and federal regulations. Laboratory wastes and hazardous materials generated by the University through research, academic and operational activities are consolidated, recycled, re-used, neutralized or disposed. For information on the Hazardous Waste Management Program please visit http://riskmanagement.ok.ubc.ca/environment/hazardousmaterials.html.

2 Risk Assessment

A risk assessment takes a careful examination of whatever, in the work or workplace, could cause harm to people, so that necessary precautions or controls can be taken to prevent harm. The intention is to prevent accidents or work-related health problems in the workplace. The risk assessment will specify control measures (Risk Control) that are determined to be necessary to adequately safeguard against accidents and work related health conditions.

A Risk Assessment Tool has been developed by RMS to help with the process of evaluating risk related to handling chemical compounds on campus.

2.1 Safe Experiment Design

2.1.1 Introduction

A comprehensive experimental design process is an essential step in running safe laboratory operation. This process should review the potential hazards associated with each experiment over its life cycle. It is instrumental in maintaining safe laboratory operations, minimizing exposure to potential hazards, minimizing waste generation and ensuring regulatory compliance.

In this process, the whole range of experimental steps should be considered. From the development of clear experiment goals and objectives, through acquisition, setup and handling of materials and equipment, detailed assessment of chemicals and reactions, all the way to storage and disposal practices, each step should be examined to determine safety issues and environmental concerns.

Detailed information related to potential hazards identified and safety measures to be implemented should be incorporated to the experimental protocol and be an integral part of it! A guide on hazard control analysis is provided in Appendix I.

Per Work Safe BC OSH Regulation 30.14, written safe work procedures must be prepared for hazardous operations, including work methods involving hazardous chemicals, spill response, and handling of a material that contains a biological agent, and workers must be adequately instructed in and follow the procedures.

2.1.2 Responsibility

Principal Investigators and supervisors are responsible for ensuring that effective pre-experiment review is implemented for each laboratory protocol prepared by a lab worker.

2.1.3 Procedure

1. State the goals and objectives of your experiment
2. Consider and state all the fundamental steps of the experiment
3. Perform hazard assessment for each step of the experiment or process. Consider the following elements:

   i) Hazard evaluation of materials and chemicals to be used:

   Complete hazard assessment for all materials and products associated with the experiment. If risks are determined to be unacceptable, redesign the experiment, minimize quantities, reduce concentrations, reduce volume or use less hazardous chemical alternatives. Consider the chemical amount, volume, flow rate, physical properties, and the potential for exposure. Special attention should be given to new materials produced whose physical properties and toxicity are unknown.

   ii) Management of chemicals and equipment:

Include provisions for acquiring and storing chemical reagents and equipment, proper equipment set up, handling and operation, inventory management, source reduction, material sharing, monitoring of reactive chemicals, compound shelf life, and storage incompatibility. Consider the potential impact of loss of air, water or power on your experiment and what the appropriate emergency response would be. Assess additional equipment hazard (noise, radiation, electrical hazard, ergonomics).

iii) Working with chemicals:

Include steps such as sample preparation, equipment assembly and commissioning, equipment startup and calibration, product isolation and characterization, storage and disposal of materials after work is completed. Special consideration should be given to planning unattended operations, introduction of new equipment, and significant process scale up.

iv) Types of reactions:

Know the chemistry of your reactions, be prepared for exothermic reactions, runaway reactions, bumping, pressure build up, generation of hazardous gases or interaction between incompatible materials. Know the physical conditions required for the reaction (e.g. high pressure, vacuum, extremely cold temperature, high temperature, high voltage) and conditions that may develop over the course of the reaction; consider the potential associated hazards.

v) Equipment, area cleaning and decontamination:

Develop a procedure for equipment and area decontamination. Make sure you are using the proper decontamination procedures and cleaning materials and know how to properly dispose of any residue or waste. Special caution should be taken with reactive materials (air/moisture/water reactive) and when cleaning with solvents. Review compatibility information of cleaning and decontamination agents.

vi) Proper disposal and deactivation procedures:

Consider waste minimization and recycling of materials. Evaluate the properties of all waste products to be generated by the experiment (see Hazardous Waste Management Manual for the Vancouver campus) for each waste stream. Consider the amount and frequency of waste generated and methods to neutralize the waste or render it non-hazardous. Have a procedure in place to deal with unstable waste or wastes that require special storage and handling. Review the compatibility of materials being accumulated. Minimize the generation of multi-hazard waste. Minimize the release of hazardous chemicals to the environment. Do not use the fume hood to dispose of volatile hazardous materials (use filters, scrubbers or other control equipment). Do not discharge hazardous chemicals into the sewer system. Consider additional procedures (e.g., specialized PPE, spill kit materials) when generating special hazardous chemical waste.

For waste disposal on Okanagan campus consult the Hazardous Materials Management RMS website.

vii) Provide a contingency plan to deal with the unexpected:

Be prepared for emergencies. Include information regarding emergency response in each procedure:

- the location and type of spill control equipment and materials
- the location and type of fire extinguisher required (eg: D type for combustible metals)
- the type and location of antidotes to special hazardous chemicals (eg: HF, cyanide)

viii) Laboratory facilities:

Assess the area proposed for the experiment. Identify any potential hazards. Consider the location of equipment relative to the location of emergency response facilities. Work with hazardous materials should be carried out in the fume hood, glove box or biosafety cabinets. Special needs for bench space, ventilation or shielding may affect experimental planning and should be stated.

ix) Personal protective equipment (PPE) and industrial hygiene monitoring:

Review the need for PPE and determine the type of PPE required for each step of the experiment. Incorporate this information to your protocol. Work with certain materials may require industrial hygiene monitoring or a special occupational health review.

2.2 Workplace Hazardous Materials Information System (WHMIS)

2.2.1 Introduction

Information regarding safety and health hazards of materials used in the work place can be obtained through the Workplace Hazardous Materials Information System (WHMIS). This system requires suppliers to provide safety information with their products and requires the University to educate and train everyone potentially exposed to hazardous materials.

The key elements of WHMIS 2015 are:

- **Classification** – hazardous products are classified by the types of hazards they present;
- **Labeling –** alerts workers to the identity and dangers of products and to the basic safety precautions;
- **Safety Data Sheets** (SDS) – technical bulletins which provide detailed hazard and precautionary information; and
- **Worker education and training**

2.2.2 Background

The purpose of WHMIS is to help reduce the likelihood of disease or injury in the workplace. It was developed through the collective efforts of labor, industry and federal, provincial and territorial regulatory agencies. WorkSafe BC has been active in formulating the system and producing the written materials for its implementation.

Legislation to implement WHMIS has been enacted on both the federal and provincial/territorial levels. Federal requirements deal with the importation and sale of controlled products; provincial legislation covers the storage, handling and use of controlled products in the workplace.

WHMIS first came into effect in 1988 across Canada. It was updated in early 2015 to reflect a new set of rules called the Globally Harmonized System of Classification and Labeling of Chemicals (GHS). Developed by the United Nations, GHS does the following:

- Defines and classifies the hazards of chemical products
- Provides health and safety information on labels and safety data sheets, or SDS (previously called material safety data sheets or MSDS in the original WHMIS)

GHS is a worldwide system and its goals are for the whole world to adopt and use the same set of rules for classifying hazardous products and the same format and content for labels and SDSs. GHS has not replaced WHMIS; instead, it introduced some important changes. Also, there are some GHS components left out of the WHMIS 2015.

Key changes from WHMIS 1988 to WHMIS 2015 include the following:

- The term “hazardous product” replaces “controlled product”.

- Hazard classification criteria are more complete. This improves the ability to show the severity of hazards.
- New hazard classes are included.
- The language has been standardized (made more consistent).
- Supplier labels have a few new requirements (for example, the use of specific signal words, hazard statements, pictograms, and precautionary statements.)
- SDSs follow a 16-section format, and the information in those sections has been standardized.

To allow time for suppliers, employers, and workers to adjust to WHMIS 2015, a three-year transition period is in place. By September 1, 2018, all suppliers are expected to comply with the updated system. By December 1, 2018, all employers are expected to comply with the updated system.

During the transition period, you may receive hazardous products that follow either WHMIS 1988 or WHMIS 2015 requirements. To ensure worker protection, employers must educate and train workers about WHMIS 2015 as new labels and SDSs appear in their workplaces. During the transition period, employers may continue to have WHMIS 1988 labels and MSDSs in the workplace – if so, they must also continue to educate workers about WHMIS 1988. Employers must review and comply with the WHMIS requirements of their occupational health and safety jurisdiction.

2.2.3 Labels

Under WHMIS 2015, hazardous products used, handled, or stored in the workplace must be labelled. Labels are your first alert about the major hazards of these products and outline the basic precautions or safety steps you should take.

A more detailed overview of the types of WHMIS labels can be found on the RMS website under the WHMIS 2015 Label Program resource.

There are two main types of WHMIS labels: supplier labels and workplace labels. Other types of identification may be used where appropriate. Examples include warning signs, colour codes, and placards.

Supplier Labels

A supplier label is provided for each hazardous product by the supplier. Supplier labels will appear on all hazardous products received at a workplace in Canada. The written information must be shown in both English and French. Supplier labels may be bilingual (as one label) or available as two labels (one in English, and one in French).

A WHMIS 2015 supplier label must include the following information:

Table 1. Information items on a supplier label

Information item		Description
1	Product identifier	The brand name, chemical name, common name, generic name, or trade name of the hazardous product.
2	Initial supplier identifier	The name, address, and telephone number of the Canadian manufacturer or importer.
3	Pictogram(s)	Hazard symbol usually contained within a red, diamond-shaped border.

Information item		Description
4	Signal word	One of just two words used to alert you to a potential hazard and to state the severity of the hazard. “Danger” is used for high-risk hazards, while “Warning” is used for less severe hazards.
5	Hazard statement(s)	A standardized phrase or phrases that describe the type of hazard(s) posed by the hazardous product, as well as its severity. Examples include “Extremely flammable gas”, “Fatal if inhaled”, and “May cause cancer”.
6	Precautionary statement(s)	A standardized phrase or phrases that describe how to reduce or prevent harmful effects resulting from the following: • Exposure to a hazardous product, or • Improper handling or storage of a hazardous product Examples include “Keep container tightly closed”, “Wear eye protection”, and “If exposed or concerned: Get medical attention”.

In rare cases, supplier labels may also include *supplemental label information*. This information gives more details about the following:

- Precautionary actions
- Hazards not yet included in GHS
- Physical state (gas, liquid, solid, etc.)
- Route of exposure (by inhaling, by swallowing, through skin, etc.)

Supplemental label information is only included on supplier label in the following cases:

- A toxic mixture has an ingredient with unknown acute toxicity, or
- A product reacts with water to produce an acutely toxic gas.

For containers of 100 ml or less the supplier label is exempted from the requirement to have precautionary statements on the label. For containers 3 ml or less, where the label will interfere with normal use of the product, the product would be required to have a label that is durable and legible for transport and storage, but may be removable during use.

SuperKleen 007

Danger

Fatal if swallowed.
Causes skin irritation.

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

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

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

Danger

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

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

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

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

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

Figure 1. Example of a bilingual supplier label

Workplace labels

A workplace label is needed in the following cases:

- In cases where chemicals will not be used exclusively in the laboratory, employers must ensure that workplace labels are prepared and applied as required by WorkSafe BC Regulations.
- If chemicals are transferred from the original container into another container or mixed with other chemicals to produce a different chemical, a workplace label must be generated and attached to the new container. Workplace labels must be placed on each container of hazardous waste handled or disposed of by the laboratory.

For exemptions, consult the WHMIS 2015 Label Program.

Workplace labels must include:

- The product identifier (name)
- Safe handling information (PPE information can be included as well)
- Reference to safety data sheet

ACETONE

No smoking, sparks, or flames

Wear eye, face, and hand protection

Use in well ventilated area, or wear NIOSH approved respirator with organic vapour cartridges

Safety Data Sheet Available

Figure 2. Example of workplace label

A template for printing workplace label is available on the RMS website. The template is provided as a tool that can be used to print workplace labels. It is not mandatory to use these labels: as long as the workplace label has all the required three items (see page 4 above), the label is WHMIS 2015 compliant.

Laboratory labels

A laboratory label is required for new compounds made in a laboratory. Most hazards associated with such a new product are not known yet and an SDS is not available. Laboratory label are also necessary for laboratory samples. These include samples for quality control testing, diagnostic specimens and industrial hygiene samples.

A laboratory label must include:

- the product identifier
- if is know: the chemical name or generic chemical name of any material or substance in the sample that would have to be disclosed on an SDS
- the statement “Hazardous Laboratory Sample. For hazard information or in an emergency call,...” followed by an emergency telephone number for the person who can provide information that would be required on a SDS.

PRODUCT IDENTIFIER

HAZARDOUS LABORATORY SAMPLE
for hazard information or in an emergency

call Tel.______________________

composer Tel.______________________

Chemical Identity if known
Appellation chimique si connue

SUPPLIER IDENTIFIER

Figure 3. Example of laboratory label

Other identification requirements

Refrigerators and freezers need content hazard identification (i.e. toxic, flammable, etc.) and whether or not they are explosion-proof.

- Chemical storage cabinets are required to have content identification signage indicating one or more of the WHMIS Hazardous Classes (pictograms or words warning i.e. corrosive, toxic, etc.).
- Cleaning baths and pipes require chemical name and/or WHMIS Hazardous Class identification.

2.2.4 Safety Data Sheets

Safety data sheets (SDSs), formerly called Material Safety Data Sheets (MSDS), are documents that provide information about hazardous products and advice about safety precautions. SDSs provide more information about products than labels do and are important resources. An SDS has four main purposes. It provides information on the following:

- **Identification** – for the product and supplier
- **Hazards** – physical (fire and reactivity) and health
- **Prevention** – steps you can take to work safely and reduce or prevent exposure
- **Response** – what to do in various emergencies (for example, first aid, a fire, or a spill)

WHMIS 2015 requires a standard 16-section SDS. All information on the SDS must appear in the order shown in the table below.

Table 2. Overview of information required in each section of an SDS

SDS Section and heading		Information requirements (partial list)
1	Identification	• Product identifier • Recommended use and restrictions on use • Supplier contact information • Emergency phone number
2	Hazard identification	• Classification (hazard class and category) • Label elements (including precautionary statements) • Other hazards (e.g. dust explosion hazard)
3	Composition/information on ingredients	For a hazardous product that is a substance: • The chemical name and synonyms • Chemical Abstract Service Number (CAS No.) • The chemical name of impurities, stabilizing solvents, and stabilizing additives, when required For a hazardous product that is a mixture: the chemical names, synonyms, CAS numbers, and concentrations for ingredients that present health hazards **Note:** Confidential business information (CBI) rules may apply
4	First-aid measures	First-aid procedures by route of exposure (inhalation, skin contact, etc.), as well as most important symptoms / effects.
5	Fire-fighting measures	• Suitable (and unsuitable) extinguishing media • Specific hazards • Special equipment and precautions for fire fighters
6	Accidental release measures	• Protective equipment • Emergency procedures • Methods and materials for containment and clean up
7	Handling and storage	Precautions for safe handling, conditions for storage including any incompatibilities
8	Exposure controls / personal protection	Exposure limits, engineering controls, personal protective equipment
9	Physical and chemical properties	• Appearance • Odour • Odour threshold • pH • Melting/freezing point • Boiling point and range • Flash point • Upper and lower flammable or explosive limits
10	Stability and reactivity	• Reactivity • Chemical stability • Possible hazardous reactions • Conditions to avoid • Incompatible materials • Hazardous decomposition products
11	Toxicological information	Description of various toxic effects by route of entry, including: • Effects of acute (short term) or chronic (long-term) exposure

SDS Section and heading		Information requirements (partial list)
		- Carcinogenicity - Reproductive effects - Respiratory sensitization
12	Ecological information*	- Aquatic and terrestrial toxicity (if available) - Persistence and degradability - Bioaccumulative potential - Mobility in soil
13	Disposal considerations*	Safe handling and methods of disposal including waste packaging
14	Transport information*	UN number and proper shipping name, hazard classes, packing group
15	Regulatory information*	Safety, health and environmental regulations specific to the product.
16	Other information	Other information including date of the latest revision of the SDS

*Sections 12 to 15 require the headings to be present. The supplier has the option to not provide information in these sections.

Suppliers

Suppliers must develop or obtain a current SDS for each controlled product they sell or import. SDSs are required to be accurate at the time of sale. An SDS will be required to be updated when the supplier becomes aware of any "significant new data". That means the SDS must be updated when there is new information that changes how the hazardous product is classified, or when there are changes to the way you will handle or store or protect yourself from the hazards of the product.

SDSs will be required to be updated within 90 days of the supplier being aware of the new information. If you purchase a product within this 90 day time period, the supplier must inform you of the significant new data and the date on which it became available in writing.

A copy of the SDS must be sent to the purchaser at the time of first purchase. Purchasers may request data sheets in either or both of the official languages.

Employers

Employers must ensure that current SDS are received for all controlled products supplied to the workplace. If the employer produces a controlled product for use at the workplace, the employer must develop an SDS to accompany workplace labeling for it (WorkSafe BC Regulations 5.14).

Copies of supplier and employer SDS must be accessible to employees, close to their work areas and available during each work shift. SDS may be hard copies or available on a computer if the employer takes all reasonable steps to keep the system in active working order (e.g. if the power goes out, the system is still accessible). Workers must know how to access SDS, and must be educated in the content required on the data sheet and the applicable information in it.

2.3 Chemicals Hazards and Handling

A series of resource documents are currently being developed by RMS. As they become available, are posted on the Chemical Safety Resources page.

2.3.1 Introduction

The way that hazardous products are classified has changed in WHMIS 2015. Hazardous products are now divided into two hazard groups:

- **Physical hazards**, based on the physical or chemical properties of the product (for example, products that are flammable, reactive, or corrosive to metals)
- **Health hazards**, 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)
    - Carcinogenicity (may cause cancer)

The two hazard groups are further divided into **hazard classes**. Hazard classes are a way of grouping together products that have similar properties.

A hazardous product is a product that falls into one or more of the hazard classes described below. Suppliers classify these products and assign one or more Pictograms.

A brief description of the physical hazard classes (Table 3) and health hazard classes (Table 4) can be found below.

Table 3. Overview of physical hazard classes

Physical hazards class	General description
Flammable gasses Flammable aerosols Flammable liquids Flammable solids	These four classes cover products that have the ability to ignite (catch fire) easily. The main hazards are fire or explosion.
Oxidizing gases Oxidizing liquids Oxidizing solids	These three classes cover oxidizers, which may cause or intensify a fire or cause a fire or explosion.
Gasses under pressure	This class included compressed gases, liquefied gases, dissolved gases, and refrigerated liquefied gases. Compressed gases, liquefied gases, and dissolved gasses are hazardous because of the high pressure inside the cylinder or container. The cylinder or container may explode if heated. Refrigerated liquefied gases are very cold. They can cause severe cold (cryogenic) burns or injury.
Self-reactive substances and mixtures	These products may react on their own to cause a fire or explosion, or may cause a fire or explosion if heated.
Pyrophoric liquids Pyrophoric solids Pyrophoric gases	These products can catch fire very quickly (spontaneously) if exposed to air.

Physical hazards class	General description
Self-heating substances and mixtures	These products may catch fire if exposed to air. These products differ from pyrophoric liquids or solids in that they will ignite only after a long period or when in large amounts.
Substances and mixtures which, in contact with water, emit flammable gases	As the class name suggests, these products react with water to release flammable gases. In some cases, the flammable gases may ignite very quickly (spontaneously).
Organic peroxides	These products are unstable, highly reactive, or explosive. They may cause a fire or explosion if heated.
Corrosive to metals	These products may be corrosive (chemically damaging or destructive) to metals.
Combustible dusts	This class is used to warn of products that are finely divided solid particles. If dispersed in air, the particles may catch fire or explode if ignited.
Simple asphyxiants	These products are gases that may displace (take the place of) oxygen in air and cause rapid suffocation.

Table 4. Overview of health hazards classes

Health hazards class	General description
Acute toxicity	These products are fatal, toxic (poisonous), or harmful if they are inhaled (breathed in), if they come into contact with skin, or if they are ingested (swallowed). “Acute toxicity” refers to effects that occur following: • Skin contact or ingestion exposure to: ▪ A single dose, or ▪ Multiple doses given within 24 hours • An inhalation exposure of 4 hours Acute toxicity could result from exposure to the product itself. It could also result from a product that, upon contact with water, releases a gas that can cause acute toxicity.
Skin corrosion / irritation	This class covers products that cause severe skin burns (corrosion) and products that cause skin irritation.
Serious eye damage / eye irritation	This class covers products that cause serious eye damage (corrosion) and products that cause eye irritation.
Respiratory or skin sensitization	A respiratory sensitizer is a product that may cause allergy or asthma symptoms or breathing difficulties if inhaled. A skin sensitizer is a product that may cause an allergic skin reaction.
Germ cell mutagenicity	This hazard includes products that may cause or are suspected of causing genetic defects. Genetic defects are permanent changes (mutations) to body cells that can be passed on to future generations.
Carcinogenicity	This hazard class includes products that cause or are suspected of causing cancer.
Reproductive toxicity	This hazard class includes products that may damage or are suspected of damaging fertility (the ability to conceive children) or embryo, fetus, or offspring. Note: there is also a category that includes products that may cause harm to breast-fed children.
Specific target organ toxicity – single exposure	This hazard class covers products that cause or may cause damage to organs (for example, the liver, kidney, or blood) after a single exposure. This class also includes a category for products that cause respiratory irritation drowsiness, or dizziness.

Health hazards class	General description
Specific target organ toxicity – repeated exposure	This hazard class covers products that cause or may cause damage to organs (for example, the liver, kidney, or blood) following prolonged or repeated exposure.
Aspiration hazard	This hazard class is for products that may be fatal if they are swallowed and enter the airways.
Biohazardous infectious materials	These materials are micro-organisms (e.g., viruses, bacteria, or fungi), nucleic acids (e.g., DNA or RNA), or proteins that cause or are probable causes of infection, with or without toxicity, in humans or animals.
Health hazards not otherwise classified	This class covers products that are not included in any other health hazard class. These hazards occur following acute or repeated exposure. They have adverse effects on the health of a person exposed to them – including injury or death. If a product is classified in this class, the hazard statement will describe the nature of the hazard.

2.3.2 Hazard Categories

Each hazard class contains at least one category. The hazard categories are assigned a number (1, 2, etc.). Categories may also be called “types”. Types are assigned an alphabetical letter (A, B, etc.). In a few cases, subcategories are also specified. Subcategories are identified with a number and a letter (for example, 1A and 1B).

The category tells you how hazardous the product is (that is, the severity of hazard).

- Category 1 is always the greatest level of hazard. 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. They do not describe the degree of hazard.

Also, the “reproductive toxicity” hazard class has a separate category called “Effects on or via lactation” which was not assigned a numbered category. Reproductive toxicity also has categories 1 and 2, which relate to effects on fertility and/or the embryo, fetus, or offspring. “Effects on or via lactation” is considered a different, bur related, hazard within the “Reproductive toxicity” class.

Table 5. Hazard categories and ranking

Hazard category	Level of hazard
1	More hazardous
2A	↕
2B	
3	Less hazardous

2.3.3 Pictograms

Pictograms are graphic images that immediately show you what type of hazard a hazardous product presents. Most pictograms have a red, diamond-shaped border. Inside this border is a symbol that represents the hazard, such as fire, health hazard, corrosive, etc. Together, the symbol and the border are referred to as a pictogram. Pictograms are assigned to specific hazard classes or categories.

The following table shows the pictograms. The name of each pictogram is in bold type; the words in the brackets describe the hazard. The table is reproduced from Canadian Centre for Occupational Health and Safety

Table 6. WHMIS 2015 pictograms

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

2.3.4 Explosive Materials

The hazard classes and categories described by the **exploding bomb** pictogram are:

- Self-reactive substances and mixtures (Types A and B)
- Organic peroxides (Types A and B)

i. Definition

Explosives are solid or liquid chemicals capable of a chemical reaction that causes damage to the surroundings. Heating the self-reactive substances and organic peroxides may cause fire or explosion (without the need for air).

Self-reactive substances/mixtures class and the organic peroxides class are also represented by the flame pictogram. The difference is the hazard category. Types A of these classes are more the most hazardous and fall into the explosive materials category. Types B materials are described by both the flammable and explosive symbols. Deflagration is a very rapid combustion of particles of an explosive that has a subsonic (below the speed of sound) rate of reaction. A detonation is an almost instantaneous combustion of an explosive accompanied by high temperature-pressure wave formation of supersonic rates. Detonation will produce a true shock wave as the result of the explosion, while deflagration will not.

Appendix E lists some explosive and potentially explosive chemicals; Appendix D lists some dangerously reactive materials.

ii. Hazards

The GHS established several categories for self-reactive substances and mixtures. Type A corresponds to the reactive substances that, as packaged, will detonate or deflagrate rapidly. Type B materials, as packaged, do not detonate or deflagrate rapidly but are capable of undergoing a thermal explosion.

A series of effects will be produced by an explosion. These effects are broken into two major categories, primary and secondary effects. Primary effects will always accompany an explosion, while secondary effects may or may not occur. Primary effects include the blast pressure, fragmentation (of the explosive container as well as materials in the same vicinity) and thermal (characterized by the flash and fireball associated with the explosion). Secondary effects are also divided into three types: shock wave modification, fire, and shock wave transfer. It is important to remember that all or none of the secondary effects may be present with any given explosion. Of these three, fire is the only one generally of concern in a laboratory.

Hazards of the explosive materials of Type B are discussed in section 2.3.5.

iii. Handling

A written, comprehensive project-specific risk assessment with additional oversight is required for any experiment involving a chemical in this category.

A chemical fume-hood and permanent or portable blast shields and remote operations should be used to isolate as much as possible the researcher from the chemical. Other important factors when handling explosive chemicals as the scale of work, using compatible tools and equipment, eliminating sources of static discharge and keeping the area as clean as possible are detailed in the Safe Work Procedures.

iv. Peroxide Testing Program

If ether peroxidation is visibly evident as a viscous layer in the bottom of the container or crystals around the cap, **do not handle the container**. If the container is more than 2 years old, and has not been opened or tested within the past 12 months, do not open the container and call the ESF Technician at 604-822-6306. On the Okanagan campus, contact Risk Management Services.

Certain ethers such as di-isopropyl ether form peroxides more rapidly than most others form and should be handled with particular care. Purchases of large quantities and long-term storage are not recommended.

There are several methods for the detection of peroxides, two of which are described below.

<u>Test Strips</u>

The simplest method for testing for the presence of peroxides in materials can be done using peroxide test strips available from local laboratory supply houses.

<u>Chemical Testing</u>

To 1 mL of the ether to be tested, add a solution of 100 mg of potassium iodide in 1 mL of glacial acetic acid. A pale yellow colour indicates a low concentration (0.001 to 0.0005 %) of peroxides, and a bright yellow or brown colour indicates a high (> 0.1%) and hazardous concentration of peroxides. This chemical test is more sensitive than the test strips, as it will detect di-alkyl peroxides as well as hydroperoxides.

It should be remembered that these tests are valid only for relatively simple chemicals. Complicated organic structures may also act as oxidizing agents and therefore appear to give positive tests for peroxides. There are no testing methods for peroxides of potassium metal.

v. Handling and Removal of Peroxides

If peroxides are detected, the solvent should be treated prior to use or being sent for disposal to ESF. See UBC's Procedure for Working with Peroxide Forming Compounds and for examples of peroxidizable compounds, Appendix F.

2.3.5 Gases under Pressure

i. Definition

Gases under pressure include compressed gases, dissolved gases or gases liquefied by compression or refrigeration within reinforced metal cylinders. This includes cryogenic liquids that are hundreds of degrees below zero Celsius, thereby representing an extreme cold hazard. There are four sub-groups of compressed gases:

- Compressed gas (O_2, helium, argon)
- Compressed liquid (chlorine, CO_2)
- Dissolved gas in liquid (acetylene in acetone)
- Cryogenic liquids (N_2, O_2)

ii. Hazards

Compressed gases present a physical danger resulting from the sudden, out-of-control release of these materials from their containers. This release is associated with a concomitant discharge of energy due to great expansion in volume of the material leaving the cylinder (i.e. the energy released is akin to a jettisoned rocket that is capable of bursting through walls or any other objects in its way). The rapid diffusion of compressed gas can increase the exposure radius, increasing the potential for acute exposure and damage (corrosive or toxic gases). The release of compressed gas can also cause asphyxiation through the displacement of oxygen in the air. Compressed gases may be flammable, pyrophoric, toxic, corrosive, oxidizer, or reactive; their additional hazards will depend on the chemical nature

Most cryogenic liquids, such as liquid nitrogen, can cause frostbite to the skin. A few cryogenic liquids, such as hydrogen, propane and liquefied natural gas, are flammable. When handling these materials, the appropriate hand and eye protection against cold hazards as well as chemical hazards must be used.

iii. Handling

The following basic precautions should be implemented when handling compressed gas cylinders:

- Chain or strap in upright position
- Protective cap in place while being moved
- Use cart to move
- Do not empty (not less than 30 psi)
- Cylinder valves closed when not in use

Compressed Gas Cylinders – Pressure Regulators:

Pressure regulators are used in a system using compressed gas to reduce pressure from high-pressure sources, such as gas cylinders or gas supply pipelines, to a safe working pressure range. The pressure regulator should be attached to a cylinder without forcing the threads. A poor fit may indicate that the regulator is not intended for use on the gas chosen.

Take additional precautions when working with cryogenic liquids:

- Use proper Personal Protective Equipment
    - Wear clothing that covers arms & legs
    - Wear cryogenic gloves under sleeves
    - Wear safety glasses and face shield
    - Wear non-slip closed shoes and apron
- Use specially designed storage, transport, and dispensing containers
- When working indoors, make sure the dispensing area is adequately ventilated

Insulated vacuum-jacketed pressure vessels are equipped with safety relief valve and rupture disk to protect from pressure build up, check them regularly.

When transporting large volume of cryogenic liquids in an elevator, whenever possible, send the cryogen container in an elevator without any passengers, and ensure that no passengers get on the elevator while the cryogen is being transported. In a power failure, a passenger could be trapped in the confined space of an elevator with the cryogen. Excessive amounts of the cryogen could vaporize and displace the oxygen.

2.3.6 Flammable Materials

i. Definitions

The hazard classes and categories described by the **flammable** pictogram are:

- Flammable gases (Category 1)
- Flammable aerosols (Categories 1 and 2)
- Flammable liquids (Categories 1, 2, and 3)
- Flammable solids (Categories 1 and 2)
- Pyrophoric liquids (Category 1)
- Pyrophoric solids (Category 1)
- Pyrophoric gases (Category 1)
- Self-reactive substances and mixtures (Types B, C, D, E, and F)
- Self-heating substances and mixtures (Categories 1 and 2)
- Substances and Mixtures Which, in Contact with Water, Emit Flammable Gases (Categories 1, 2, and 3)
- Organic Peroxides (Types B, C, D, E, and F)

A description of these classes can be found in Table 3 above.

The use, storage and handling of flammable and combustible materials are governed by WorkSafe BC and the BC Fire Code.

There are several definitions used when referring to the flammability of a compound. One of the physical properties used to describe flammability is the vapour pressure defined as the pressure that is exerted by a saturated vapour above its own liquid in a closed container. It is reported in mm Hg, and it is positively correlated with temperature.

Table 7 Definitions of flammability descriptors

Descriptor	Definition
Flash point	The minimum temperature at which a liquid within a container gives off vapour of sufficient concentration in air that can ignite in the presence of an ignition source.
Flammable liquid	A liquid having a flash point below 37.8°C (100°F), and having a vapour pressure not exceeding 275.8 kPa (absolute) at 37.8°C. (per the BC Fire Code)
Combustible liquid	A liquid with a flash point at or above 37.8°C.
Explosive limits	The vapour concentration range of a combustible or flammable material that will ignite in the presence of an ignition source; the LEL (lowest explosive limit) and UEL (upper explosive limit) are usually indicated by the percentage by volume of vapour in air.
Auto-ignition temperature	The temperature at which the vapour from a liquid will ignite without a source of ignition such as a spark or flame.
Self-accelerating decomposition temperature (SADT)	The lowest temperature at which an organic peroxide in a typical vessel or shipping package will undergo a self-accelerating decomposition within one week. The SADT is the point at which the heat evolution from the decomposition reaction and the heat of removal rate from the package of interest become unbalanced.

For a flammable liquid to ignite, three conditions must exist simultaneously: (1) the concentration of the vapor must be between the upper and lower flammable limits of the substance; (2) an oxidizer (usually the oxygen in air) must be present; and (3) a source of ignition must be present. This phenomenon is usually referred to as the "Fire Triangle" (Figure 4). Removing any of the three components will extinguish a fire.

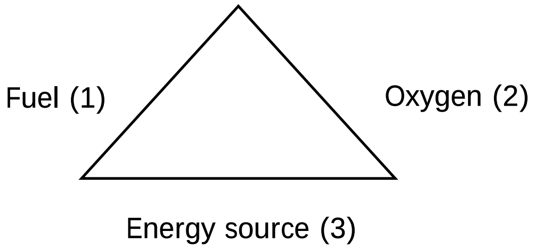


Figure 4. The fire triangle

ii. Hazards

Flammable materials may readily burn or explode if placed near heat, sparks, or open flames. Flammable liquids do not burn themselves but give off vapours that, when mixed with air, burn. In most cases, these vapours are heavier than air and can travel long distances until reaching a source of ignition such as an open flame, hot surfaces, static sparks, etc. at which time a fire or explosion could result.

Flammable liquids pose many serious problems. The misuse of a small amount can have a disastrous effect. As liquids, they can flow and thus any spillage will increase the fire hazard. Many common solvents (e.g., acetone, ether, toluene, etc.) present in laboratories have flash points well below room temperature. Flammable liquids and mixtures containing flammable liquids are assigned to one of four hazard categories, as indicated in safety data sheets (SDSs), based on their flash points and boiling points (Table 8 below).

Table 8 Criteria for flammability hazard statements

Category	Criteria	Hazard statement
1	Flash point < 23°C and initial boiling point ≤ 35°C	Extremely flammable liquid and vapour
2	Flash point < 23°C and initial boiling point > 35°C	Highly flammable liquid and vapour
3	Flash point ≥ 23°C and initial boiling point ≤ 60°C	Flammable liquid and vapour
4	Flash point ≥ 60°C and initial boiling point ≤ 93°C	Combustible liquid

The flash points of several commonly used solvents are provided in Appendix B.

Flammable vapours can also be carcinogenic or otherwise harmful to one's health, and should generally be used in a fume hood.

iii. Handling (basic instructions)

Flammable compounds

- Should be kept away from heat, sparks, and open flames
- A minimum quantity should be available in the work area.
- Store the chemicals away from oxidizers
- Label containers FLAMMABLE
- In the **open** laboratory area, the UBC Flammable Liquid Guidelines restrict the volume of flammable liquids to a maximum of 25 L. Amounts in excess of this must be kept in approved safety cans, a flammable liquid cabinet or proper flammable storage facility.

Pyrophoric compounds

- A protective anhydrous inert atmosphere of either nitrogen or argon gas must be maintained over the surface of the liquids
- Keep reagent bottle within a secondary containment vessel, if necessary store in refrigerator (see SDS for instructions)
- Pyrophoric solids should be used in a sealed glove box flushed with inert gas
- Mild pyrophoric solids (e.g. $LiAlH_4$, NaH) may be handled in the air for brief periods of time, but the containers must be flushed with inert gas before storage
- Alkali metals should be stored under mineral oil
- Avoid storage areas with heat/flames, oxidizers, and water sources

Self-reactive substances and mixtures

- Purchase the smallest amount necessary as hazard rating relates to the amount packaged

Self-heating substances and mixtures

- Keep away from light, sources of heat, moisture, and other flammable and combustible materials (e.g. in desiccator, dry box or glove box)
- Keep amounts on-hand to a minimum, conduct work on the smallest scale possible

Substances and mixtures, which, in contact with water, emit flammable gases

- Conduct operations in a manner to prevent exposure to the atmosphere.

- Purchase the most stable chemical that will do the job. Purchase those that contain stabilizing diluents or other hazard reducing additives.
- Conduct work on the smallest scale possible.

Organic Peroxides

- Store organic peroxides separately (away from incompatible materials such as strong acids and bases, flammable or combustible liquids and materials that can be oxidized)
- Store organic peroxides out of direct sunlight and away from steam pipes, boilers or other heat sources.

When working with these hazardous compounds, always read first the corresponding safe work procedures.

2.3.7 Oxidizing Materials

The hazard classes and categories described by the **flame over circle** pictogram are:

- Oxidizing gases (Category 1)
- Oxidizing liquids (Categories 1, 2, and 3)
- Oxidizing solids (Categories 1, 2, and 3)

i. Definition

Oxidizing materials are substances that readily yield oxygen or its equivalent to stimulate the combustion (oxidation) of organic matter. Chromic acid and chromates, nitric acid and nitrates, perchloric acid and perchlorates, permanganates, peroxides and bleach (hypochlorite) are all examples of oxidizing reagents. Oxidizers are incompatible with reducing agents (e.g. hydrides, bisulfites and thiosulfates), and with flammable and combustible materials (e.g. solvents, Varsol and acetic acid). An oxidizing liquid might not be itself combustible but, by yielding oxygen, can cause or contribute to the combustion of another material.

Nitric and perchloric acids are both strongly oxidizing acids. They will act rapidly on exposed skin through a denaturing mechanism. Nitric and perchloric acids will also act explosively with organic compounds and reducing agents. Safe work procedures to follow when working with perchloric acid is being developed and will be posted on the RMS website.

ii. Hazards

Oxidizing materials can cause fire without an ignition source when mixed with flammable or combustible materials. These materials can also increase the speed and intensity of a fire, and cause generally non-combustible materials to burn rapidly. Oxidizing materials may also react with other chemicals to produce toxic gases.

iii. Handling

Oxidizing materials should be used in an area free of combustible, flammable and reducing materials. Minimum amounts of oxidizing material should be left out of storage when in use. Oxidizing materials that contain peroxidizable compounds must have a label, and must be tested regularly to ensure that a build-up of peroxide has not occurred. Follow the specific procedure for Working with Peroxide Forming Compounds.

2.3.8 Acutely Toxic Compounds

The hazard classes and categories described by the **skull and crossbones** pictogram are:

- Acute toxicity
    - Oral (Categories 1, 2, and 3)
    - Dermal (Categories 1, 2, and 3)
    - Inhalation (Categories 1, 2, and 3)

i. Definition

A toxic chemical is any substance that may cause damage to structure or disturbance to function when it is ingested, inhaled or absorbed, or when applied to, injected into or developed within the body, in relatively small amounts, by its chemical action.

The toxicity of chemicals is assessed by their Lethal Dose or LD. An LD_{50} is the amount of a material, given all at once, which causes the death of 50% (one-half) of a group of test animals. The LD_{50} is one way to measure the short-term poisoning potential (acute toxicity) of a material. Lethal doses may occur *via* different routes of exposure. The most common lethal dose notations on Safety Data Sheet (SDS) are the $LD_{50\ oral}$. This is defined as the oral dose at which 50 percent of the exposed test animals (rats or mice) died, usually within 1-2 hours. LC_{50} is defined as the concentration in air at which 50 percent of the test animals (rats or mice) died, usually within 1 hour. Some chemicals may also have an associated $LD_{50\ dermal}$, which is reflective of the amount of chemical in mg/Kg applied to the skin that caused 50% of the test animals to die. Not all chemicals have been tested and animal testing has fallen out of favor, so it is important to remember lack of this information on an SDS does not necessarily mean the chemical has no toxic properties.

A chemical is considered acutely toxic when it falls within any of the following categories:

- A chemical with a median lethal dose (LD_{50}) of 50 mg or less per kg of body weight when administered orally to albino rats weighing between 200 and 300 gm each
- A chemical with a median lethal dose (LD_{50}) of 200 mg or less per kg of body weight when administered by continuous contact for 24 hours (or less if death occurs within 24 hours) with the bare skin of albino rabbits weighing between 2 and 3 Kg each
- A chemical that has a median lethal concentration (LC_{50}) in air of 500 ppm by volume or less of gas, 2.0 mg per liter for vapor, or 0.5 mg per liter or less of dust and mists, when administered by continuous inhalation for 4 hours.

ii. Hazards

The effects of toxic chemicals are related to the routes of entry, dose, and duration. Of the three routes of exposure (oral, dermal, and inhalation) the inhalation tends to pose the greatest risk. Relative to skin (dermal-absorption) and the digestive system (oral-ingestion), the respiratory system has the largest exposed surface area at 70 to 100 square meters, most of which consists of the lungs. In comparison, the digestive system has an exposed surface area of 10 square meters; the skin 2 square meters. In addition, the respiratory system is designed to absorb oxygen and release carbon dioxide. This exchange occurs in the alveoli (primary gas exchange unit of the lungs), which are fragile and moist. This is a perfect environment in which chemicals can dissolve and either be absorbed by the body or directly damage the lungs.

Like the respiratory system, the digestive tract is also designed to absorb certain chemicals (e.g., food, water) while excreting wastes. Inadvertent ingestion occurs in one of two ways. Either the chemical is caught in or dissolves in nasal or throat mucus and is swallowed, or chemicals contaminate the hands, cups or eating utensils, food, etc. and are swallowed while drinking and eating. Like the respiratory system, the digestive system is moist which can aid absorption. In addition, digestion in the stomach involves acids, which can draw metals and other chemicals into solution where they can be absorbed by the body.

The skin, by design, is a protective barrier to many chemicals. Generally speaking, solids, gases, chemical salts in solution and other polar (i.e., water miscible) chemicals find it difficult to pass the protein layer of the epidermis (surface layer of skin) and the fatty tissues of the dermis (under layer of skin). In contrast, some chemicals readily pass both the epidermis and the dermis and can be transported throughout the body by the circulatory system. Some chemicals, like dimethyl sulfoxide, while not very toxic in and of themselves are capable of significantly aiding other chemicals that are toxic across the barrier posed by the skin.

iii. Occupational exposure limits

Several organizations establish numerical occupational exposure limits for various chemicals.

- The American Counsel of Governmental Industrial Hygienists (ACGIH) publishes inhalation exposure limits as Threshold Limit Values (TLVs).
- The National Institute of Occupational Safety and Health (NIOSH) publishes inhalation exposure limits as Recommended Exposure Limits (RELs).
- The Occupational Safety and Health Administration (OSHA) publishes inhalation exposure limits as Permissible Exposure Limits (PELs).

In British Columbia, the occupational exposure limit values posted by WorkSafe BC have legislative power. The values are usually based on the ACGIH exposure limits. For the Table of Exposure Limits for Chemical and Biological Substances, refer to the Worksafe BC OHS regulations.

All three types of limits, TLVs, RELs, and PELs, can be expressed in one of three ways. These are:

- An 8-hour Time-Weighted Average (TWA), which is an expression of the level of exposure when averaged over a typical 8-hour workday. The level of exposure can vary greatly during any given period of the day.
- A Short-Term Exposure Limit (STEL), which is an expression of the maximum amount of exposure that can occur during a short period of time (e.g., 15 minutes) regardless of the exposure when calculated as an 8-hour TWA.
- A Ceiling Limit (C), which is the maximum amount of exposure that can occur for any period regardless of how short the duration.

In addition to this, NIOSH has also created an IDLH (Immediately Dangerous to Life and Health), which represents the concentration of a substance that may be fatal even during extremely brief exposure.

Acutely toxic substances are usually characterized by a ceiling limit value and an IDLH value.

iv. Handling

The physical state of the chemical is important when considering both the hazard level and handling of the toxic substance. Chemical gases and vapors generally pose the most risk by inhalation. Levels of gases and vapors that pose a threat by absorption are generally already lethal by inhalation.

Liquids generally pose the greatest risk by absorption though they can also pose a threat by ingestion. With chemical solids, the form of the solid is important. Granules, chips, and other relatively large particles do not readily become airborne and so are not likely to be inhaled, nor do they readily stick to other surfaces such as the hands to be ingested. However, dusts can become airborne and easily inhaled and/or ingested. Due to static and other attractive forces, they are more likely to stay on surfaces such as the hands.

Independent of the physical state of the chemical, working in a well-ventilated area (fume-hood) with personal protection equipment (PPE) is mandatory. Additional PPE is required depending on the specifics of the toxic chemical being used (e.g. goggles and/or face shield when there is potential for splashes, additional protective clothing for dermal toxic compounds, etc.).

2.3.9 Health Hazardous Compounds

The hazard classes and categories described by the **health hazard** pictogram are:

- Respiratory or skin sensitization – Respiratory sensitizer (Categories 1, 1A, and 1B)
- Germ cell mutagenicity (Categories 1, 1A, 1B, and 2)
- Carcinogenicity (Categories 1, 1A, 1B, and 2)
- Reproductive toxicity (Categories 1, 1A, 1B, and 2)
- Specific target organ toxicity – Single exposure (Categories 1 and 2)
- Specific target organ toxicity – Repeated exposure (Categories 1 and 2)
- Aspiration hazard (Category 1)

The hazard classes and categories described by the **exclamation mark** pictogram are:

- Acute toxicity – Oral, Dermal, Inhalation (Category 4)
- Skin corrosion/irritation – Skin irritation (Category 2)
- Serious eye damage/eye irritation – Eye irritation (Categories 2 and 2A)
- Respiratory or skin sensitization – Skin sensitizer (Categories 1, 1A, and 1B)
- Specific target organ toxicity – Single exposure (Category 3)

i. Definition

A description of these health hazard classes can be found in Table 4. Substances in these hazard classes can cause serious health problems including cancers, dermatitis and asthma. As opposed to acutely toxic substances, the health effect of health hazardous compounds will not occur until some point after the exposure. This is called a chronic effect and may occur hours, days, months or even years after exposure. Some toxic materials can have both acute and chronic health effects.

ii. Hazards

Each of the classes belonging to the health hazardous compounds pose a particular hazard to the health of a human (e.g. sensitization, mutagenicity, carcinogenicity, etc.). They can also have other hazards associated with them; they can also be corrosive and flammable.

The exclamation mark pictogram usually describes compounds with a less hazardous health effect (categories 2, 3, or 4) compared to the health hazard pictogram.

Two agencies classify carcinogenic compounds. These are the American Conference of Governmental Industrial Hygienists (ACGIH) and the International Agency for Research on Cancer (IARC). ACGIH also identifies compounds that are reproductive toxins and/or sensitizers. The

ACGIH and IARC classification of carcinogens and a list of carcinogens, reproductive toxins and sensitizers can be found in Appendix C.

iii. Handling

Whenever possible, it is always best to avoid using a toxic material either by eliminating its use (by changing the method or process for example) or by substituting the toxic material with a less hazardous material. Unfortunately, it is not always possible to find a non-toxic substitute that still does the job effectively and safely.

Since the health effect of these compounds is not immediately apparent, there is the risk of not taking all precautions when handling these chemicals. The Safety Data Sheet for these compounds identifies specific handling instructions and needs to be carefully consulted whenever working with a compound in this class. Adequate engineering controls and personal protective equipment is essential in reducing the risk associated with working with toxic of health hazardous compounds.

Worksafe BC identifies as designated substances:

- Carcinogens: Categories 1, 1A, 1B, and 2 (ACGIH A1 or A2; IARC 1, 2A or 2B)
- Reproductive toxins: Categories 1, 1A, 1B, and 2 (ACGIH reproductive toxin)
- Sensitizers: Respiratory or skin sensitizer (ACGIH sensitizer)
- ACGIH L endnote

According to the regulation, if a designated substance is identified in a workplace the employer must replace it, if practicable, with a material, which reduces the risk to the workers. If it is not practicable to substitute, a designated substance than the employer must implement an exposure control plan to maintain the worker's exposure as low as reasonably achievable (ALARA) below the exposure limit. These exposure limits are posted in the WorkSafe BC's Table of Exposure Limits for Chemical and Biological Substances. An Exposure Control Plan for Carcinogens, Reproductive Toxins and Sensitizers is currently being developed and will be posted on the RMS website. A list of chemical and biological substances identified as carcinogens, reproductive toxins and sensitizers is included in Appendix C.

2.3.10 Biohazardous Materials

The hazard classes and categories described by the **biohazardous infectious materials** pictogram are:

- Biohazardous infectious materials (Category 1)

i. Definition

These materials are organisms or the toxins they produce that can cause diseases in people or animals. Included in this division are bacteria, viruses, fungi and parasites.

ii. Hazards and handling

As these organisms can live in body tissues and fluids, they should be treated as toxic. Urine and feces should be treated as toxic only if they are visibly contaminated with blood. Biohazardous infectious materials are usually found in a hospital, health care facility, laboratories, veterinary practices and research facilities. Workers in these places do not usually know which tissues or fluids contain dangerous organisms. For this reason, the workers assume that every sample is dangerous and proper protection is used all the time. Examples of biohazardous infectious materials include the AIDS/HIV virus, Hepatitis B and salmonella.

Please refer to the Biological Safety Training Manual for detailed information on the use, handling and storage for these biohazardous materials.

2.3.11 Corrosive Materials

The hazard classes and categories described by the **corrosion** pictogram are:

- Corrosive to metals (Category 1)
- Skin corrosion/irritation – Skin corrosion (Categories 1, 1A, 1B, and, 1C)
- Serious eye damage/eye irritation – Serious eye damage (Category 1)

The first class (corrosive to metals) is a physical hazard while the other two classes (Skin corrosion/irritation – Skin corrosion and serious eye damage/eye irritation) belong to the health hazards.

i. Definition

A corrosive material is a highly reactive substance that causes obvious damage to living tissue. Corrosives act directly, either by chemically destroying the part (oxidation), or indirectly by causing inflammation.

Acids and bases are common corrosive materials. Corrosives such as these are also sometimes referred to as caustics.

ii. Hazards

Corrosives attack and chemically destroy exposed body tissues and metal. They begin to cause damage as soon as they touch the skin, eye, respiratory tract, digestive tract, or the metal. They might be hazardous in other ways too, depending on the particular corrosive material.

Non-penetrating corrosives react with human tissue to form a protective layer that limits the extent of damage. Most acids are non-penetrating corrosives. Penetrating corrosives, such as most alkalis, hydrofluoric acid and phenol, enter the skin or eyes deeply. Penetrating corrosives require longer water flushing (a minimum of 60 minutes) than non-penetrating corrosives (a minimum of 20 minutes).

Some corrosives are also flammable or combustible and can easily catch fire and burn or explode. Some corrosives are incompatible with other chemicals. They may undergo dangerous chemical reactions and give off toxic or explosive products if they contact each other.

Corrosives comprise both acids and bases (caustics). The pH of a solution describes the degree of acidity or alkalinity of a solution, on a scale of 0 to 14. Materials with pH 7 are considered neutral and non-corrosive; those below 7 are acidic and those above 7 are caustic or basic. The further away from pH 7 that a substance is, the more corrosive it is.

iii. Handling

When mixed together, acids and bases will react vigorously with each other through an exothermic (heat releasing) neutralization reaction. Proper handling and usage of corrosives require protective clothing to prevent skin, eye, or lung exposure. Serious burns and eye or lung damage can result from contact with corrosive materials.

Mineral acids (e.g. phosphoric, hydrochloric, nitric, sulfuric, and perchloric acid) can be stored in a cabinet designed for corrosive acids. Nitric acid can also be stored with oxidizers. These non-metallic cabinets have no internal metallic parts, acid resistant coating and a cabinet floor constructed to be able to contain spillage. Volatile acids, such as oleum or fuming nitric acid, should be stored either in an acid cabinet or in a vented cabinet, such as the fume hood base, particularly after they have been opened.

Organic acids such as acetic acid should be stored separately from mineral acids. When there is only one suitable storage cabinet, secondary containment can be used for separation.

It is very important to use all recommended personal protective equipment when handling corrosive materials. Some corrosives have very specific handling instructions and emergency procedures and separate safe working procedures have been developed for them. These corrosives are Hydrofluoric acid, Picric acid and Perchloric acid.

3 Risk Control

3.1 Introduction

At UBC there are many types of laboratories, each with very different hazards, however common control measures can be implemented to prevent accidents, injuries, and disease.

Once the hazards have been identified and assessed, it is necessary to control these chemical hazards used in the laboratory. There are five types of controls for minimizing or eliminating hazards. They are listed below in order of effectiveness from most to least effective:

- Elimination
- Substituting with less hazardous material
- Engineering controls
- Administrative controls
- Personal protective equipment

Elimination of a hazardous product or substitution with a less hazardous product represents the best solution. Engineering controls are the next best choice for controlling hazardous materials. They do not require continual monitoring and are more likely to be used; however, they do require regular maintenance and are more expensive to implement. The next type of control is administrative and it includes written procedures, training, supervision and scheduling of activities. The use of personal protective equipment represents the least effective type of control; its effectiveness is limited by the dependence on individuals wearing it.

3.2 Elimination and Substitution

Elimination is the most effective engineering control as it completely removes the hazard. However, in a research academic setting it can be quite difficult to eliminate a hazardous chemical substance, as it might be instrumental to the actual research project.

Substitution occurs when a new chemical or substance that is less hazardous is used instead of another chemical. It is sometimes grouped with elimination because, in effect, you are removing the first substance or hazard from the workplace. The goal, obviously, is to choose a new chemical that is less hazardous than the original.

Another type of substitution includes using the same chemical but to use it in a different form. For example, a dry, dusty powder may be a significant inhalation hazard but if this material can be purchased and used as pellets or crystals, there may be less dust in the air and therefore less exposure.

Due to the nature of chemistry research work, it is often difficult to eliminate or substitute hazardous chemicals. However, when possible, they should be considered.

3.3 Engineering Controls

There are several standard laboratory-engineering controls: fume hoods, biosafety cabinets and glove boxes.

- protect the user from inhaling toxic gases (fume hoods, biosafety cabinets, glove boxes)
- protect the product or experiment (biosafety cabinets, glove boxes)
- protect the environment (recirculating fume hoods, certain biosafety cabinets, and any other type when fitted with appropriate filters in the exhaust airstream)

3.3.1 Laboratory Fume Hoods

Fume hoods are found in virtually every chemistry lab. A fume hood is typically a large piece of equipment enclosing five sides of a work area, the bottom of which is most commonly located at a standing work height. Their purpose is to protect the user from inhalation hazards.

In order for a fume hood to be effective, it has to be correctly used and regularly maintained. The following work practices should be followed in order to assure proper airflow inside the fume hood:

- Keep fume hood exhaust fans on at all times when hazardous materials are present. On the Okanagan campus, control boxes should show the fume hood running on high with a green light showing; fume hoods running in yellow or red should not be used.
- Perform all work six inches inside the hood to minimize turbulence at entrance to hood as this can cause some of the contaminants to be swirled out of the hood. Do not put your head inside a fume hood.
- Keep the hood sash at the level indicated on the maintenance sticker. When not actively working in the fume hood, keep the sash closed to provide an extra layer of protection from chemicals, splashes, gases and other events within the fume hood.
- Keep lab doors closed to ensure negative room pressure to the corridor and proper airflow into the hood.
- Avoid rapid movements in front of the hood including opening and closing the fume hood sash rapidly and swift arm and body movements in front of or inside the hood. These actions may increase turbulence and reduce the effectiveness of fume hood containment.
- With the exception of placing larger equipment / chemical containers inside the fume hood, do not raise the sash higher than the labeled height as this will reduce the hood efficiency.
- Avoid blocking the rear ventilation slot. Material stored at the back of the hood should be stored on an elevated shelf so that the slot airflow is not impeded.
- Keep the bypass grill clean and unobstructed.

Depending on the campus location (type of fume hood), the response in case of failure is different.

Vancouver Campus

If Fume Hood Air Flow Stops:

- Note pressure gauge reading, if one is provided.
- Shut off experiments, turn off heat, relieve system pressure.
- Seal containers; remove compressed gas cylinders from the hood.
- Ensure no other lab equipment is vented into the hood.
- Place “Do Not Use; Hood Out of Order” sign on the fume hood.
- Where radioisotopes are used, contact the Radiation Officer at 2-7052.
- Call Service Centre at 2-2173.
- Advise your departmental administrator

Okanagan Campus

All fume hoods are fitted with electronic monitors, on the right hand side.

- If allarm light is yellow
    - Users should stop their work, lower the sash and wait for the light to change
    - If light returns to green, work in the fume hood can be continued
    - If light stays yellow or becomes red
        - stop work, cap all chemicals, put them away
        - contact Campus Security at (250) 807-9236
        - leave the lab
- If allarm light is red
    - stop work, cap all chemicals, put them away
    - contact Campus Security at (250) 807-9236
    - leave the lab

Storage of chemicals in the fume hood is **NOT** recommended. If a fume hood is to be used as chemical storage, it must be labelled as such, and cannot be used for active experiments. In addition, a notice posted on the fume hood must identify fume hoods that are being strictly used for perchloric acid or radiation.

Fume hoods are certified **annually** by Risk Management Services. They should also be tested before they are used, after repair, or when a malfunction is suspected. If a fume hood does not meet WorkSafeBC regulations, the fume hood is repaired. Depending on the nature of the work involved (e.g. whether the actual fume cupboard is included or whether the fume hood system has leaks or not) there are standard procedures that must be performed by fume hood users prior to work being done by maintenance personnel.

There are three levels of fume hood maintenance; they differ with respect to the type of work or maintenance being done and consequently with respect to the activities to be assumed by the fume hood user. For fume hood shutdowns on the Vancouver Campus, the following protocols should be followed: Fume hood Shutdown. On the Okanagan campus, please contact Risk Management Services.

3.3.2 Biosafety Cabinets and Glove Boxes

A biosafety cabinet is an enclosed, ventilated laboratory workspace for safely working with materials contaminated with pathogens. All exhaust air is HEPA-filtered as it exits the biosafety cabinet, removing harmful bacteria and viruses. On Vancouver campus, please refer to the Biological Safety Training Manual for detailed information on the use of biosafety cabinets. For the Okanagan campus, the information is located on the RMS Biosafety page.

A glove box is a sealed container that is designed to allow one to manipulate objects where a separate atmosphere is desired. Built into the sides of the glovebox are gloves arranged in such a way that the user can place their hands into the gloves and perform tasks inside the box without breaking containment. Two types of gloveboxes exist: one allows a person to work with hazardous substances, such as radioactive materials or infectious disease agents; the other allows manipulation of substances that must be contained within a very high purity inert atmosphere, such as argon or nitrogen. It is also possible to use a glovebox for manipulation of items in a vacuum chamber.

Glove box work practices are developed on individual basis, depending on the model and intended use. It is the responsibility of the manager of the lab owning a glove box to schedule the necessary maintenance and inspections as per instructions from manufacturer.

4 Administrative Controls

Administrative controls consist of various hazard control requirements that are established at an administrative level (e.g., by the principal investigator, laboratory manager, laboratory supervisor, department chair, laboratory safety coordinator, department safety committee, or University Risk Management Services) to promote safety in the laboratory.

Administrative controls describe the way the work is done and include other measures to reduce employee exposure to hazards. Administrative controls do not remove hazards, but limit or prevent exposure to the hazards.

Examples of administrative controls include written plans and standard operating procedures, signs, labels, training, supervision, timing of work, personnel substitutions, using a lab partner, and more.

4.1 Chemical Safety Training

The UBC Risk Management Services offers training to meet the requirements of the Transport Canada, WHMIS and WorkSafeBC. The training is mandatory for all faculty, staff, visiting scientists and students prior to applying for or on having access to areas where chemical hazards are being handled or stored. The elements required under the “Worker education” section of Worksafe BC regulations (5.6) are covered by the “Chemical Safety Training” and/or “WHMIS and other Hazard Identification Systems”.

The “Worker training” section of the regulation (5.7) is more specific and involves direct training by the supervisor.

Supervisors are responsible for maintaining the training records of their employees including training specific to the workplace safe work procedures and emergency response procedures. Training records are also kept by the Risk Management Services for the courses it administers.

4.2 Laboratory Hazard Door Signage

Laboratory Hazard Door Signage provides emergency responders with a comprehensive view of the hazard classes contained within a laboratory space to determine an appropriate and effective response to emergencies. These signs are placed at the entrance of workspaces where hazards exist (Figure 5). To see what each sign symbolizes, see the Laboratory Hazard Signage Document (PDF).

Figure 5. Example of a laboratory hazard door signage

Whenever hazardous materials of a specific class are added to or removed from the laboratory's inventory, this information must also be passed on to Risk Management Services to update the sign. To request, update, or replace an existing poster on Vancouver campus fill out the Laboratory Hazard Signage Application Form (WORD) and email to the RMS Research Safety Office. On the Okanagan campus contact RMS or submit an updated laboratory registration document.

4.3 Working Alone Procedure

Students, staff and faculty may engage in activities that require them to work alone with hazardous materials. In these situations, a fail-safe communication procedure must be in place to ensure the individual receives help if an accident or emergency should occur.

Whenever possible, an effort should be made to avoid working alone situations. However, for situations where a person will be working alone or in isolation and where assistance would not readily be available:

- in case of an emergency, or
- in case the worker is injured or in ill health

A formal risk assessment needs to be completed and a procedure developed to ensure the health and safety of the worker. Most often a working alone procedure involves regular documented contact with other UBC personnel, preferably within the building. Alternatively, workers can schedule times for contacting a supervisor, friend, partner or a commercial service provider.

For guidance on implementing working alone procedures that meet workplace regulations see Risk Management Services' Working Alone Procedure (PDF).

4.4 Chemical Storage and Segregation

Safety Data Sheets (SDSs) contain general recommendations for the safe storage of hazardous products. These recommendations provide a good starting point for deciding where and how the product should be stored. The storage conditions should be based on workplace-specific factors: the hazards of the product (health, fire and reactivity), the amounts in storage, types of containment (bulk or smaller containers), and the way the product is used.

- DO NOT STORE chemicals in alphabetical order, except within a grouping of compatible chemicals.
- DO NOT STORE materials in a fume hood unless the hood is dedicated (and labeled) to that purpose.
- DO NOT STORE food or drinks in a refrigerator or freezer where chemicals are or have been stored.

4.4.1 Inventory

An annual inventory of hazardous materials is required. According to the WorkSafeBC Occupational Health and Safety Regulation, Part 5, Section 5.98, “An inventory must be maintained which identifies all hazardous substances at the workplace in quantities that may endanger workers in an emergency including controlled products covered by WHMIS, explosives, pesticides, radioactive materials, hazardous wastes, and consumer products. The inventory must identify the nature, location, and approximate quantity of all such substances, and the location of SDSs.”

Annual inventories serve as a reminder to:

- Check chemicals with limited shelf life;
- Remove surplus and old chemicals;
- Correct incompatible storage;
- Know what you have; and
- Cleanup containers & shelves.

Develop a system for locating your chemicals and finding information about them. A good system should:

- Direct you quickly to the chemical;
- Be easy to use;
- Be easy to maintain; and
- Be updated annually.

Laboratories are not storerooms, particularly with respect to chemicals and solvents. Chemicals in laboratories should be stored in areas away from experimental activities, and limited to the requirements of 12 months or less. Whenever possible, excess stock should be kept in a proper chemical storage facility.

4.4.2 General Rules for Safe Storage

Chemical storage, whether in a laboratory or central storeroom, should be under the supervision of a qualified person; storerooms must have adequate security. Specialized cabinets should be used for specific groups of compatible substances.

Best practices include:

- Do not overcrowd shelves.
- Store solvents in a proper flammable liquid cabinet and keep door closed.
- Use appropriate containers for solvents and waste.
- Store highly toxic or controlled materials in a secure (locked) cupboard.
- Store in central, properly ventilated area that includes forced ventilation from floor to ceiling and with exhaust above roof level.
- Store working quantities (small containers that are used daily or frequently) on bench side shelving.
- Shelving should be accessible with chemicals at eye level or lower; no high shelf chemical storage.
- Avoid floor chemical storage (even temporary).
- Shelf assemblies are firmly secured to walls.
- Provide anti-roll lips on all shelves.
- All chemical containers must be sealed, intact, properly labeled and made of compatible material.
- Regularly vent materials capable of building up pressure; e.g., formic acid, nitric acid, and hydrogen peroxide.
- Do not store chemicals in fume hoods unless the fume hoods are used exclusively for this purpose and are labeled as a storage area only

(More information: WorksafeBC Sections 5.20-26 Containers and Storage)

When chemicals need to be stored in a refrigerator or freezer, certain guidelines must be followed. The materials must be securely packaged, tightly sealed and properly labeled. The containers for highly reactive materials must be inspected regularly to ensure they are secure, tightly sealed and in good condition. Refrigerators should be frost free to prevent water drainage. **Flammable materials** (flash point < 37.8°C) that require cold storage must be stored in an **explosion proof unit.** All volatile materials must be compatible with the construction materials of their containment.

4.4.3 Chemical Segregation for Storage

Each chemical must be evaluated to determine where and how it should be stored. Manufacturers' recommendations should be followed. As a rule, flammable or combustible liquids, toxic chemicals, explosive chemicals, oxidizing agents, corrosive chemicals, water-sensitive chemicals, and compressed gases should be segregated from each other. They must be stored in such a way that they will not mix with each other if a container leaks or breaks.

It is important to segregate chemicals for storage in a compatible manner. Two segregation storage systems are provided below.

i. Storage segregation based on Hazard Classes

- Sort according to the categories described below.
- Prioritize the separation process in the following order:

Flammable & Combustible Materials

Oxidizing Materials

Corrosive Materials

Gases Under Pressure

Toxic Materials

ii. Segregation for storage based on the BC Fire Code

(BC Fire Code, 2012 - Table 3.2.7.6)

Table 9. Separation Chart for Storage of Dangerous Goods

Class	Flammable gases	Non-flammable /non toxic	Toxic/ corrosive gases	Flammable liquids	Flammable solids	Substances subject to spontaneous ignition	Water reactive	Oxidizing substances	Organic Peroxides	Poisonous Substance	Corrosives
Flammable gases	-	P	X	P	P	A	DS	X	X	X	X
Non-flammable /non toxic gases	P	-	P	P	P	P	P	P	P	P	P
Toxic/corrosive gases	X	P	-	X	A	A	DS	A	X	DS	A
Flammable liquids	P	P	X	-	P	A	A	X	X	DS	A
Flammable solids	P	P	A	P	-	A	DS	X	X	DS	A
Substances subject to spontaneous ignition	A	P	A	A	A	-	DS	X	X	DS	A
Water reactive	DS	P	DS	A	DS	DS	-	X	X	DS	X
Oxidizing substances	X	P	A	X	X	X	X	-	X	A	X
Organic Peroxides	X	P	X	X	X	X	X	X	-	X	X
Poisonous Substance	X	P	DS	DS	DS	DS	DS	A	X	-	A
Corrosives	X	P	A	A	A	A	X	X	X	A	-

X = Incompatible goods: do not store goods together in the same *fire compartment*

A = Incompatible goods: separate goods by a horizontal distance of no less than 1 m

P = Permitted: goods are permitted to be stored together

DS = Refer to Material Safety Data Sheet (MSDS) or Safety Data Sheet (SDS)

4.4.4 Storage Guidelines of Specific Hazard Classes

4.4.4.1 Compressed Gases

- Protect cylinders from excessive variations in temperature, ignition sources, and direct contact with the ground.
- Label empty cylinders and store them separately from other cylinders.
- Keep all compressed gas cylinders upright and fully secured against falling.
- Individually chain or strap compressed gas cylinders.
- Store lecture bottles upright and chain, or secure in a proper holder.
- Store in central, properly ventilated area that includes forced ventilation from floor to ceiling and with exhaust above roof level.
- Storage according to compatibility.
- If flammable gasses are stored indoors, the room must have a 2-hour fire separation with entry from the exterior. Natural ventilation to outside wall must exist, and the room must have no other purpose. This applies to gas cylinder “not in use”.
- Separate flammable gases from oxidizing gases with noncombustible partitions.
- If pressure testing is required, indicate on the cylinder when it was pressure-tested.
- Routily check hazard gases for leaks.
- Store hazardous gases with poor warning properties in exhausted enclosures.

4.4.4.2 Flammable Liquids

Flammable liquids should be stored in a dry, cool well-ventilated area, preferably a flammable materials storage cabinet or room.

a) Laboratory Storage

Flammable liquids should be stored:

- Storage cabinets must be conspicuously labeled to indicate that they contain flammable liquids.
- No combustible material is permitted in storage rooms.
- Do not store in or adjacent to exits, elevators, or routes that provide access to exits.
- Consult the 2012 BC Fire Code and your local fire department for specific details.
- If flammable liquids are to be stored cold, the refrigerators and freezers must meet explosion proof standards.
- According to the BC Fire Code, the maximum volume of flammable and combustible liquid allowed outside a flammable safety cabinet is 10L including not more than 5L of flammable liquids.
- Flammable liquid safety cans of up to 25L can be used for flammable liquid storage outside safety cabinet.

  - In listed approved metal safety cans which meet the fire code requirements that are equipped with a flash arrestor and self-closing lid.
  - In appropriate 5 liter waste solvent containers that are capped when not in active use.
- Water sensitive chemicals
  - Store in cool, dry areas designed to prevent accidental contact with water and other incompatible substances.
  - Storage construction should be fire-resistant.
  - Protect chemicals from water from sprinkler systems.
- For air reactive chemicals use a glove box or fill the head space of the container with an inert gas before sealing the container.

b) Flammable Liquid Cabinets

An approved flammable liquid storage cabinet may be used when quantities of flammables are near or exceed 25 litres. An approved flammable liquid storage cabinet must be listed by an acceptable testing agency and approved by the local Fire Department.

Flammable liquid cabinets provide:

- A safe means of storage over a short period of time.
- A time-saving method of storage by locating cabinets in, or adjacent to work areas which reduces the frequency of trips to the drum storage or dispensing facility.

Flammable liquids cabinets must:

- Be Underwriters Laboratories of Canada (ULC) listed and approved.
- Be closed at all times, with door latches operable.
- Have vents that are either plugged or vented directly to the outside.
- Be either wood (must meet specifications of fire code) or metal.
- Be suitably placed; ie. not located near an exit door or blocking access to an exit route.
- May have to be in a room which has a second exit depending on the quantity and hazards of flammable liquids in the room.
- Contain no more than 500 litres maximum of flammable and combustible liquids of which no more than 250 litres may be flammable.
- Be no more than one (1) per fire compartment, unless approved by the local Fire Department.

c) Flammable Liquid Storage Rooms

A properly designed flammable liquids room must satisfy many requirements, e.g. location, ventilation, electrical equipment, fire protection, etc. It must also meet the needs of the user, e.g. adequate size, conveniently located, etc.

The flammable liquids storage room should be easily accessible to fire fighting; i.e. located in corners of buildings over window openings and doors all providing sufficient entry. Explosion venting can then be incorporated into the exterior walls.

Specific guidelines for flammable liquid storage rooms include the maximum number of litres per square metre of floor space, maximum room size with and without a sprinkler system (or other automatic extinguishing system) and the fire resistance rating of the interior walls. These guidelines are part of the British Columbia Fire Code.

d) Refrigerator Storage

Refrigerators must be approved (ULC) for storage of flammable liquids (explosion-proof), or acceptably tested and approved. A number of refrigerators have exploded due to flammable vapours.

4.4.4.3 Toxic Materials

- Store in secured area.
- For carcinogen and reproductive toxins, secondary containment is recommended.

4.4.4.4 Corrosive Acids and Bases

- Store acids and bases separately.
- Secondarily contain incompatible substances.
- Store in dedicated corrosive cabinets.
- Store oxidizing acids (eg. nitric acid) away from organic acids (e.g. acetic acid).
- Store hydrofluoric and perchloric acids in secondary containers made from compatible materials.
- Safety showers and eye wash facilities must be within easy access.
- Protective equipment must be inspected regularly to insure proper working order, especially in corrosive atmospheres.

4.4.4.5 Oxidizers and Peroxidizable Compounds

Store oxidizers separate from flammable or combustible materials and reducing agents e.g. nitrates; chromates; permanganates; chlorates; peroxides.

All peroxidizable compounds should be stored away from heat and light (which catalyse the peroxidation reaction) and reducing agents, and protected from physical damage and ignition sources.

An inventory of all peroxidizable material is required. These substances must be inspected and tested for peroxides regularly after the container is opened (WorksafeBC Regulation 30.23). Frequency of these tests depends on the class of peroxidizable chemical: see Appendix F for a non-comprehensive list.

A simple test procedure for detection of peroxides in substances such as alkali metals, alkali metal alkoxides, amides or organometallics is not available.

4.5 Laboratory Inspections

At the University of British Columbia, various individuals, groups, and regulatory agencies conduct inspections. Periodically WorkSafe BC carries out unannounced inspections. Vancouver Fire and Rescue Services also conduct annual inspections of fire extinguishers and other fire-safety issues such as storage of flammable liquids and condition of fire exits.

Under WorkSafe BC Regulation, employers and workers have the right to have a representative accompany the WorkSafe BC officer during regular inspections. The worker representative should be selected from the Joint Health and Safety Committee.

Worksafe BC Regulation 3.5 General requirement states**:**

Every employer must ensure that regular inspections are made of all workplaces, including buildings, equipment, work methods and practices, at intervals that will prevent the development of unsafe working conditions.

Any deficiencies found during regular inspection by committee members should be reported immediately to the supervisor. If corrective action is not taken to the satisfaction of the committee, the item should be included on the agenda for consideration at the next meeting.

Risk Management Services periodically conducts consolidated inspections. These inspections include:

- reviewing training records
- ensuring first aid/fire procedures are posted
- reviewing safe work procedures
- inspecting storage and handling of chemicals
- inspecting equipment safety
- observing use of PPE
- and inspecting safety controls in place

In addition, there are four types of inspections that are required to be conducted by UBC personnel. They are:

- Daily (conducted by each individual, employee or student, of their own work area, to identify and correct hazardous conditions or report them to their supervisor).
- Monthly (conducted by area supervisors or their designate to identify hazardous conditions, using an abbreviated checklist that is posted at the work site).
- Annually (formal laboratory inspections that are the responsibility of the Local Safety Team; detailed checklist and report to supervisor with appropriate follow-up).
- Special (equipment; post-incident; post-repair; etc.)

Supervisors and Workers are responsible for:

- participating in workplace inspections when requested
- making suggestions for corrective actions to those conducting workplace inspections
- taking part in training or the development of safe work practices
- developing procedures required as the result of the workplace inspection.

Annually formal laboratory inspections are the responsibility of Local Safety Teams. The frequency of inspections will vary depending on the size of department, the extent of the potential hazards in the department and the ability of the team to carry out the inspections.

Larger inspection teams should include both worker and management representatives. The team should be familiar with the work process and, whenever possible, include members of the joint committee or the worker health and safety representative.

For the UBC Okanagan campus, a template for lab inspections can be found in the Laboratory Safety Guidebook. An example of a chemical laboratory inspection checklist can also be found in Appendix K.

4.6 Occupational and Preventive Health Program

The University of British Columbia has developed and implemented a comprehensive Workplace Health Service program at the University. This program supports the health and safety of UBC personnel whose work involves potential health risks by establishing best practice activities within the evolving research and occupational environment at UBC.

The fundamental purpose is to detect and eliminate the underlying causes of occupationally acquired health issues of faculty, staff, and students, and thus has a prevention focus. As such, a comprehensive medical surveillance program contributes significantly to the success of worksite health and safety programs by:

- impacting faculty and staff in a positive and meaningful way through well defined
- processes of risk reduction
- applying targeted expertise to support the research community in a critical area
- covering all staff at risk regardless of location
- supporting the excellence of research programs; and
- ensuring that the University's duty of care is fulfilled, thereby minimizing reputational risk.

4.6.1 Program Description

The program is the applied analysis of health information based on risk and hazard assessments that addresses problems that may be occurring in the workplace that require targeted prevention. As such, it serves as a critical feedback loop to ensure the health and well-being of faculty, staff and students. It is a proactive and responsive system of informing and activating the assessment, protection, mitigation, treatment and restoration of employee and student health status related to occupational health risks and exposure (ongoing or episodic). This entails a collaborative partnership with regulators, accreditors, funders, faculty, researchers, laboratories, institutes, and departments at UBC. The Program is consistent with the approach at other Canadian universities and research institutes.

Services include but are not limited to:

- Immunizations
- Occupational health screenings
- Respiratory protection
- Hearing conservation
- Consultation with the Occupational Health Physician
- Diver's medicals
- Advisements and education concerning health and safety in the workplace
- Referrals to RMS for workplace safety consultations
- Annual health screenings

Please note that the Workplace Health Services program is for those individuals who are staff, post docs, and faculty of UBC only. Students who have concerns about their exposure risks should contact their area manager or supervisory staff and may be directed to their Family Physician or Student Health Service at UBC for vaccination needs.

On Vancouver campus, for further information on the program or your risks in the workplace, please speak with your direct supervisor or manager or the Workplace Health Services at 604-827-4713. On the Okanagan campus, users should contact Risk Management Services to discuss their services and implementation of the program.

5 Personal Protective Equipment

Personal Protective Equipment (PPE) is the last line of defense against laboratory hazards. PPE should be considered only after Engineering and Administrative Controls have been examined. In order for PPE to protect the user, it must be stored, maintained, and worn properly. Since PPE can fail, those who wear it should be trained to understand its limitations.

PPE does not eliminate the hazard. The need for PPE is dependent upon a risk assessment of the work and the materials in use. A Personal Protective Equipment Hazard Reference Guide is attached as Appendix G and can be used as a tool to choose appropriate PPE for the task.

The supervisor must ensure appropriate PPE is available to workers; it is properly worn when required and is properly cleaned, inspected, maintained and stored.

A worker who is required to use PPE must use the equipment in accordance with training and instructions, inspect the equipment before use and report any equipment malfunction to the supervisor or employer.

5.1 Basic PPE

When working in a lab, wearing loose fitted pants and fully enclosed shoes is part of proper lab attire. Though usually mentioned in the PPE section, they are personal clothing and not actual PPE. Dangling jewelry (e.g. necklaces, bracelets) and/or loose pieces of garments (e.g. loose scarves) should be removed when working in lab areas. Long hair should be restrained away from the face area.

Clothing made of natural fabrics is recommended. Nylons and leggings offer little to no protection against hazardous materials, and often react with chemicals to cause more harm. Cotton is one of the best fabrics to wear, as it will not react with many hazards

For basic laboratory work always wear lab coat, safety glasses and appropriate gloves (depending on task). Additional PPE may be required based on the hazards identified during the risk assessment process.

PPE should not be worn in common areas. Before traveling from a lab into hallways, breakrooms, elevators, or bathrooms, all PPE must be removed.

5.2 Lab Coats and Aprons

The purpose of a lab coat is to protect the user against accidental spills and/or contact with hazardous materials in general. It also prevents spreading contamination from the lab to public areas (or home). Aprons are generally designed to offer an extra layer of protection in addition to the lab coat.

Lab coats are made of different materials, and it is important to select a coat or coats of appropriate material for the types of hazards in the lab. The first step in this selection process is to determine the types of hazards that exist in your lab and the reasons for the lab coats.

While there are many different style features, from a protection standpoint the best coats have the following characteristics:

- Tight cuffs (knitted or elastic)
- Snap closures on the front for easy removal in case of contamination
- Coats with different properties are easy to tell apart (ex: FR coats should have outer markings clearly identifying them as FR coats and can be ordered in a different color than other coats present in the lab)
- Proper fit
- Appropriate material for hazards to be encountered

5.3 Eye and Face Protection

Adequate eye protection is required for all individuals in the laboratory. The eye protection should not be removed until physically leaving the lab. Face protectors and protective glasses must meet the requirements of CSA Standard CAN/CSA-Z94.3-92 (Industrial Eye and Face Protectors) or ANSI Standard Z87.1-1989 (Practice for Occupational and Educational Eye and Face Protection).

Eye and face PPE provides protection from:

- Accidental chemical or biological splashes
- Unexpected flying objects or particles (chips, shards) from a nearby machine or hand tool
- Non-ionizing radiation
- UV light

Normal prescription eyeglasses or safety glasses are acceptable as long as the lenses are shatterproof and cover a large enough area surrounding the eye (frames must be a minimum 4 cm from top to bottom as well as from side to side). Bifocal and trifocal eyeglasses should be worn behind impact-rated goggles or other eye protection. Protective glasses/goggles and face shields that cover prescription eyeglasses are available commercially.

In most laboratory settings, contact lenses can be worn as long as safety glasses/goggles are also worn. If you choose to wear contact lenses in the laboratory, inform and discuss the issue with the supervisor. This information is important in case of an injury to your eye. Contact lenses should not be worn when working with acrylonitrile, methylene chloride, 1,2 dibromo-3-chloropropane, ethylene oxide, and methylene dianiline.

Table 10. Types of Eye and Face Protection

Type of protection	Uses
 **Face shield**	Full face (and possibly throat) protection from splash and/or impact is commonly required for work on or in the presence of human pathogens, some laboratory chemicals, explosion hazards, heavy grinding and heavy spraying or splashing, and with large (2 L and larger) quantities of dangerous liquids such as acids, bases, and many organic liquids. A face shield can also afford extra protection against extreme temperatures. If the face shield is the type which has a wide opening on the sides or bottom, and when quantities of dangerous liquids are very large (4 L and over), ***protective eyewear must be worn along with*** the face shield. Your work area's hazard assessment will tell you if a face shield is required for specific work.
 **Safety googles**	Safety goggles are intended to shield the wearer's eyes from impact hazards such as flying fragments, objects, large chips, and particles. Goggles fit the face immediately surrounding the eyes and form a protective seal around the eyes. This prevents objects from entering under or around the goggles. Direct vented goggles do not protect against splashes or vapor but protect against projectiles. Indirect vented googles provide protection from splash entry by a hooded or covered vent. Non-vented googles have no venting of any kind and offer protection against the passage of dust, mist, liquid and vapors.
 **Safety glasses**	Safety glasses with side shields give protection for the sides of your eyes. They must be used when flying-object hazards are present. They protect you from flying particles coming from in front of you or from the side. Safety glasses can also protect eyes against certain types of harmful light (e.g. laser radiation, UV). Safety glasses also allow the option of being fitted with corrective lenses therefore acting as both prescription and safety glasses.

5.4 Laboratory Gloves

Suitable hand protection is required for workers handling materials that may cause damage such as punctures, scrapes, cuts, animal bites, chemical burns, heat burns, irritations, sensitization, and exposure to toxic substances. Gloves should be carefully selected because most gloves provide protection from certain types of hazards only.

Different chemical hazards require different types of gloves; no gloves provide protection from all chemicals. For example, gloves that provide protection from corrosive agents, such as acids and caustics, may offer little or no protection from most organic solvents. Research laboratories usually need to have available different types of gloves to accommodate various chemicals being used.

There are several factors to consider when choosing the right glove. These factors are detailed in the Glove Selection Guideline and are just outlined below:

- Chemical to be used: consult the compatibility charts to ensure that the gloves will protect you.

- Dexterity needed: the thicker the glove, typically the better the chemical protection, as the glove will be more resistant to physical damage, like tears and cracks, but it will be harder to handle and feel the work.
- Extent of the protection required: determine if a wrist length glove provides adequate protection, or will a glove that extends further up the arm be required.
- Type of work to be done: gloves are specific to the task. Ensure the correct glove is chosen to avoid injuries. Examples: A nylon cryogenic glove will be damaged if a hot item is handled, where as a “hot mitt” will not protect the wearer when liquid nitrogen is used, as it may be too porous.

Rules for glove use in the lab:

- Wear the correct gloves when needed.
- Wear gloves no longer than 2 hours.
- Wash hands once gloves have been removed.
- Disposable gloves must be discarded once removed; do not save for future use.
- Dispose of gloves into the proper container (biologically contaminated gloves will need to go into a red bag); while other chemically contaminated gloves may not.
- Non-disposable/reusable gloves must be washed and dried, as needed, and then inspected for tears and holes prior to reuse.
- Remove gloves before touching personal items, such as phones, computers, pens and one’s skin. Remember the “designated area rule” where “science” does not mix with personal space (one’s desk or lunch space). Gloves used in research are considered “science”.
- Do not wear gloves out of the lab. If gloves are needed to transport anything, wear one glove to handle the transported item. The free hand is then used to touch doorknobs, elevator buttons, etc. If you are wearing gloves to “protect your sample from you” and are in the hall, no one else understands this and will be concerned about the items you have contaminated with those gloves.
- If for any reason a glove fails, and chemicals come into contact with skin, consider it an exposure and seek medical attention.

5.5 Footwear

Footwear must be of a design, construction, and material appropriate to the protection required. Shoes with non-slip soles should be worn in laboratories. Open-toed shoes and sandals must not be worn by laboratory workers who work with or near chemicals.

To determine appropriate protection the following factors must be considered: slipping, uneven terrain, abrasion, ankle protection and foot support, crushing potential, temperature extremes, corrosive substances, puncture hazards, electrical shock and any other recognizable hazard.

Appropriate footwear for chemistry laboratory work requires:

- Shoes made of a material that resists rapid penetration by spilled liquids or sharp; shoe should cover the entire foot.

- Safety shoes or foot guards may be required under certain circumstances (e.g., when moving compressed gas cylinders).
- When cleaning up floor spills wear plastic foot covers available on spill carts.

5.6 Respiratory Protection

Typically, respiratory protection is not needed in a laboratory to eliminate exposures. Under most circumstances, safe work practices and engineering controls (e.g., fume hoods) adequately protect the workers. Under certain circumstances, however, respiratory protection may be needed. These situations can include:

- Chemical spills outside the fume hood, or spills of biohazard outside a biosafety cabinet.
- An unusual operation that cannot be conducted in fume hood or biosafety cabinet.
- Weighing powders outside a glove box or other protective enclosure, disposable filtering face-piece respirators are generally recommended for nuisance dusts.
- As required by a specific laboratory protocol or as defined by applicable regulations.

Vancouver Risk Management Services through the Respiratory Safety Program offer information regarding the various types of respirators available, selection process and respiratory maintenance. Contact Risk Management Services on the Okanagan campus for questions regarding respiratory use.

Fit testing a respirator assures an effective seal with the face and it is mandatory for proper functioning. Worksafe BC regulations (8.40 Fit test) requires an individual to be fit tested prior to wearing a respirator. A fit test must be carried out before initial use of a respirator and at least one a year after.

5.7 Hearing Protection

Hearing protection in a laboratory is important but rarely needed. If working with heavy machinery or a device that creates loud “bangs” then hearing protection may be necessary. The most common need for hearing protection in a lab is when using a sonicator. Sonicators generate sound waves in the 20,000 Hz range. These sonicator-generated sound waves are outside the normal range of hearing. Often the sound heard while using a sonicator is produced by cavitations of the liquid in the sample container or vibrations from loose equipment. Actions you can take to reduce the hazards include:

- Wear earphone-type sound mufflers to protect your hearing while sonicating
- If possible, have the sonicator located in a "sound-proof" cabinet while sonicating
- Do not sonicate in a room containing people not wearing ear protection
- Shut doors of the room where sonication is taking place

Ensure that the hearing protection chosen is effective for the sound waves generated. Machinery usually creates low Hz as compared to sonicators. Vancouver Risk Management Services can be contacted at 604-822-6098 if a noise assessment is required. Contact Risk Management Services on the Okanagan campus for assistance.

6 Emergency Equipment and Procedures

Worksafe BC regulations (5.97 Emergency plan) state: "a workplace must have a written emergency plan, appropriate to the hazard of the workplace". The plan must address emergency conditions that may arise from within the workplace and from adjacent workplaces. Major concerns in a chemistry laboratory setting are chemical spills/splashes, fires and explosions and personnel injuries.

6.1 Safety Showers and Eye Wash Stations

"The employer must ensure that appropriate emergency washing facilities are provided within a work area where a worker's eyes or skin may be exposed to harmful or corrosive materials or other materials which may burn or irritate" – Worksafe BC regulations (5.85 Where required).

Emergency showers and eyewash stations should be available to all laboratory personnel who work with large quantities of hazardous materials. Plant Operations personnel, on the Vancouver campus, or Facilities management, on Okanagan campus, are responsible for the annual testing of showers. Laboratory supervisors are responsible for ensuring that eyewash stations are flushed regularly, for a sufficient time to completely flush the branch of the water line supplying the eyewash (WorksafeBC regulation 5.93 Testing) to clear them of particulate that could damage eyes during emergency use. The frequency of this flushing can be increased depending on the conditions of the pipes and water quality in the facility.

Safety showers provide an effective means of treatment in the event that chemicals are spilled or splashed onto the skin or clothing. Safety shower facilities should be installed wherever corrosive chemicals are used (e.g. acids or alkalis) and must be readily available to all personnel.

Safety showers and eyewash stations should be in a clearly marked location. The shower/eyewash should be no more than 100 feet, or 10 seconds, away from every lab workbench. Laboratory workers should be able to locate the shower/eyewash with their eyes closed (emergencies may leave victims temporarily blind). Safety showers are often operated by grasping a ring chain or triangular rod.

The first few seconds after exposure to a hazardous chemical (especially a corrosive chemical) are critical. Delaying treatment, even for a few seconds, may result in irreparable eye/tissue damage. Drains are rarely designed into floor plans to accommodate emergency shower stations. Never let that stop you from using the equipment if needed. Do not hesitate to use emergency eyewash or shower!

6.2 Spill Clean-Up Procedures

Laboratory personnel can take various steps in the event of a laboratory spill. The laboratory worker may be able to respond to a small, contained lab spill. Laboratory workers should never put themselves in harm's way. If there is any doubt about the safety of the individual in the lab, immediately call 911 or 2-4444 (Vancouver Campus) or 7-8111 (Okanagan Campus). The response to a spill depends on:

- The amount of chemical spilled
- The chemical properties of the chemical
    - Flammable
    - Corrosive

  - Toxic
- The potential for impact outside the lab

In order to place your laboratory in a position to be able to handle a small spill, preplanning is necessary. Laboratories must have a minimum amount of PPE and appropriate clean-up materials present prior to an incident. The minimum PPE needed in order to be able to clean a small spill contains:

- safety goggles
- lab coat
- rubber booties (where available)
- a spill kit (exact items vary depending on the lab)

For All Spills: if appropriate equipment and trained personnel are not available on site, the clean-up should not proceed. Contact the local Fire and Rescue Services and Risk Management Services for support on Vancouver campus. On Okanagan campus, call Campus Security.

WorkSafe BC Regulations require written safe work procedures to be prepared for hazardous operations, including chemicals, spill response, and the workers to be adequately instructed in and follow the procedures. Accidental release or spills of chemicals or other hazardous substances must be controlled immediately, and cleaned up under the supervision of persons knowledgeable in the hazards involved and the precautions to be taken during the cleanup operations. It is the responsibility of the supervisor to ensure PPE required during emergency cleanup or escape is immediately available (30.18 Spills and other emergencies).

You should call 911 whenever you:

- Feel unsafe!
- Don’t have anyone in the lab to assist you with clean-up
- Don’t have appropriate clean-up materials
- Don’t have trained personnel available
- Don’t have the appropriate PPE available
- Don’t know the identity of the chemical
- Have a solvent spill near an ignition source
- Spill more than 1L of a flammable, toxic or highly hazardous chemical

For detailed information, please see the special clean-up procedure for:

- Flammable solvents
- Acids
- Caustics
- Hydrofluoric Acid
- Perchloric Acid
- Cytotoxic substances

- Mercury

6.3 Fire Safety Procedures

Where fire is involved, the procedure is to:

- Activate the fire alarm, alert others, and move everyone away from the area of the fire, closing doors behind you.
- Call 911 from a safe place.
- Use the stairway, proceeding down to the ground floor, never up. Never use elevators if fire is suspected.
- Use a fire extinguisher only if it is safe (i.e. there is a means of exiting if the fire cannot be controlled) and you have been trained and are comfortable using an extinguisher; otherwise leave the area.
- Return to workplace only when authorized by fire warden or fire safety director.
- Once outside, proceed to the predetermined area so that a head count can be taken. Find out the location of your predetermined area *before* a fire occurs.

6.3.1 General Guidelines for Buildings

Work and storage areas must be kept clean and free of accumulations of combustibles not essential to operations. Access to buildings must be maintained for fire fighters.

A fire safety emergency and evacuation plan and procedures must be developed.

a) The plan will include:

- sounding the alarm
- notifying the fire department
- instructing personnel on procedures to follow
- when alarm sounds, confine/control and extinguish fire if safe, evacuate building
- schedule of fire drills and inspections.

b) Fire exit rules include:

- Access to exits and exits must be kept clear.
- Corridors and stairwells must be kept free of obstructions and combustibles.
- Fire doors must not be wedged open.
- Know the locations of the exits: some labs have two exits.

6.3.2 Extinguishing a Fire

Portable extinguishers must be provided and maintained. Occupants should know:

- Where they are;
- How to use them – consider taking a hands-on fire extinguisher training course from the local fire department;
- Not to block access to them – do not use them for hanging lab coats; and

- Contact Building Operations at (604) 822-2173 for replacement of discharged extinguishers on Vancouver campus. Contact Facilities management at (250) 807 9272 on the Okanagan campus.

Note – small fire extinguishers, about 10 lb (4 kg) in size, last for less than 15 seconds, and have an effective spray for about 7 seconds before the pressure begins to lessen. Keep this in mind when trying to fight a fire with a small extinguisher. If the fire is larger than a garbage can, the fire extinguisher will most likely be unable to control it.

It is important that the appropriate fire extinguisher be used on a particular fire. The table below describes the four different types of extinguishers and the types of fires they are meant for.

Table 11. Types of Fire Extinguishers and their Uses

Class	Type of Fire
A	For ordinary combustible materials such as paper, wood, cardboard, and most plastics.
B	Flammable or combustible liquids such as gasoline, oil, grease, tar, oil-based paint and lacquer.
C	For electrical equipment such as appliances, wiring, circuit breakers and outlets.
D	Commonly found in chemical laboratories for fires that involve combustible metals such as magnesium, titanium, potassium and sodium
K	Commonly found in restaurants and cafeteria kitchens for cooking oils, trans-fats, or fats in cooking appliances.
ABC	Multipurpose dry chemical extinguisher for combination Class A, B & C fires.

It is important to make sure your lab has the type(s) of fire extinguisher(s) appropriate for the hazards present in the lab. In general, all publically available fire extinguishers on campus are ABC type. Labs using flammable materials should have a class D fire extinguisher.

6.4 Medical Emergencies

6.4.1 Vancouver Campus

In the event of personal injury, the treatment of the injury must take precedence.

- For minor injures when first aid is required contact your local/departmental first aid attendant or dial 2-4444 to activate the 24 hours Mobile First Service. This service is provided to the user free-of-charge to all university employees.

For serious injuries, where more than first aid treatment is required:

- Call *911* for ambulance.
- Obtain first aid assistance by calling local first aider; 911 (if student or visitor) or 2-4444 (Mobile First Service).
- Treat the immediately threatening condition, which may require control of bleeding, CPR or washing of chemical exposed skin for 15 minutes.
- Advise emergency personnel of the chemical name, extent of injuries, hazards of the material and location of victim.

Supplemental (Departmental/Area) First Aid Stations: As a supplement to the Mobile First Aid Service, local first aid stations and attendants have been established in a variety of locations on campus, on a voluntary basis. The location of the closest one should be identified during the initial building/lab orientation.

6.4.2 Okanagan Campus

- For minor injures when first aid is required contact Campus Security at (250) 807-8111 or local 7-8111
- For serious injuries, where more than first aid treatment is required:
  - Obtain first aid assistance by calling Campus Security art 250-807-8111 or local 7-8111
  - Campus security will then call 911 and send help
  - Treat the immediately threatening condition, which may require control of bleeding, CPR or washing of chemical exposed skin for 15 minutes.
  - Advise emergency personnel of the chemical name, extent of injuries, hazards of the material and location of victim. If available, provide MSDS / SDS to ambulance staff if the emergency involves a chemical exposure.

7 Waste Disposal

Risk Management Services coordinates the disposal of hazardous waste materials at the UBC Vancouver campus through the Environmental Services Facility (ESF) located on South Campus. The facility safely manages hazardous waste in accordance with relevant regulations. At the Environmental Services Facility (ESF), laboratory wastes and hazardous materials generated by the University through research, academic and operational activities are consolidated, recycled, re-used, neutralized and/or disposed. UBC Okanagan works with a licensed Hazardous Waste Depot (located in the Quonset area) that serves the same purpose.

All UBC generators need to be aware of the environmental and financial impacts of hazardous waste and actively seek to minimize the amount of waste generated. Principal investigators, supervisors, technicians and students MUST be familiar with current waste disposal procedures for waste handled in their respective areas. Supervisors are responsible for ensuring that all employees receive the required training and that all laboratory procedures are in conformance UBC"s requirements. These procedures are available through the Hazardous Waste Manual for the Vancouver campus or on the Hazardous Materials Management website on the Okanagan campus.

7.1 Chemical Waste – UBC Vancouver

Chemical waste comprises of unused chemicals (toxic, corrosive, flammable, oxidizing and reactive), in their original containers or mixtures of chemicals and byproducts generated from experiments.

To ensure compliance with the federal, provincial and municipal bylaws, chemical waste generated at UBC must go through the Chemical Waste Inventory System (CWIS) online approval process. All hazardous waste generators must complete the Chemical Safety Training before using CWIS.

Unknown chemicals, explosives & potentially explosive materials, compressed gas cylinders & lecture bottles of hazardous gases are not acceptable by the Environmental Services Facility. The cost of waste removal and disposal by external contractor is the generators' and/or their department's responsibility.

Not all chemical waste is hazardous. Check the list of chemicals Safe to dispose down drain and the list of chemicals Safe for garbage disposal. If the chemical is on that list, dispose of it accordingly (*via* drain or garbage). Non-hazardous waste often mistakenly considered hazardous include certain salts (e.g., potassium chloride and sodium carbonate), many natural products (e.g., sugars and amino acids), and inert materials (e.g., non-contaminated chromatography resins and gels). These materials can be disposed of safely and legally in the normal trash if not contaminated.

Solvent, oil, photographic and contaminated soil waste does not need to be pre-approved for disposal *via* CWIS.

7.1.1 Solvent Waste

Solvent waste includes various types of flammable organic solvents. It is collected in a specially provided UBC Jeri cans, and uses a blue solvent waste tag. Halogenated and non-halogenated waste must be segregated for accumulation and disposal.

ESF's Solvent Recovery Program identifies, segregates and purifies organic waste solvents for re-use on campus. The purified distilled product is technical grade. The Solvent Recovery Program is successful in recovering acetone and methanol. The recovery laboratory consists of two spinning band distillation units that are capable of distilling up to 60 liters of solvents per day. Purified products are analyzed on the gas chromatography unit. Gas chromatography analysis ensures the quality of the product.

7.1.2 Oil Waste

Oil waste includes automotive lubricating, cutting, gear, hydraulic, refined petroleum based oil, synthetic, emulsion, crude and, vacuum pump oil. Important note: Waste oils must not be contaminated with water, solvents, toxic materials, or poly-chlorinated biphenyls (PCB's). Uncontaminated waste oil is sent for recycling through M&R Technologies.

7.1.3 Non-regulated Contaminated Solid Waste

Includes lab solid waste contaminated with traces of ethidum bromide and silica gel contaminated with solvents. A yellow tag must accompany this waste. Refer to detailed manual procedure (PDF) for additional information.

For more information on hazardous waste disposal at UBC contact the Environmental Services Advisor (604.822.9840) or the ESF Technician (604.827.5389).

7.2 Chemical Waste - UBC Okanagan

RMS Okanagan manages and handles hazardous materials generated on campus. For all questions regarding disposal of hazardous materials consult the Hazardous Materials Management website.

8 Transportation and Receiving of Hazardous Materials on Campus

8.1 Transportation of Dangerous Goods

The transport of dangerous goods (i.e. hazardous materials) from any UBC site to another location off-campus is regulated by the Transportation of Dangerous Goods (TDG) Act. Persons who ship, carry or receive such goods must have current certification of training.

The TDG Act (1992) was enacted by the federal government to promote the safety of human life and health, property and the environment.

A dangerous good is a product, substance, waste, or organism included by its nature or by the regulations in any of the nine classes listed in the TDG Regulations.

The TDG Act places specific requirements on personnel who engage in the act of shipping, transporting and receiving dangerous goods within the province, the country or across Canadian borders by all modes of transport. These requirements ensure that, in the event of an emergency, emergency responders have immediate access to information about the dangerous goods as a result of consistent documentation, labeling and vehicle placarding.

RMS's Transportation of Dangerous Goods site.

8.2 Receiving Dangerous Goods

Any person who is unloading or unpacking dangerous goods must be trained to examine packages, check documentation, and respond to emergencies such as spills. This is to ensure that materials are received in safe, intact containers and accompanying hazard information and documentation is complete.

TDG legislation provides that an employer representative must provide a signed certificate for anyone receiving dangerous goods. The certificate is valid for three years and must be available upon the request of an inspector.

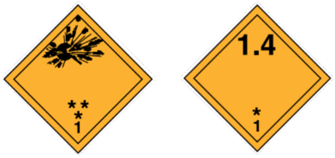
Receiving dangerous goods (DG) involves the following steps:

1. Examine each package containing DG to ensure the packaging is intact and the DG have not leaked or spilled from the container.
2. Each package must have the appropriate safety symbols and labels attached.
3. The labels and shipping documents must match. Correct any classification errors.
4. The package must be stored safely and segregated by hazard classes in accordance with the University's chemical storage guidelines (see 4.4.2 General Rules for Safe Storage).
5. File shipping documents for a minimum of two years.
6. Respond to and report any dangerous occurrences.

8.3 Dangerous Goods Hazard Categories

There are nine hazards classes recognized under TDG. The following table lists the classes and their hazard symbols:

Table 12. TDG Classes of Dangerous Goods

TDG Class	Label Symbol	Comments
Class 1 – Explosives		6 divisions: 1.1 to 1.3 For explosives that represent a greater risk, the bursting bomb symbol is used. 1.4 to 1.6 For explosives that represent less risk, the bursting bomb symbol is not used.
Class 2 – Gases		3 divisions: 2.1 Flammable gases (e.g. propane or hydrogen) 2.2 Non-flammable, non-toxic gases (e.g. nitrogen) 2.3 Toxic gases (e.g. hydrogen sulfide or chlorine)
Class 3 – Flammable liquids		Separated into packing groups (PG) based on the flash point and the boiling point. PG I represents great danger, while PG III represents minor danger.
Class 4 – Flammable substances		3 divisions: 4.1 Flammable solids (e.g. matches) 4.2 Spontaneous combustible (e.g. pentaborane) 4.3 Dangerous when wet (e.g. sodium)
Class 5 – Oxidizers / Organic peroxides		2 divisions: 5.1 Oxidizers (e.g. potassium superoxide) 5.2 Organic peroxides (e.g. *tert*-butyl hydroperoxide)
Class 6 – Toxic / Infectious substances		2 divisions: 6.1 Toxic (e.g. arsenic, chloroform) 6.2 Infectious; two categories: A (most hazardous) and B (less hazardous)
Class 7 – Radioactives		Separated into **hazard categories** based on the level of radioactivity. Category III represents the greatest risk, while category I represents the lowest risk.
Class 8 – Corrosives		Separated into packing groups. PG I represents great danger, while PG III represents minor danger.
Class 9 – Miscellaneous		Goods that are not covered by the other 8 classes, but are still dangerous if they leak or spill during transport. (e.g. asbestos, lithium batteries)

Anyone receiving goods classified as explosive must contact Risk Management Services to determine appropriate procedures and storage facilities required.

Regulations require that departments that ship or receive materials associated with bio-medical labs or animal units must have personnel with current TDG 6.2: Infectious Substances training and certification. Contact Risk Management Services for information on this training.

Anyone receiving a good classified as a radioisotope must obtain certification through the UBC Radiation Safety Program. The Risk Management Services Radionuclide Safety and Methodology Course include certification for *receiving* radioactive materials only.

8.4 Shipping Description

When shipping dangerous goods, each package must display the following information:

- A four-digit material identification number (e.g. "UN 1789" for hydrochloric acid)
- The shipping name of the material in the package (e.g. "hydrochloric acid")
- All primary and subsidiary hazard class labels
- Any other special information such as "Keep from freezing" or "Keep upright"

8.5 Safety Symbols and Labels

Each package must display the appropriate safety symbols. Table 12 provides examples for each hazard class.

Symbols and labels must remain visible until the goods are removed from the packaging. Empty containers must have labels defaced or removed, and the boxes flattened. Labels must be oriented upwards as a square on a point (a diamond with one corner pointing upwards). Reduced size labels may be used on compressed gas cylinders and are often located on a reinforced tag attached to the neck of the cylinder.

8.6 Documentation Required

A TDG shipping document must accompany all dangerous goods shipments. The receiver must retain this document for at least two years. TDG shipping documents may be combined with commercial documents such as a Bill of Lading for convenience.

The shipping document must contain:

- The name and address of the shipper
- The date of shipment
- A description of the goods including UN number, shipping name, hazard class(es), packing group, and any other special provisions

The receiver is responsible for ensuring that information on the document matches the safety marks, labels, and other information on the packages. A receiver must reject shipments that are damaged, mislabeled, or do not have a shipping document.

8.7 Dangerous Occurrences

Reporting must happen if one of the following incidents occurs:

- Any transportation accident involving infectious or radioactive substance;
- Any unintentional explosion or fire involving dangerous goods; or
- Dangerous goods in class 1, 2, 6.2, or 7 are spilled
- Dangerous goods in class 3, 4, 5, 6.1, or 8, packing group I or II are spilled

For more information, please see the specific Incident/Accident Report form and Spill Clean Up Procedure.

8.8 Packaging Damaged in Transport

Damaged gas cylinders can be extremely dangerous if rapid release occurs. Leaking cylinders must be returned and may be handled and transported in a road vehicle. Keep the cylinder in a safe (outdoor) location. Contact the supplier immediately to arrange for its return.

Damaged packages containing solid materials of hazard classes 4, 5, 6.1, 8, or 9 may be handled and transported in a road vehicle provided the damaged packages are repaired. Packages will be marked with the words “FOR SALVAGE” and are transported directly to a point for repackaging or disposal.

Damaged packages containing liquid materials of hazard classes 3, 5, 6.1, 8 or 9 may be handled and transported in a road vehicle provided the damaged packages are placed in a steel or plastic drum over-pack.

9 References

UBC Department of Chemistry Safety Policies 2015

WorkSafe BC Occupational Health and Safety Regulations

- Part 5- Chemical Agents and Biological Agents
- Part 6- Substance Specific Requirements
- Cytotoxic Drugs 6.42-6.58
- Pesticides application
- Part 7- Noise, Vibration, Radiation and Temperature
- Part 8- Personal Protective Clothing and Equipment
- Part 30- Laboratories

Canadian Centre for Occupational Health and Safety (CCOHS)

WorkSafe BC Laboratory Safety Hand Book

WorkSafe BC WHMIS Instructor's Manual

Transport Canada TDG Regulations

BC Fire Code 2012

- Part 3- Indoor and Out Door Storage
- Part 4- Flammable and Combustible Liquids

Prudent Practices in the Laboratory: Handling and Disposal of Chemicals (1995), National Research Council.

IARC Classifications of Carcinogenic Agents

ACGIH Threshold Limit Values for Chemical Substances and Physical Agents & Biological Exposure Indices

10 Appendices

Appendix A: General Laboratory Safety Rules

Work Habits

- Do not store food or beverages in the laboratory (Except where food is clearly part of experimentation and has been marked as such).
- Do not eat, drink, smoke or pipette by mouth in the lab.
- Do not casually dispose of chemicals down the drain; follow hazardous waste disposal guidelines on the Risk Management Services website.
- Wash hands before and after work in a laboratory, and after spill clean-ups.
- Restrain loose clothing (e.g. sleeves, full cut blouses, neckties etc.), long hair and dangling jewelry.
- Protection should be provided for the lab worker and for nearby co-workers.
- Always inform co-workers of plans to carry out hazardous work *before* starting.
- First aid and CPR training is recommended for all lab personnel.
- Review all procedures before commencing any work.
- Always wash your hands before leaving lab.
- Gloved hands must not touch common equipment and items such as telephones, elevator buttons or door-knobs.
- Avoid working alone. If working alone, follow the Work Alone Policy.

Safety Wear

- Lab coats must be worn at all times in the laboratory.
- Fully enclosed shoes and long pants must be worn in the lab.
- Wear gloves that will resist penetration by the chemical being handled and which have been checked for pinholes, tears, or rips.
- Always wear ANSI (or equivalent standard) approved eye or face protection when working with chemicals in the laboratory.
- Contact lenses should only be worn if other forms of corrective eyewear are not suitable.
- Use respiratory protection when appropriate.

Purchasing, Use and Disposal

- Label all chemicals accurately with date of receipt, or preparation, and initialed by the person responsible. Add pertinent precautionary information for handling.
- Never open a reagent container until the label has been read and completely understood.
- Unlabeled bottles must be identified to the extent that they can then be classified as hazardous or non-hazardous wastes.
- Incompatible and hazardous wastes are properly segregated in clearly marked containers affixed with hazardous waste labels.
- Disposal of solvents meets all municipal, provincial, and federal regulations.

Substitutions

- Where possible, reduce risks by using diluted substances instead of using concentrates.
- Use micro/semi-micro techniques instead of macro-techniques.
- Use visual recording/remote observation methods instead of direct observation whenever possible.
- Evaluate all substitutions before changing procedures.
- Always substitute a less toxic material when possible.

Appendix B: Flash Points of Common Flammable Liquids

The following are Category 1 flammable liquids (flash point < 23°C; boiling point ≤ 35°C). Closed cup values are given :

Category 1:

Flammable Liquid	Flash Point (˚C)	Flammable Liquid	Flash Point (˚C)
Ethyl chloride	-50	Methanol	11
Pentane	-49	Isopropanol	12
Ethyl ether	-45	Dioxane	12
Acetaldehyde	-38	Ethylene dichloride	13
Isopropylamine	-37	Octane	13
Ethyl formate	-19	Propanol	15
Ethylamine	-18	Sec-butyl acetate	17
2-pentanone	7	Pyridine	20
Methyl methacrylate	10	Allyl alcohol	21

The following are Category 2 flammable liquids (flash point < 23°C; boiling point > 35°C), and Category 3 flammable liquids (23°C < flash point < 60°C):

Category 2 and 3:

Flammable Liquid	Flash Point (˚C)	Flammable Liquid	Flash Point (˚C)
Allyl chloride	-31	Heptane	-4
Carbon disulfide	-30	Acrylonitrile	-1
Isopropyl ether	-28	Methyl isobutyl ketone	22.5
Acrolein	-26	2-butanol	24
Hexane	-21	n-Amyl acetate	25
Cyclohexane	-20	2-hexanone	25
Ethyl bromide	-20	Isoamyl acetate	25
Nickel carbonyl	-20	Xylene	25
Acetone	-17	Butyl alcohol	29
Naphtha	-18	Chlorobenzene	29
1,1-dimethylhydrazine	-15	p-anisidine	30
Tetrahydrofuran	-14	Sec-amyl acetate	31
Butylamine	-12	Styrene	32
Benzene	-11	Ethylenediamine	33.5
Methyl acetate	-10	Morpholine	35

Flammable Liquid	Flash Point (˚C)	Flammable Liquid	Flash Point (˚C)
Methyl ethyl ketone	-6	Turpentine	35
Ethyl acetate	-4		

Flash point values were taken from *NIOSH Pocket Guide to Chemical Hazards, NIOSH Publication Number 2005-149*

Category 4 flammable liquids have a flash point 60˚C < flash point < 93˚C. Other flammable and combustible liquids might not have been tested for flash point and this may be reflected in the individual SDS as ‘unknown’ or ‘not tested’ in the physical properties section.

Appendix C: Carcinogens, Reproductive Toxins and Sensitizers

The following is a list of confirmed or suspected carcinogens, reproductive toxins and sensitizers. Note: this list is based on the WorkSafe BC Table of exposure limits for chemical and biological substances and may not be comprehensive.

IARC- International Agency for Research on Cancer
Group 1: carcinogenic to humans
Group 2A: probably carcinogenic to humans
Group 2B: possibly carcinogenic to humans

ACGIH- American Conference of Governmental Industrial Hygienists
Group A1: confirmed human carcinogen
Group A2: suspected human carcinogen
Group A4: not classifiable as a human carcinogen
Group A5: not suspected as a human carcinogen
R: confirmed reproductive toxin
S: a substance that has the potential to produce sensitization
S(D): a substance with specific evidence of sensitization by dermal route
S(R): a substance with specific evidence of sensitization by respiratory route

Chemical (CAS #)	Designation	Chemical (CAS #)	Designation
Acetaldehyde [75-07-0]	A2, 2B	Acetamide [60-35-5]	2B, (I)
Acetophenone [98-86-2]	R	Acrylamide, Inhalable [79-06-1]	2A
Acrylic acid [79-10-7]	R	Acrylonitrile [107-13-1]	2B
Alachlor, Inhalable [15972-60-8]	S(D)	Allyl glycidyl ether [106-92-3]	S
Allyl propyl disulfide [2179-59-1]	S(D)	4-Aminodiphenyl [92-67-1]	A1, 1
Amitrole [61-82-5]	R	Ammonium sulfamate [7773-06-0]	R
tert-Amyl methyl ether (TAME) [994-05-8]	R	o-Anisidine [90-04-0]	2B
Antimony trioxide - Production [1309-64-4]	A2, 2B	Arsenic and inorganic compounds, as As [7440-38-2]	A1, 1
Asbestos - All forms [1332-21-4]	A1, 1	Atrazine [1912-24-9]	R
Azinphos-methyl, Inhalable [86-50-0]	S(D)		
Benomyl, Inhalable [17804-35-2]	R, S(D)	Benz[a]anthracene [56-55-3]	A2, 2B
Benzene [71-43-2]	A1, 1	Benzidine [92-87-5]	A1, 1
Benzidine based dyes	2A	Benzo[b]fluoranthene [205-99-2]	A2, 2B
Benzo[a]pyrene [50-32-8]	A2, 1	Benzotrichloride [98-07-7]	A2, 2A
Benzoyl chloride [98-88-4]	2A	Benzyl chloride [100-44-7]	2A
Beryllium and compounds, Inhalable, as Be [7440-41-7]	A1, 1; S(D), S(R)	1-Bromopropane [106-94-5]	R
1,3-Butadiene [106-99-0]	A2, 1	n-Butyl acrylate [141-32-2]	S(D)

Chemical (CAS #)	Designation	Chemical (CAS #)	Designation
n-Butyl glycidyl ether (BGE) [2426-08-6]	S(D), R	n-Butyl mercaptan [109-79-5]	R
Cadmium and compounds, as Cd [7440-43-9]	A2, 1	Cadmium and compounds, Respirable, as Cd [7440-43-9]	A2, 1
Calcium chromate, as Cr [13765-19-0]	A2, 1	Captafol [2425-06-1]	2A; S(D); S(R)
Captan, Inhalable [133-06-2]	S(D)	Carbaryl [63-25-2]	R
Carbon black, Inhalable [1333-86-4]	2B	Carbon monoxide [630-08-0]	R
Carbon tetrachloride [56-23-5]	A2, 2B	Catechol [120-80-9]	2B
Chlordane [57-74-9]	2B	Chlorinated camphene [8001-35-2]	2B
2-Chloroacetophenone [532-27-4]	S	p-Chloroaniline [106-47-8]	2B
o-Chlorobenzylidene malononitrile [2698-41-1]	S(D)	Chlorodiphenyl (42% chloride) [53469-21-9]	2A
Chlorodiphenyl (54% chloride) [11097-69-1]	2A	Chloroform [67-66-3]	2B, R
bis(Chloromethyl) ether [542-88-1]	A1, 1	Chloromethyl methyl ether [107-30-2]	A2, 1
1-Chloro-2-propanol [127-00-4]	R	2-Chloro-1-propanol [78-89-7]	R
beta-Chloroprene [126-99-8]	A2, 2B, R	2-Chloropropionic acid [598-78-7]	R
4-Chloro-o-Toluidine [95-69-2]	2A	Chromite ore processing (Chromate), as Cr	A1
Chromium (VI) inorganic compounds - Insoluble, as Cr [7440-47-3]	A1, 1	Chrysene [218-01-9]	2B
Citral, inhalable [5292-40-5]	S(D)	Coal tar pitch volatiles, as benzene-soluble aerosol [65996-93-2]	A1, 1
Cobalt and inorganic compounds, as Co [7440-48-4]	2B	Cobalt carbonyl, as Co [10210-68-1]	2B
Cobalt hydrocarbonyl, as Co [16842-03-8]	2B	Cumene [98-82-8]	2B
DDT (Dichloro-diphenyltrichloroethane) [50-29-3]	2A	Demeton-S-methyl, Inhalable [919-86-8]	S(D)
2,4-Diaminoanisole [615-05-4]	2B	2,4-Diaminotoluene [95-80-7]	2B
Diazinon, Inhalable [333-41-5]	2A	Diazomethane [334-88-3]	A2
1,2-Dibromo-3-chloropropane [96-12-8]	2B	Dibutyl phthalate [84-74-2]	R
Dichloroacetic acid [79-43-6]	2B, R	p-Dichlorobenzene [106-46-7]	2B
1,4-Dichloro-2-butene [764-41-0]	A2	Dichloromethane [75-09-2]	2A
1,3-Dichloropropene [542-75-6]	2B	Dichlorvos (DDVP), Inhalable [62-73-7]	2B, S(D)
Dieldrin [60-57-1]	R	Diethanolamine [111-42-2]	2B
Diethylene triamine [111-40-0]	S	Di(2-ethylhexyl)phthalate (DEHP) [117-81-7]	2B
Diethyl sulfate [64-67-5]	2A	Diglycidyl ether (DGE) [2238-07-5]	R
Diisocyanates, not elsewhere specified, NOS	S	3,3'-Dimethoxybenzidine [119-90-4]	2B
Dimethyl carbamoyl chloride [79-44-7]	A2, 2A	1,1-Dimethylhydrazine [57-14-7]	2B
1,2-Dimethylhydrazine [540-73-8]	2A	Dimethyl sulfate [77-78-1]	2A
Dinitrotoluene [25321-14-6]	2B, R	1,4-Dioxane [123-91-1]	2B
1,3-Dioxolane [646-06-0]	R	Dodecyl mercaptan [112-55-0]	S(D)
Epichlorohydrin [106-89-8]	2A, R	2-Ethoxyethanol (EGEE) [110-80-5]	R

Chemical (CAS #)	Designation	Chemical (CAS #)	Designation
2-Ethoxyethyl acetate (EGEEA) [111-15-9]	R	Ethyl acrylate [140-88-5]	2B, S(D)
Ethyl benzene [100-41-4]	2B	Ethyl tert-butyl ether (ETBE) [637-92-3]	R
Ethylenediamine [107-15-3]	S	Ethylene dibromide [106-93-4]	2A
Ethylene dichloride (1,2-dichloroethane) [107-06-2]	2B	Ethylene oxide [75-21-8]	A2, 1, R
Ethyleneimine [151-56-4]	2B	2-Ethylhexanoic acid, Inhalable [149-57-5]	R
Ethyl isocyanate [109-90-0]	S(D)		
Flour dust, Inhalable	S(R)	Folpet [133-07-3]	S(D)
Formaldehyde [50-00-0]	A1, 1, S(D), S(R)		
Gasoline [86290-81-5]	2B	Glutaraldehyde, Activated & inactivated [111-30-8]	S(D); S(R)
Glycidol [556-52-5]	2A	Glyoxal, Inhalable [107-22-2]	S(D)
Halothane [151-67-7]	R	Hard metals, containing Cobalt and Tungsten Carbide, as Co [7440-48-4; 12070-12-1]	A2; S(R)
Heptachlor [76-44-8]	2B	Hexachlorobenzene (HCB) [118-74-1]	2B
Hexachloroethane [67-72-1]	2B	Hexafluoroacetone [684-16-2]	R
Hexahydrophthalic anhydride, all isomers, Inhalable [85-42-7; 13149-00-3; 14166-21-3]	S(R)	Hexamethyl phosphoramide [680-31-9]	2B
Hexamethylene diisocyanate (HDI) [822-06-0]	S(R)	1-Hexene [592-41-6]	R
Hydrazine [302-01-2]	2B	Hydroquinone [123-31-9]	S(D)
2-Hydroxypropyl acrylate [999-61-1]	S(D)		
Indium and compounds, as In [7440-74-6]	2B	Isophorone diisocyanate [4098-71-9]	S(R)
Lead - elemental and inorganic compounds, as Pb [7439-92-1]	Elemental 2B, R, other 2A, R	Lead chromate, as Cr [7758-97-6]	A2, 1; R
Lead chromate, as Pb [7758-97-6]	A2, 1; R		
Malathion, Inhalable [121-75-5]	2A	Maleic anhydride [108-31-6]	S(D), S(R)
Manganese - Elemental & inorganic compounds, as Mn [7439-96-5]	R	Mercury - Elemental, as Hg [7439-97-6]	R
Mercury - Inorganic compounds, as Hg [7439-97-6]	R	Mercury - Methyl, as Hg [7439-97-6]	2B
Methomyl [16752-77-5]	R	2-Methoxyethyl acetate (EGMEA) [110-49-6]	R
Methyl acrylate [96-33-3]	S(D)	Methyl tert-butyl ether (MTBE) [1634-04-4]	R
Methyl n-butyl ketone [591-78-6]	R	Methyl chloride [74-87-3]	R
Methylene bisphenyl isocyanate (MDI) [101-68-8]	S(R)	4,4'-Methylene bis(2-chloroaniline) (MBOCA; MOCA) [101-14-4]	A2, 1
Methylene bis (4-cyclo-hexyl-isocyanate), [5124-30-1]	S(R)	4,4'-Methylene dianiline [101-77-9]	2B
Methyl isobutyl ketone [108-10-1]	2B	Methyl isocyanate [624-83-9]	S(D)
Methyl isopropyl ketone [563-80-4]	R	Methyl methacrylate [80-62-6]	S(D)
alpha-Methyl styrene [98-83-9]	R; 2B	Methyl vinyl ketone [78-94-4]	S

Chemical (CAS #)	Designation	Chemical (CAS #)	Designation
Naled, Inhalable [300-76-5]	S(D)	Naphthalene [91-20-3]	2B
beta-Naphthylamine [91-59-8]	A1, 1	Natural rubber latex, as total proteins, Inhalable [9006-04-6]	S(D); S(R)
Nickel - Insoluble inorganic compounds, as Ni [7440-02-0]	A1, 1	Nickel - Elemental, Soluble inorganic compounds, as Ni [7440-02-0]	1, 2B
Nickel carbonyl, as Ni [13463-39-3]	1	Nickel subsulfide, as Ni, Inhalable [12035-72-2]	A1, 1
Nitrobenzene [98-95-3]	2B	4-Nitrodiphenyl [92-93-3]	A2
Nitromethane [75-52-5]	2B	2-Nitropropane [79-46-9]	2B
n-Nitrosodiethanolamine [1116-54-7]	2B	n-Nitrosodiethylamine [55-18-5]	2A
n-Nitrosodimethylamine [62-75-9]	2A	n-Nitrosomethylethylamine [10595-95-6]	2B
n-Nitrosomorpholine [59-89-2]	2B	n-Nitrosopiperidine [100-75-4]	2B
n-Nitrosopyrrolidine [930-55-2]	2B	Nitrotoluene, all isomers [88-72-2; 99-08-1; 99-99-0]	2A
Nitrous oxide [10024-97-2]	R		
Oil mist - mineral, mildly refined	1	p,p'-Oxybis(benzenesulfonyl hydrazide), Inhalable [80-51-3]	R
Parathion, Inhalable [56-38-2]	2B	Pentachlorophenol [87-86-5]	2B
p-Phenylenediamine [106-50-3]	S(D)	Phenyl glycidyl ether (PGE) [122-60-1]	2B, S(D), R
Phenyl isocyanate [103-71-9]	S(D), S(R)	Phenylphosphine [638-21-1]	R
Phthalic anhydride [85-44-9]	S(D), S(R)	Picric acid [88-89-1]	S(D)
Piperazine and its Salts, as Piperazine [110-85-0]	S(D); S(R)	Platinum - Soluble salts (as Pt) [7440-06-4]	S
Propane sultone [1120-71-4]	2A	beta-Propiolactone [57-57-8]	2B
Propylene dichloride [78-87-5]	1; S(D)	Propylene oxide [75-56-9]	2B; S(D)
Propyleneimine [75-55-8]	2B	Pyrethrum [8003-34-7]	S
Rosin core solder thermal decomposition products (colophony) [8050-09-7]	S(D); S(R)		
Silica, Crystalline - alpha quartz [14808-60-7; 1317-95-9] and Cristobalite, Respirable [14464-46-1]	A2, 1	Silicon carbide, Fibrous (including whiskers) [409-21-2]	A2
Strontium chromate, as Cr [7789-06-2]	A2	Styrene - monomer [100-42-5]	2B
Subtilisins, as crystalline active enzyme [1395-21-7; 9014-01-1]	S(R)	Sulfuric acid, Thoracic [7664-93-9]	A2, 1
Synthetic Vitreous Fibres - Special purpose glass fibres	A2, 2B		
Talc - Containing asbestos fibres [14807-96-6]	A1, 1	1,1,2,2-Tetrachloroethane [79-34-5]	2B
Tetrachloroethylene (Perchloroethylene) [127-18-4]	2A	Tetrafluoroethylene [116-14-3]	2A
Tetranitromethane [509-14-8]	2B	Tetrakis (hydroxymethyl) phosphonium sulfate [55566-30-8]	S(D)
Tetryl [479-45-8]	S	Thiram [137-26-8]	S(D)
Titanium dioxide [13463-67-7]	2B	o-Tolidine [119-93-7]	2B
Toluene [108-88-3]	R	Toluene-2,4-diisocyanate (2,4-TDI) [584-84-9]	2B; S(D); S(R)
Toluene-2,6-diisocyanate (2,6-TDI) [91-08-7]	2B; S(D); S(R)	2,4- and 2,6-Toluene diisocyanate as a mixture [584-84-9; 91-08-7]	2B; S(D); S(R)

Chemical (CAS #)	**Designation**	**Chemical (CAS #)**	**Designation**
o-Toluidine [95-53-4]	1	Trichloroacetic acid [76-03-9]	2B
Trichloroethylene [79-01-6]	A2, 1	1,2,3-Trichloropropane [96-18-4]	A2, 2A
1,3,5-Triglycidyl-s-triazinetrione [2451-62-9]	R; S	Trimellitic anhydride [552-30-7]	S(D); S(R)
Turpentine [8006-64-2] and selected monoterpenes [80-56-8; 127-91-3; 13466-78-9]	S(D)		
Uranium (Natural) - Insoluble compounds, as U [7440-61-1]	A1, 1	Uranium (Natural) - Soluble compounds, as U [7440-61-1]	A1, 1
Vanadium pentoxide, as V, Inhalable [1314-62-1]	2B	Vinyl acetate [108-05-4]	2B
Vinyl bromide [593-60-2]	A2, 2A	Vinyl chloride [75-01-4]	A1, 1
4-Vinyl cyclohexene [100-40-3]	2B; R	Vinyl cyclohexene dioxide [106-87-6]	2B; R
Vinyl fluoride [75-02-5]	A2, 2A		
Warfarin [81-81-2]	R	Wood dust - Allergenic species	A1, A2, 1
Wood dust - Non-Allergenic Hardwood	A1, A2, 1	Wood dust - Non-Allergenic Softwood	1
Zinc chromates, as Cr [13530-65-9; 11103-86-9; 37300-23-5]	A1, 1		

Appendix D: Dangerously Reactive Materials (from TDG List)

Note: this list may not be comprehensive.

Self-reactive substances and solid desensitized explosives

Chemical compound	Chemical compound
2-Bromo-2-nitropropane-1,3-diol	Nitrocellulose w alcohol (alcohol>25%, nitrogen<12.65%)
2-Amino-4,6-dinitrophenol (>20%water)	Nitrocellulose w water (water >25%)
5-tert- Butyl-2,4,6-trinitro-m-xylene	Nitroguanidine (water>20%)
Aluminum powder	Nitronaphthalene
Aluminum resinate	Nitrostarch (water>20%)
Ammonium picrate (dry or w less than 10% water)	Paraformaldehyde
Azodicarbonamide	Phosphorus, amorphous
Barium azide (dry or wetted with less than 50% water)	Phosphorus heptasulfide
Borneol	Phosphorus sesquisulfide (free from yellow and white phosphorus)
Calcium resinate	Phosphorus trisulfide (free from yellow and white phosphorus)
Cobalt naphthenates powder	Picrite (water>20%)
Cobalt resinate	Silicon powder, amorphous
Decaborane	Silver picrate (water>30%)
Dicyclohexylammonium nitrate	Sodium dinitro-o-cresolate (15%<water)
Dinitrophenolates (w more than 15% water)	Sodium picramate (20% >water)
Dinitroresorcinol (w more than 15% water)	Sulfur
Dipicrylsulfide (w more than 10% water)	Titanium hydride
Dipicrylsulphide (w more than 10% water)	Titanium powder wetted(25%<water)
Ferrocerium (unstabilized against corrosion or w less than 10% iron)	Trinitrophenol (30%<water)
Hexamethylenetetramine	Trinitrotoluene (30%<water)
Isosorbide-5-mononitrate	Urea nitrate (water <20%)
Lead phosphate dibasic	Zinc resinate
Magnesium alloys (>50% magnesium)	Zirconium hydride
Manganese resinate	Zirconium picramate (20%<water)
Molten sulfur	Zirconium powder (25%<water)
Naphthalene	

Materials liable to spontaneous combustion

Chemical compound	**Chemical compound**
Aluminum borohydride	Phosphorus, yellow (dry, solution, under water)
Barium alloys, pyrophoric	p-Nitrosodimethylaniline
Calcium alloys, pyrophoric	Potassium hydrosulfite
Calcium hydrosulfite	Potassium sulfide (30%> water)
Calcium, pyrophoric	Potassium sulfide, anhydrous
Carbon activated	Sodium dithionite
Copra	Sodium hydrosulfide (water<25%)
Cyclooctadiene phosphine	Sodium hydrosulfite
Hafnium powder	Sodium methylate
Iron oxide	Sodium sulfide (water<30%)
Lithium alkyls	Sodium sulfide anhydrous
Magnesium alkyls	Thiourea dioxide
Magnesium diamide	Titanium trichloride, pyrophoric
Magnesium diphenyl	Titanium disulfide
Maneb	Titanium powder dry
Pentaborane	Xanthates
Phosphorus, white (dry, solution, molten)	Zirconium powder dry

Substances that release flammable gases in contact with water

Chemical compound	**Chemical compound**
Aluminum carbide	Lithium silicon
Aluminum ferrosilicon powder	Magnesium alloys powder
Aluminum hydride	Magnesium aluminum phosphide
Aluminum phosphide	Magnesium hydride
Aluminum silicon powder	Magnesium phosphide
Barium	Magnesium powder
Boron trifluoride dimethyl etherate	Magnesium silicide
Caesium	Methyldichlorosilane
Calcium	Phosphorus pentasulfide (free from yellow and white phosphorus)

Chemical compound	Chemical compound
Calcium carbide	Potassium
Calcium cyanamide (w > 0.1 calcium carbide)	Potassium borohydride
Calcium hydride	Potassium metal alloys
Calcium phosphide	Potassium phosphide
Calcium silicide	Potassium sodium alloys
Cerium	Rubidium
Chlorosilanes	Sodium
Ferrosilicon (90%>silicon>30%)	Sodium aluminum hydride
Lithium	Sodium borohydride
Lithium aluminum hydride	Sodium hydride
Lithium borohydride	Trichlorosilane
Lithium ferrosilicon	Zinc dust
Lithium hydride	Zinc phosphide
Lithium nitride	Zinc powder

Appendix E: Explosives and Potentially Explosive Chemical Lists

When using or synthesizing chemicals, keep in mind that if a chemical is included in any of the families below, it is potentially explosive. Also, consider the ratio of nitrogen and oxygen to other atoms. The higher the ratio, the more likely the chemical is going to be explosive.

Potentially Explosive Chemical Families with Examples

Note: this list may not be comprehensive.

Acetylene or acetylide compounds:
- Calcium carbide
- Propiolic acid

Azides:
- Acyl azides
- Hydrogen azide
- Lead azide
- Sodium azide

Diazo and Diazonium compounds:
- Benzenediazonium-2-carboxylate
- Diazomethane
- Diethyl diazomalonate

Fulminates:
- Lead fulminate
- Mercury fulminate

Hydrides:
- Stibine

Inorganic nitrates:
- Ammonium nitrate

***N*-Halides:**
- 1,1-Difluorourea
- N-Chloro-3-aminopropane
- Nitrogen trifluoride

Nitrides:
- Cadmium nitride
- Disulfur dinitride
- Lithium nitride

Nitro compounds:
- Nitromethane
- Picric acid
- RDX
- Trinitrotoluene

***N*-Oxides and Oximes:**
- Bromoacetone oxime

Organic nitrates:
- Nitrocellulose
- Nitroglycerin
- Propyl Nitrate

Perchlorates:
- Ethyl perchlorate
- Perchloric acid
- Pyridinium perchlorate

Peroxides:
- Benzoyl peroxide
- Peroxyacetic acid
- *tert*-Butyl hydroperoxide
- Triacetone triperoxide
- Most transition metal peroxide compounds

Picrates:
- Ammonium picrate
- Uranyl picrate

Ring-strained compounds:
- Aziridines
- Dicyclopropyldiazomethane
- Prismane

Tetrazoles:
- 5-Aminotetrazole

Violent polymerizing compounds:
- Acrylic acid
- Ethylene oxide

Ozonides

Others compounds:
- Sodium amide

Chemicals that May Deteriorate to Hazardous Conditions

Many mechanisms can trigger an explosion. These include light, heat, friction, shock, or chemical catalysis. Always be mindful of how you handle a potentially explosive chemical. Dilution generally reduces the risk of explosion.

The following is a selection of chemicals that can deteriorate to a dangerous condition with age under common storage conditions

From M.J. Pitt and E. Pitt, Handbook of Laboratory Waste Disposal, Ellis Horwood Publisher, UK, 1985

Chemical Compound	**Chemical Compound**	**Chemical Compound**
2-Acetylfuran	Ethylene glycol monobutyl ether	Diethylazodicarboxylate
Acetaldehyde diethyl acetal	Ethylene glycol ether acetate	Diethyleneglycol dimethyl ether
Acetyl peroxide	2-Methoxyethanol	Diglyme
Ammonium dichromate	Magnesium perchlorate	Dihydropyran
Anethole	Mercury fulminate	Dimethoxymethane
Anisaldehyde	Methyl cellosolve	Diphenyl ether
Anisole	Methyl ethyl ketone peroxide	Furan
Benzoyl peroxide	Methyl isobutyl ketone	Glyme iodine pentoxide
1-Butoxyethylacetate	Methyl vinyl ketone	Isoamyl ether
n-Butyl glycidyl ether	Nitromethane	Isobutyl ether
n-Butyl ether	Sodamide	Isopentyl ether
t-Butyl hydroperoxide	Sodium amide	Isopropyl alcohol
Cellosolve	Sodium perchlorate	Peracetic acid
Chromium trioxide	Sodium chlorate	Perchloric acid
Cumene	Sodium metal dispersions	Picric aid
Cyclohexene	1,1-Diethoxyethane	Picryl chloride
Cyclopentadiene	1,2-Dimethoxyethane	Picryl sulphonic acid
Cyclopentene	1,4-Dioxane	Potassium (metal)
2-Ethoxyethanol	2,4-Dinitrophenol	Potassium amide
2-Ethoxyethyl acetate	2,4-Dinitrophenylhydrazine	Potassium chlorate
Ethyl cellosolve	Decahydronaphthalene	Propargyl bromide
Ethylene glycol monomethyl ether	Decalin	Propargyl chloride
Ethylene glycol monoethyl ether	Diisoamyl ether	Tetralin
Ethylene glycol dimethyl ether	Diisobutyl ether	Trinitrobenzene sulphonic acid
Dicyclopentadiene	Diisopropyl ether	Diethyl ether

Diethyl azidoformate	Dibenzyl ether	Diethylacetal
Sodium chlorite	Trinitrobenzene	Vinyl pyridine
Styrene	Urea nitrate	Vinylidene chloride
		Vinyl acetate

Chemicals That May Explode Due to Over-Pressurized Container

From M.J. Pitt and E. Pitt, Handbook of Laboratory Waste Disposal, Ellis Horwood Publisher, UK, 1985. Formic acid and phenol have been added to the list.

Chemical Compound	**Chemical Compound**	**Chemical Compound**
Aluminum chloride	Cyclohexane	Sodium borohydride
Ammonia solution	Diethyl pyrocarbonate	Sodium dithionite
Ammonium hydroxide	Dimethylamine	Sodium hydride
Ammonium persulfate	Formic acid	Sodium hydrosulfite
Anisyl chloride	Hydrogen peroxide	Sodium hypochlorite
Aqua regia	Lauroyl peroxide	Sodium peroxide
Benzenesulfonyl chloride	Lithium aluminum hydride	Sodium persulfate
Bleach	Lithium hydride	Thionyl chloride
Bleaching powder	Nitric acid	Urea peroxide
Calcium carbide	Nitrosoguanidine	Zinc
Calcium hydride	Peracetic acid	
Calcium hypochlorite	Phenol	
Chloroform	Phosphorous trichloride	
Chromic acid	Potassium Persulfate	
Cumene hydroperoxide	Silicon tetrachloride	

Appendix F: Peroxidizable Compounds

Note: this list may not be comprehensive.

Testing Schedule

There are four classes of peroxide-forming chemicals based upon the peroxide formation hazard:

- Class A – Severe Peroxide Hazard
- Class B – Concentration Hazard
- Class C – Shock and Heat Sensitive
- Class D – Potential Peroxide-Forming Chemicals

	Class A	**Class B**	**Class C**	**Class D**
Date Opened	3 months	6 months	6 months	1 year

Class A – Severe Peroxide Hazard

Spontaneously decompose and become explosive with exposure to air without concentration.

Butadiene (liquid monomer)	Isopropyl ether	Sodium amide (sodamide)
Chloroprene (liquid monomer)	Potassium amide	Tetrafluoroethylene (liquid monomer)
Divinyl acetylene	Potassium metal	Vinylidene chloride

Class B – Concentration Hazard

Require external energy for spontaneous decomposition. Form explosive peroxides when distilled, evaporated or otherwise concentrated.

Acetal	Diethylene glycol dimethyl ether (diglyme)	4-Methyl-2-pentanol
Acetaldehyde	Diethyl ether	2-Pentanol (isopropyl alcohol)
Benzyl alcohol	Dioxanes	4-Penten-1-ol
2-Butanol	Ethylene glycol dimethyl ether (glyme)	1-Phenylethanol
Cumene	ran	2-Phenylethanol
Cyclohexanol	Heptanol	2-Propanol
Cyclohexene	2-Hexanol	Tetrahydrofuran
2-Cyclohexen-1-ol	Methylacetylene	Tetrahydronaphthalene
Decahydronaphthalene	3-Methyl-1-butanol	Vinyl ethers
Diacetylene	Methylcyclopentane	Other secondary alcohols
Dicyclopentadiene	Methyl isobutyl ketone	

Class C – Shock and Heat Sensitive

Highly reactive and can auto-polymerize as a result of internal peroxide accumulation. The peroxides formed in these reactions are extremely shock and heat sensitive.

Acrylic acid	Chlorotrifluoroethylene	Vinyl acetate
Acrylonitrile	Methyl methacrylate	Vinylacetylene (gas)
Butadiene (gas)	Styrene Vinylpyridine	Vinyladiene chloride
Chloroprene	Tetrafluoroethylene (gas)	Vinyl chloride (gas)

Class D – Potential Peroxide Forming Chemicals

May form peroxides but cannot be clearly categorized in Class A, B, or C.

Acrolein	p-Chlorophenetole	4,5-Hexadien-2-yn-1-ol
Allyl ether	Cyclooctene	n-Hexyl ether
Allyl ethyl ether	Cyclopropyl methyl ether	o.p-Iodophenetole
Allyl phenyl ether	Diallyl ether	Isoamyl benzyl ether
p-(n-Amyloxy)benzoyl chloride	p-Di-n-butoxybenzene	Isoamyl ether
n-Amyl ether	1,2-Dibenzyloxyethane	Isobutyl vinyl ether
Benzyl n-butyl ether	p-Dibenzyloxybenzene	Isophorone
Benzyl ether	1,2-Dichloroethyl ethyl ether	b-Isopropoxypropionitrile
Benzyl ethyl ether	2,4-Dichlorophenetole	Isopropyl-2,4,5-trichlorophenoxy acetate
Benzyl methyl ether	Diethoxymethane	n-Methylphenetole
Benzyl-1-napthyl ether	2,2-Diethoxypropane	2-Methyltetrahydrofuran
1,2-Bis(2-chloroethoxyl)ethane	Diethyl ethoxymethylenemalonate	3-Methoxy-1-butyl acetate
Bis(2-ethoxyethyl)ether	Diethyl fumarate	2-Methoxyethanol
Bis(2-(methoxyethoxy)ethyl) ether	Diethyl acetal	3-Methoxyethyl acetate
Bis(2-chloroethyl) ether	Diethylketene	2-Methoxyethyl vinyl ether
Bis(2-ethoxyethyl) adipate	Diethoxybenzene (m-,o-,p-)	Methoxy-1,3,5,7-cyclooctatetraene
Bis(2-methoxyethyl) carbonate	1,2-Diethoxyethane	b-Methoxypropionitrile
Bis(2-methoxyethyl) ether	Dimethoxymethane	m-Nitrophenetole
Bis(2-methoxyethyl) phthalate	1,1-Dimethoxyethane	1-Octene
Bis(2-methoxymethyl) adipate	Di(1-propynl) ether	Oxybis(2-ethyl acetate)
Bis(2-n-butoxyethyl) phthalate	Di(2-propynl) ether	Oxybis(2-ethyl benzoate)
Bis(2-phenoxyethyl) ether	Di-n-propoxymethane	b,b-Oxydipropionitrile
Bis(4-chlorobutyl) ether	1,2-Epoxy-3-isopropoxypropane	1-Pentene
Bis(chloromethyl) ether	1,2-Epoxy-3-phenoxypropane	Phenoxyacetyl chloride

2-Bromomethyl ethyl ether	p-Ethoxyacetophenone	a-Phenoxypropionyl chloride
beta-Bromophenetole	1-(2-Ethoxyethoxy)ethyl acetate	Phenyl-o-propyl ether
o-Bromophenetole	2-Ethoxyethyl acetate	p-Phenylphenetone
p-Bromophenetole	(2-Ethoxyethyl)-a-benzoyl benzoate	n-Propyl ether
3-Bromopropyl phenyl ether	1-Ethoxynaphthalene	n-Propyl isopropyl ether
tert-Butyl methyl ether	o,p-Ethoxyphenyl isocyanate	Sodium 8-11-14-eicosatetraenoate
n-Butyl phenyl ether	1-Ethoxy-2-propyne	Sodium ethoxyacetylide
n-Butyl vinyl ether	3-Ethoxypropionitrile	Tetrahydropyran
Chloroacetaldehyde diethylacetal	2-Ethylacrylaldehyde oxime	Triethylene glycol diacetate
2-Chlorobutadiene	2-Ethylbutanol	Triethylene glycol dipropionate
1-(2-Chloroethoxy)-2-phenoxyethane	Ethyl-b-ethoxypropionate	1,3,3-Trimethoxypropene
Chloroethylene	Ethylene glycol monomethyl ether	1,1,2,3-Tetrachloro-1,3-butadiene
Chloromethyl methyl ether	2-Ethylhexanal	4-Vinyl cyclohexene
beta-Chlorophenetole	Ethyl vinyl ether	Vinylene carbonate
o-Chorophenol	2,5-Hexadiyn-1-ol	

References:

National Safety Council: Data Sheet I-655 Rev. 87

NFPA: NFPA 432, Code for the Storage of Organic Peroxide Formulations

Reactive Hazards Reduction, Inc. http://www.rhr-inc.com/

FDNY: 3 RCNY Chapter §10-01 – Chemical Laboratories

Appendix G: Personal Protective Equipment Hazard Reference Guide

Chemical Hazards			
Check All That Apply	**Task**	**Potential Hazard**	**Recommended PPE**
☐	Working with ml amount of less hazardous chemicals.	Slight skin or eye damage	Safety glasses Light chemical resistant gloves, closed shoe, pants
☐	Working with small volumes of corrosive liquids (< 1 liter).	Skin or eye damage	Safety glasses or goggles Light chemically resistant gloves Lab coat, closed shoe, pants
☐	Working with large volumes of corrosive liquids (> 1 liter), acutely toxic corrosives, or work which creates a splash hazard	Large surface area skin or eye damage, poisoning, or great potential for eye and skin damage	Safety goggles and face shield Heavy chemically resistant gloves Lab coat, closed shoe, pants, and chemically resistant apron
☐	Working with small volumes of organic solvents (< 1 liter).	Skin or eye damage Slight poisoning potential through skin contact	Safety glasses or goggles Light chemically resistant gloves Lab coat, closed shoe, pants
☐	Working with large volumes of organic solvents (> 1 liter), very dangerous solvents, or work which creates a splash hazard	Major skin or eye damage, or potential poisoning through skin contact	Safety goggles and face shield Heavy chemically resistant gloves Lab coat, closed shoe, pants, and chemically resistant apron
☐	Working with toxic or hazardous chemicals (solid or liquid).	Potential skin or eye damage, potential poisoning by skin contact.	Safety glasses (goggles for large quantities), light chemically resistant gloves, lab coat, closed shoe, pants.
☐	Working with acutely toxic or hazardous chemicals (solid or liquid).	Great potential skin or eye damage, great potential poisoning through skin contact.	Safety goggles, appropriate heavy chemically resistant gloves, lab coat, closed shoe, pants Coveralls and booties if necessary.
☐	Working with explosives.	Skin or eye damage from flying projectiles or chemicals.	Blast shield, safety goggles or full face shield, chemically resistant gloves, lab coat, closed shoe, pants.
☐	Working with chemical dusts.	Skin or eye damage, respiratory damage.	Safety glasses or goggles, appropriate gloves, lab coat, closed shoes or boots if necessary, pants, Approved respiratory protection
☐	Chemical spill cleanup.	Skin or eye damage, respiratory damage.	Safety glasses or goggles, appropriate gloves, lab coat, closed shoes or boots, pants, (contact hazmat for clean-up if respiratory protection necessary)

Physical Hazards			
Check	**Task**	**Potential Hazard**	**Recommended PPE**
☐	Working with cryogenic liquids.	Major skin, tissue, or eye damage.	Safety glasses or goggles for large volumes, heavy insulated gloves, lab coat, closed shoe, pants.
☐	Working with very cold equipment or dry ice.	Frostbite, hypothermia.	Safety glasses, insulated gloves & warm clothing, lab coat, closed shoe, pants.
☐	Working with hot liquids, equipment, open flames (autoclave, bunsen burner, water bath, oil bath).	Burns resulting in skin or eye damage.	Safety glasses or goggles for large volumes, insulated gloves, lab coat, closed shoe, pants.
☐	Instrument repair	Eye damage from foreign objects.	Safety glasses, no loose clothing or jewelry.
☐	Metal or woodworking.	Eye damage from foreign objects, lacerations.	Safety glasses, gloves, no loose clothing or jewelry.
☐	Working in nuisance dusts.	Skin or eye damage, respiratory damage.	Safety goggles, appropriate gloves, lab coat, closed shoes or boots if necessary, pants, NIOSH approved dust mask or other respiratory protection
☐	Glassware washing.	Lacerations.	Heavy rubber gloves, lab coat, closed shoes, pants.
☐	Working with sharp objects or potential for glass braking	Cuts	Cut resistant gloves, safety glasses
☐	Working with loud equipment, noises, sounds, or alarms, etc.	Potential ear damage and hearing loss.	Ear plugs or headphones as necessary.

Appendix H: General Spill Kit Check List

The following are suggested items to be included in a spill kit:

Quantity	Description
2 each	Plastic liners
1 each	Instruction Booklet
1 each	Safety Flashlight
1 each	Printed Floor Sign (slippery when wet)
1 roll	Barricade tape
2 each	Chemical Spill Clothing Kit - MUST BE SEALED
10 each	Spill Control Pillows, 1 litre size
1-10 litres	Damming Material (unreactive, absorbent such as vermiculite)
1 each	Acid Neutralizer shaker, 2.8 kg (Spill X -A)
1 each	Caustic Neutralizer Shaker, 2.8 kg (Spill X- C)
1 each	Solvent Absorbent Shaker, 2.8 kg (Spill X- S)
1 box	Mercury/VAP ABSORB
1 each	Tongs, 20" long (for picking up broken/contaminated glass)
1 each	Mop Bucket, 35 quart
1 each	Wringer
1 each	24 ounce Mop Head and Handle
1 each	Spill Squeegee, Floor Size, 18" Head
1 each	Spill Squeegee, Bench Size, 8" Head
1 each	Polypropylene Broom
1 each	Bench Brush
1 each	Dust Pan
1 roll	Chem/Kleen-Ups Towels, 9 3/4" X 100 ft. roll
1 each	Glass Disposal Box, 8" X 8" X 10"
5 each	Hazardous Waste Disposal Bags 12" X 18"
1 each	Sponge
1 each	Liquid Cleaner, 32 ounce
1 each	Bleach, 1 gallon
1 roll	pH Paper
1 roll	Barricade Tape, 100 feet
1 each	Cover, for CART

Checked by:___________________________________

Date:________________________

Note any shortages

Replace ASAP

If Clothing kit disturbed, check item by item.

Personal Protective Clothing Check List

Quantity	Description
1 each	Total Body Coverall, Polylaminated TYVEK
2 pair	Foot Covers, Disposable, Polyethylene
1 pair	Nitrile Gloves
1 package	Disposable Polyethylene Gloves
1 pair	Chemical Splash Goggles, Fog Free Lens
1 each	Hydrogen Fluoride Respirator
1 each	Dust and Mist Respirator
1 each	Toxic and Hazardous Chemicals Industry Chart, Pocket Size

Checked by:___________________________

Date:_______________________

The Clothing Kit must be sealed up again with the Tape provided for this purpose.

Note: When a cartridge respirator is required for chemical spill clean-up, only those who have been trained and fit-tested are authorized to do so. For this reason, cartridge respirators are not included in the spill kit

Appendix I: Project Hazard and Control Analysis

Department / Building name: ______________________________ **Date:** ______________________________

Hazard Grade: High ( ) (potentially life threatening)
Medium ( ) (potential for significant equipment or building damage)
Low ( ) (minor equipment damage)

Equipment Type	
Previous Inspection Date	
Room No.	
Experimenter(s)	
Inspected By	

SOP documented and reviewed: Yes ( ) No ( )
Location:

Training of users documented: Yes ( ) No ( )
Location:

Potential Hazards	Y/N	Specific Control Measures
High pressure or Vacuum		
High temperature		
High voltage		
Risk of explosion		
Toxic materials		
Reactive/oxidizing materials		
Cryogenics/compressed gases		
Solvents		
Loss of air		
Loss of water		
Loss of power		
Trip/Fall		
Other		

List principle hazardous chemicals used:

Item	Quantity	SDS Available (✓)	SDS Reviewed (✓)

Waste generation information:

Type of Waste	Quantity	Disposal Method

Spill kit available for which WHMIS hazard classes: ______________________________

Emergency Contact Information First aid station location:
Name:
Phone number: Required Personal Protective Equipment Available:
Location: Eye protection: Yes ( )No ( ) Location:
Foot protection: Yes ( )No ( ) Location:
Emergency Shutdown Procedures posted: Hand protection: Yes ( )No ( ) Location:
Yes ( ) No ( ) Location: Lab coat/apron: Yes ( )No ( ) Location:
Respirator: Yes ( )No ( ) Location:
Emergency Safety Equipment
Fire extinguisher location:
Eye wash fountain location:
Emergency shower location:
Spill kit location:

Analysis reviewed by Local Safety Committee: **Yes ( ) No ( ) Date:**

Other Remarks:

Appendix J: UBC Chemical Laboratory Safety Check List

Laboratory Supervisor: ____________________ Room Number: ____________________

Inspected By: ____________________ Date: ____________________

ITEM	YES	NO	N/A	COMMENTS
A. EMERGENCY and INFORMATION MATERIAL				
Emergency contact info posted and legible	☐	☐	☐	
SDS information available in the lab	☐	☐	☐	
Chemical inventory, current (<1 year)	☐	☐	☐	Last updated:
Monthly inspections posted and up-to-date	☐	☐	☐	
Shower available and accessible	☐	☐	☐	Date tested:
Eyewash available and accessible	☐	☐	☐	Date tested:
Fire extinguisher present and accessible	☐	☐	☐	Date tested:
Spill kit(s) available and stocked	☐	☐	☐	
B. FIRST AID				
First aid kit available and stocked	☐	☐	☐	
Inventory list available	☐	☐	☐	
Treatment record sheet available and used	☐	☐	☐	
C. PERSONAL PROTECTION				
Safety glasses available and worn	☐	☐	☐	
Laboratory coats and gloves available and worn	☐	☐	☐	
Appropriate clothing used (long loose fitting pants, fully covered liquid resistant shoes)	☐	☐	☐	
Facial shields available and in good condition	☐	☐	☐	
Blast shields available and in good condition	☐	☐	☐	
Respirator user(s) trained & fit-tested	☐	☐	☐	
Vacuum ballasts/Dewar flasks taped or meshed	☐	☐	☐	
D. HOUSEKEEPING				
Bench tops and sink areas tidy	☐	☐	☐	

ITEM	YES	NO	N/A	COMMENTS
Tripping hazards absent, passageways clear	☐	☐	☐	
Laboratory exits clear and doors unlocked	☐	☐	☐	
Food and drink absent; “No Eating/Drinking” signs posted	☐	☐	☐	
Chipped or broken glassware not in use	☐	☐	☐	
Step-ladder available for out-of-reach items	☐	☐	☐	
E. WASTE CONTAINERS				
Glass-waste containers labeled	☐	☐	☐	
Needles and sharps in “Sharps” container	☐	☐	☐	
Bulk solvent-waste containers closed and labeled	☐	☐	☐	
Halogenated and non- Halogenated solvents segregated	☐	☐	☐	
Bulk solvent-waste stored in flammable storage cabinet	☐	☐	☐	
Recyclable solvents segregated	☐	☐	☐	
Interim solvent waste containers closed and <1 litre	☐	☐	☐	
F. COMPRESSED GAS CYLINDERS				
Individually secured to wall or bench	☐	☐	☐	
Lecture bottles stored upright or slanted/secure	☐	☐	☐	
G. FUME HOODS				
Sash at recommended height and air flow on	☐	☐	☐	
Area within and under hood tidy	☐	☐	☐	
Fumehood labelled if for special use	☐	☐	☐	
H. ELECTRICAL APPARATUS				
Vacuum pumps stored safely and belts guarded	☐	☐	☐	
Refrigerator spark-proof (or “***NO Flammables”*** sign posted if flammables are absent)	☐	☐	☐	
Frayed or cracked electrical cords absent	☐	☐	☐	
I. RUBBER OR PLASTIC TUBING				
Cracked/brittle/pinched tubing absent	☐	☐	☐	
Water hoses wired at all connectors	☐	☐	☐	
J. CHEMICAL STORAGE AND LABELLING				
Solvent containers ***outside*** solvent cabinet: < 25 L if in safety cans, otherwise <10 L	☐	☐	☐	

ITEM	YES	NO	N/A	COMMENTS
Solvent-still contents labeled	☐	☐	☐	
Reagent chemicals stored securely (lips on shelves or doors on cupboards)	☐	☐	☐	
Labels compliant with WHMIS	☐	☐	☐	
Chemical labels intact, legible, not overwritten	☐	☐	☐	
Cleaning baths labeled	☐	☐	☐	
Peroxide forming chemicals:				
Stored (& used) out of direct sunlight	☐	☐	☐	
Containers display opening date	☐	☐	☐	
Checked for peroxides (3 to 6 months)	☐	☐	☐	
K. BIOLOGICAL HAZARDS (if applicable)				
Biosafety cabinets kept tidy, functional, & annually certified	☐	☐	☐	
Biosafety Permits are posted in the space	☐	☐	☐	
Vacuum lines have an in-line HEPA filter	☐	☐	☐	
Biohazardous waste containers have lids and are labelled	☐	☐	☐	
L. RADIATION HAZARDS (if applicable)				
Autorized personnel are listed in the records binder	☐	☐	☐	
Radioisotope Permits are posted in the space (Each Radioisotope permit must be accompanied by a CNSC rules poster)	☐	☐	☐	
Survey meters have been calibrated within the last year	☐	☐	☐	

PLEASE ENSURE CORECTIONS ARE MADE BY: ____________________

Supervisor: ____________________ (Please sign after violations have been corrected)

UPON CORRECTION OF VIOLATIONS, PLEASE RETURN TO LOCAL SAFETY TEAM

11 Glossary of Terms

Term	Definition
acid	a substance that increases the concentration of hydronium ions (H30+) in solution; acts as a proton donor; has a pH of less than 7
acute	a rapid onset
aerosol	a suspension of fine solid particles or liquid droplets in a gas
asphyxiation	a condition of severely deficient supply of oxygen to the body
auto-ignition	spontaneous combustion without an ignition source
base	a substance that can accept hydrogen ions/ donate electron pairs; has a pH greater than 7
break-through	when referring to PPE it is when the protection is no longer effective in blocking a substance from making contact with the individual wearing said protection
Cardex	the index to periodicals subscribed to
caustic	a corrosive substance that will destroy or damage another surface or substance it comes in contact with
CCOHS	Canadian Centre for Occupational Health and Safety
ceiling limit	concentration of a substance in air which may not be exceeded at any time during the work period
chronic	long-lasting or recurrent
combustibility	measure of how easily a substance will set on fire (flash point>37.8degC)
condensation	the change of the physical state of matter from gaseous phase into liquid phase
controlled products	a material that exceeds hazard criteria for inclusion in the WHMIS hazard classes and divisions
corrosive	a substance that will destroy or damage another surface or substance it comes in contact with
cryogenic	a substance with a boiling point below -150degC at sea level
cytotoxin	an agent that possesses a specific destructive action on certain cells or that may be genotoxic, oncogenic, mutagenic, teratogenic, or hazardous to cells in any way
decomposition	the process where an unstable chemical breaks down into simpler chemicals
decontamination	the process of cleansing a surface, equipment or person to remove hazardous materials
distillation	a method of separating mixtures based on differences in their volatilities through boiling; it is a physical separation process, not a chemical reaction
endothermic	the process or reaction where energy is absorbed from the surroundings as heat; in chemical reactions this heat is converted into chemical bond energy
ESF	Environmental Services Facility
evaporation	the process of the phase transition from the liquid to gas phase that occurs at temperatures below the boiling temperature.

exothermic	the process or reaction where energy is released to the surroundings as heat
Explosives	materials that contains a great amount of stored energy that can produce a sudden expansion of the material after initiation, usually accompanied by the production of light, heat, sound, and pressure
flammability	measure of how easily a substance will set on fire (flash point<37.8degC)
flash point	temperature at which the vapor pressure of a liquid results in a vapor concentration great enough to ignite (flash) in the presence of a spark or flame
HEPA	High Efficiency Particulate Air
homogenous	uniform in composition or character
IDLH	Immediately Dangerous to Life or Health
infectious	detrimental colonization of a host organism by a foreign species
irritant	substance that causes inflammation or painful reaction
LC50	concentration required of a toxic substance to kill 50% of the members of a tested population
LD50	dose required of a toxic substance to kill 50% of the members of a tested population
LEL	Lower Explosive limit (as a concentration)
local	immediate area
mutagen	physical or chemical agent that changes the genetic material, usually DNA, of an organism and increases the frequency of mutations above background
n95	a rating of respirators: filters 95% of airborne particles
narcotic	psychoactive compound with sleep-inducing effects
neutralizer	a substance that bring the pH of an acid or base
NIOSH	National Institute for Occupational Safety and Health
nitrocellulose	a highly flammable compound formed by nitrating cellulose through exposure to nitric acid or another powerful nitrating agent
oxidizer	a chemical compound that readily transfers oxygen atoms
oxoacid	an acid that contains oxygen
PEC	Potentially Explosive Chemical
Pesticide	a substance or mixture of substances intended for preventing, destroying, repelling or mitigating any pest
pH	a measure of the acidity or basicity of an aqueous solution
poison	a substance that can cause disturbances to organisms, usually by chemical reaction or other activity on the molecular scale
polymerization	a chemical reaction in which many small molecules (monomers) join together to form large, chain-like molecule (polymer)
ppm	parts per million

pyrophoric	a substance that will ignite spontaneously in air
reactivity	the rate at which a chemical substance tends to undergo a chemical reaction
reagent	substance or compound that is added to a system in order to bring about a chemical reaction or is added to see if a reaction occurs
reflux	a technique involving the condensation of vapors and the return of this condensate to the system from which it originated
reproductive toxin	a substance that effects reproductive organs or processes
respirator	a device designed to protect the wearer from inhaling harmful dusts, fumes, vapors, and/or gases
run-away reaction	a chemical reaction that cannot be controlled and/or contained
saponification	a chemical process that produces soap from fatty acid derivatives
SCBA	Self-Contained Breathing Apparatus
SDS	Safety Data Sheet
sensitizer	a chemical that causes a substantial proportion of exposed people or animals to develop an allergic reaction in normal tissue after repeated exposure to the chemical
solvent	a liquid, solid, or gas that dissolves another solid, liquid, or gaseous solute, resulting in a solution that is soluble in a certain volume of solvent at a specified temperature
STEL	Short Term Exposure Limit
suck-back	a process where a liquid is pulled from a vessel due to a vacuum
systemic	affecting the whole body
TDG	Transport of Dangerous Goods
teratogen	a substance that causes abnormalities in physiological development
TLV	Threshold Limit Value
Toxicity	the degree to which a substance can damage an organism
TWA	Time Weighted Average
UEL	Upper Explosive limit (as a concentration)
ULC	Underwriters' Laboratory of Canada
vapour pressure	the pressure exerted by a liquid's vapor when the liquid and vapor are in dynamic equilibrium
VFRS	Vancouver Fire and Rescue Services
VOC	volatile organic compound
WHMIS	Workplace Hazardous Material Information System